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SENATE BILL 990 IMPLEMENTATION TECHNICAL MEMORANDUM
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LIST OF ACRONYMS AND ABBREVIATIONS

Boeing	The Boeing Company
Cal-EPA	California Environmental Protection Agency
CEQA	California Environmental Protection Act
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
cy	cubic yard
DOE	Department of Energy
DTSC	Department of Toxic Substances Control
D&D	decommissioning and decontamination
EIR	Environmental Impact Report
EPC	exposure point concentration
ERA	ecological risk assessment
ESADA	Empire State Atomic Development Authority
FSDF	Former Sodium Disposal Facility
ILCR	incremental lifetime cancer risk
HRA	health risk assessment
HHRA	human health risk assessment
HI	hazard index
HQ	hazard quotient
MWH	MWH Americas, Inc.
NASA	National Aeronautics and Space Administration
NFA	no further action
OCY	Old Conservation Yard
ORISE	Oak Ridge Institute of Science and Education
PAH	polynuclear aromatic hydrocarbons
PCB	polychlorinated biphenyl
PRG	preliminary remediation goal
RAIS	Risk Assessment Information System
RBSL	risk-based screening level
RCRA	Resource Conservation and Recovery Act
RR_d RBSL	Default SB990 Alternative rural residential risk-based screening level
RR_s RBSL	SSFL SB990 Alternative rural residential risk-based screening level
RFI	RCRA Facility Investigation
RL	reporting limit
SB990	California Senate Bill 990
SRAM	Standardized Risk Assessment Methodology
SRAM RBSL	SRAM residential risk-based screening level
SSFL	Santa Susana Field Laboratory
UCL	upper confidence limit
USEPA	U.S. Environmental Protection Agency
VOC	volatile organic compound

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1.0 INTRODUCTION

This technical memorandum describes alternatives for implementing California Senate Bill 990 (SB990) at the Santa Susana Field Laboratory (SSFL). This document has been prepared for The Boeing Company (Boeing) in response to a request by California Environmental Protection Agency (Cal-EPA) Department of Toxic Substances Control (DTSC).

1.1 BACKGROUND

The SSFL is located approximately 29 miles northwest of downtown Los Angeles, California, in the southeast corner of Ventura County (Figure 1). The site is divided into four administrative areas (Areas I, II, III, and IV) and undeveloped land areas to both the north and south (Figure 2). Areas I and III are operated by Boeing, which owns most of Area I and all of Area III. A portion of Area I and all of Area II are owned by the federal government administered by the National Aeronautics and Space Administration (NASA) and operated by Boeing. Area IV is owned and operated by Boeing for the Department of Energy (DOE), although DOE owns facilities located on a portion of Area IV. The northern and southern undeveloped lands of the SSFL were not used for industrial activities and are owned by Boeing.

Chemical investigation and cleanup at the SSFL is being performed as part of the Resource Conservation and Recovery Act (RCRA) Corrective Action Program with oversight by the DTSC. The SSFL RCRA Corrective Action Program is currently in the RCRA Facility Investigation (RFI) phase. Subsequent phases include remedial alternatives evaluation in the Corrective Measures Study (CMS), and the implementation of remedial actions in the Corrective Measures Implementation (CMI) phases. Environmental investigation at the SSFL is being conducted at areas identified with potential chemical use called “RFI sites.” The RFI sites identified for investigation at the SSFL are shown on Figure 1. The site boundaries shown on this figure generally include the known or suspected chemical use operational areas at the SSFL, and are not meant to represent the extent of sampling or contamination. In many cases, environmental sampling is conducted outside of these site boundaries to delineate the nature and extent of contamination.

Radiological investigation and cleanup at the SSFL is being performed by DOE. To date, 25 of the 27 radiological facilities have been closed. Radiological cleanup has been halted until DOE completes an Environmental Impact Statement for Area IV. Both buildings and land undergo a formal process of decommissioning and decontamination (D&D) involving cleanup, surveys by

Boeing, surveys by a third party DOE contractor (usually the Oak Ridge Institute of Science and Education (ORISE)), and the State Department of Public Health. Eleven of the radiological facilities have also undergone validation surveys and/or document reviews by the USEPA. Documentation of this process for all radiological facilities may be found at *http://www.etec.energy.gov/Reading-Room/DDTable.html*.

1.2 SB990 REQUIREMENTS

SB990 establishes risk assessment and cleanup requirements for the SSFL. The Senate Bill was passed by the California legislature and signed into law in October 2007 and is codified at California Health and Safety Code Section 25359.20.

The portion of SB990 that refers to risk assessment and site cleanup states:

> "In calculating risk, the cumulative risk from radiological and chemical contaminants at the site shall be summed, and the land use assumption shall be either suburban residential or rural residential (agricultural), whichever produces the lower permissible residual concentration for each contaminant. In the case of radioactive contamination, the department shall use as its risk range point of departure the concentrations in the Preliminary Remediation Goals (PRGs) issued by United States Environmental Protection Agency (USEPA) in effect as of January 1, 2007." *(acronyms and definitions inserted)*

Several statements in this text require interpretation to allow for effective implementation of SB990. Table 1 presents the elements that have been considered in this technical memorandum for developing alternatives for how SB990 would be implemented at the SSFL. The following summarize the most significant issues subject to interpretation:

- SB990 does not define exposure pathway requirements for the rural resident. Although default exposure pathways are defined by USEPA for a rural residential (agricultural) risk assessment of radionuclides, the default exposure pathways or parameters are not defined for chemical risk assessments in USEPA or California risk assessment guidance. Regulatory guidance encourages the use of site-specific data and pathways whenever possible in order to more accurately represent potential risks associated with a site (USEPA, 1989, 1991a, and 1991b).

- SB990 does not define how risk assessments will be used to determine remediation areas, nor does it set target risk goals. One option is to use a standard forward risk assessment method to achieve the target risk level (e.g., residual risks for a hypothetical rural resident must be less than 10^{-6}). Another option is to designate site-wide cleanup levels for each chemical and radionuclide.

- SB990 does not define a risk range point of departure for chemicals, nor an acceptable risk range for cumulative risk.

- SB990 does not specify when cumulative risk for chemicals and radionuclides is added, leaving open to interpretation whether this process is to be followed for baseline risks or for determining the acceptability of proposed cleanup when residual risks are calculated.

- SB990 does not define how risks above background levels are to be determined. Radiological risks are calculated incrementally above background levels, while chemical risk estimates are typically inclusive of background risk levels for chemicals of potential concern.

- SB990 does not specify risk assessment calculation requirements for exposure point concentrations (EPCs), nor how area-averaging should be performed. Area-averaging is a standard risk assessment procedure (USEPA, 2002).

As shown in Table 1 and summarized in the bullets above, SB990 does not sufficiently define risk assessment methodologies and procedures for implementation at the site. Because of these limitations, implementation of SB990 is subject to interpretation.

1.3 PURPOSE AND SCOPE

This technical memorandum presents procedures, assumptions, estimated results, and potential environmental impacts for two SB990 implementation alternatives for chemicals at the SSFL and compares these alternatives to the current remediation estimates (Base Case). Because of the wide range in interpretation for some of the key elements discussed above, a detailed analysis of two alternative interpretations has been performed to estimate and compare remedial extents for four representative RFI sites at the SSFL, and to evaluate potential environmental impacts based on extrapolating these results for all sites at the SSFL. These alternatives are then compared to the currently planned approach of implementing the SSFL Standardized Risk Assessment Methodology (SRAM) work plan (MWH. 2005). This analysis has been performed in detail only for soil media chemical risk assessment and potential remediation areas, and does not include specific radiological risk assessment procedures, nor cumulative radiological and chemical risk assessment methods. However, once a process to address chemicals has been established, a work plan inclusive of both chemical and radionuclides can be prepared.

The SB990 alternatives considered for detailed analysis were defined to meet SB990 standards where specified, and follow other regulatory guidance documents for risk assessment (USEPA 1989, 1991a, and 1991b). In summary, the two alternatives analyzed are:

Default SB990 Alternative. In this case, rural residential exposure pathways for chemical risk assessment are defined based on the default rural residential scenario in USEPA's *Soil Screening Guidance for Radiolonuclides: PRG Calculator* (USEPA, 2008), and include exposure to home-grown fruits and vegetables, swine, beef, milk, poultry, and eggs. These are in addition to the urban residential exposures and indirect exposure to volatile organic compounds (VOCs) that are SSFL-requirements by DTSC. The one exception to the use of USEPA (2008) default radiological exposure pathways for chemical risk assessment under the Default SB990 Alternative is exclusion of the fish consumption pathway (see Section 3.0). Data at the RFI site are considered for remediation by doing a 'sample by sample' comparison to risk-based screening levels (RBSLs). RBSLs are back-calculated to achieve an incremental life time cancer risk (ILCR) of 10^{-6} and a non-cancer hazard index (HI) equal to 1 for the hypothetical future rural resident, cumulatively for all Default SB990 Alternative exposure pathways. These are termed in this document as Default SB990 Alternative rural residential RBSLs (RR_d RBSL).

SSFL SB990 Alternative. In this case, rural residential exposure pathways for chemical risk assessment are defined based on SSFL-specific considerations and include exposure to home-grown fruits and vegetables, beef, poultry, and eggs, in addition to the urban residential exposures and indirect exposure to VOCs required by DTSC. Risk assessment is performed over the RFI site area, and an arithmetic average of the chemical data is used as the basis for remedial cleanup recommendations. Risk assessment results and site data are interpreted spatially to develop remedial estimates using back-calculated RBSLs to achieve an ILCR of 10^{-4} and a non-cancer HI equal to 1 for the hypothetical future rural resident, cumulatively for all SSFL SB990 exposure pathways. These are termed in this document as SSFL SB990 Alternative rural residential RBSLs (RR_s RBSL).

The resultant remedial estimates (cleanup volumes) from these two SB990 alternatives were compared to remedial estimates based on the existing DTSC-approved risk assessment methodology based on the SRAM. This case, called the Base Case, includes:

Base Case. In this case, the SRAM residential exposure pathways for chemical risk assessment are included (urban). Consumption of fruits and vegetables grown in home gardens (the typical 'suburban resident') is also calculated, but not cumulatively added into remedial planning estimates because of the high level of uncertainty in these estimates. However, they are considered in evaluating post-remediation risks. Risk assessment results and site data are interpreted spatially to develop remedial estimates using back-calculated

RBSLs to achieve an ILCR of 10^{-6} and a non-cancer HI equal to 1 for the hypothetical future urban resident. These are termed in this document as SRAM RBSLs (SRAM RBSL).

The Base Case presented in this technical memorandum is based on reporting and risk assessment findings as of September 2007 since the analysis presented herein uses site data collected and reported as of that date. It is important to note that data gap analysis, associated with significant additional sampling programs, reporting, and risk assessments are ongoing at the SSFL. As such, the current remedial estimates in the base case will most likely change as new information is obtained and as additional risk assessment is performed. Also, the base case planning estimates presented herein are not meant to be portrayed as final cleanup plans approved by DTSC; rather the base case represents estimates used for long-range planning.

To further contrast the two alternatives with the base case, a preliminary environmental impact analysis was performed to assess environmental consequences associated with implementing the alternative remediation estimates (excavation was assumed for all chemicals other than VOCs). Findings from this analysis show a significant difference between the Base Case, Default SB990 Alternative, and SSFL SB990 Alternative results, as documented in this technical memorandum.

The remedial estimates put forward in this technical memorandum are meant for comparison purposes and do not reflect actual cleanup recommendations. As noted above, Base Case estimates will likely change based on new data or risk assessment results. The remedial estimates presented for the two alternatives were prepared using abbreviated procedures to approximate baseline risk assessment results, and are not intended as complete risk assessments or remediation proposals for the sites evaluated. The SB990 alternatives presented here focus on evaluations of soil media since it represents the predominant media to be remediated at the SSFL, and not other media that would be considered in a full SB990 baseline risk assessment (e.g., soil vapor, surface water, or indirect groundwater). It is worth noting that direct exposures to groundwater will not be considered in a SB990 implementation plan since Boeing intends to obtain a land use covenant prohibiting drinking water use; as such, this exposure pathway is considered incomplete for risk assessment.

As discussed in the main sections of this technical memorandum, abbreviated risk evaluations were performed for the purposes of comparing the Base Case and SB990 alternatives. This approach also reduced the complexity of the tasks performed by reducing receptors and reducing the number of chemicals. An equally-important reason for an abbreviated risk assessment approach was the time constraint presented by the need to submit this analysis to DTSC on September 12, 2008. The implementation process, risk calculations and volume estimates, although abbreviated, are complex and detailed. As such, this document should be considered as a draft since some secondary review processes could not be completed prior to submittal. Although a complete check of all calculations or point by point data interpretation could not be performed, the overall results of this analysis are representative and allow comparison of the Base Case and two SB990 alternatives. Once the general process for SB990 implementation has been established, then a detailed and complete SB990 Risk Assessment Implementation Work Plan can be prepared.

Finally, it is worth noting that the Default and SSFL SB990 Alternatives presented in this document are just two of multiple possible approaches for SB990 implementation. For example, an implementation plan could include cleanup of surficial soils differently than deeper soils, or include cleanup to California regional background levels rather than local background levels. Consideration of these alternatives or others may have merit either separately or in conjunction with the two alternatives presented herein.

1.4 TECHNICAL MEMORANDUM ORGANIZATION

This Technical Memorandum is organized as follows:

- Section 1 provides SSFL background information, describes SB990 risk assessment and cleanup requirements, and presents an overview of the alternatives considered for SB990 implementation. Attachment 1 presents previously published RFI documents for the SSFL relevant for the evaluations presented in this technical memorandum.
- Section 2 describes the Base Case, with details presented in Attachment 2. The Base Case is presented first in this document since both SB990 alternatives build on current remediation estimates.
- Section 3 describes the Default SB990 Alternative, with details presented in Attachment 3.
- Section 4 describes the SSFL SB990 Alternative, with details presented in Attachment 4.
- Section 5 provides conclusions and recommendations.

Sampling analytical results used for this evaluation are provided in Attachment 5 for the four example RFI sites. The environmental impact analysis for remedial estimates generated using these cases is provided in Attachment 6.

2.0 BASE CASE

The Base Case is defined as the characterization of contamination, evaluation of human health and ecological risk, and estimation of the extent of remediation under the current, DTSC-approved RFI process for the SSFL. It is noteworthy that since the goal of the human health risk assessment (HHRA) and ecological risk assessment (ERA) processes for the SSFL is to accurately, yet conservatively, predict exposures and potential adverse effects, the DTSC-approved SRAM (MWH, 2005) defines the future potential human exposures to include residential, industrial, and recreational land use, as well as including ecological exposures. The Base Case for this technical memorandum includes the SRAM residential exposures as described below.

The definition of the Base Case is important in this evaluation of SB990 implementation alternatives. It is used as a benchmark to determine the additional remediation that would be required under a hypothetical future rural residential (i.e., agricultural) use of the SSFL. Contrasting the exposure assumptions (pathways and parameters) with that of the two SB990 alternatives (discussed in Sections 3.0 and 4.0), and comparing the relative increase in environmental impacts associated with each remediation effort (e.g., volume of soil to be addressed, duration of cleanup, number of hauling trucks) provides a reasonable basis for decisions regarding how to implement an SB990-compliant remediation at SSFL.

2.1 PROCESS FOLLOWED IN BASE CASE

The process followed for the Base Case evaluation is the current RFI process, as defined in numerous SSFL documents including the SRAM, the RFI Program Report, and RFI Group Reports (MWH, 2004, 2005, 2006, 2007a, and 2007b). For the purpose of contrasting the Base Case to the two SB990 alternatives, this technical memorandum focuses on site characterization, risk assessment methodology, and remediation decision criteria.

2.1.1 Site Characterization

The purpose of site characterization is to determine the nature (i.e., what chemicals are present) and extent (i.e., the concentrations and their spatial distribution) of contamination. There are many inputs into site characterization. A few of the key inputs are:

- Site history and operations
- Site physical characteristics

- Characteristics of chemicals and their release
- Background concentrations of selected chemicals
- Analytical reporting limits and RBSLs
- Sample analytical results

Each of these inputs is used to guide the site characterization. For the purposes of the Base Case, the current process of site characterization, as represented by data collected for RFI reporting serves as the basis for evaluation. As noted in Section 1, there will be additional site characterization as a result of continued data gap analysis or to address DTSC comments on the RFI Reports.

For the Base Case and SB990 alternative analysis, four RFI sites were selected for detailed evaluation. These include the:

- Old Conservation Yard (OCY) RFI Site from the Group 6 RFI Report (MWH, 2006);
- Former Sodium Disposal Facility (FSDF) and Empire State Atomic Development Authority (ESADA) RFI Sites from the Group 8 RFI Report (MWH, 2007b); and,
- Coca Area RFI Site from the Group 4 RFI Report (MWH, 2007a).

Copies of these RFI Site reports and baseline risk assessments are provided in Attachment 1. These four sites were selected because they represent a range of site conditions and chemical contamination at the SSFL, and because RFI Reports including SRAM baseline risk assessments have been previously submitted to DTSC. These four RFI sites are considered representative of SSFL contamination and risk assessment findings, and serve as examples of potential representative site-wide remediation plans (see Section 2.2).

An aspect of the SSFL RFI characterization that should be considered when making decisions based on the characterization data is the type of sampling strategy employed. There are generally two categories of environmental sampling: judgmental (biased) and probabilistic or statistical-based (unbiased or random). Regulatory agencies recommend that in order to make sound risk assessment and risk management decisions, a certain amount of statistical-based sampling is necessary in the characterization (USEPA, 2002). Statistical-based sampling is characterized by random sampling across the potential exposure areas in order to obtain a non-biased estimate of exposure point concentrations. Judgmental sampling is a biased sampling approach that targets source areas and therefore provides only biased (higher) EPCs.

The RFI characterization of the SSFL has been primarily judgmental in nature. Although some statistical-based sampling has been performed at the SSFL, a biased sampling approach has been predominantly used based on the knowledge of potential sources and historical operations, and in consideration of geographic and topographic conditions at the SSFL. While this judgmental sampling strategy does provide good information about the nature and extent of the contamination, it also results in risk assessment EPCs that are biased high. This bias should be considered in evaluating the alternatives presented in this document.

2.1.2 Risk Assessment

The purpose of the health risk assessment (HRA), which contains both the HHRA and ERA, is to estimate the potential for adverse effects on humans and ecological receptors. For the purposes of the Base Case, the HRAs have been completed according to the DTSC-approved SRAM, with any deviations noted in the baseline assessments. The four example site baseline risk assessments and SRAM are provided in Attachment 1. The risk drivers/contributors identified in the Base Case and associated RBSLs based on SRAM requirements are presented in Table 2.

Several of the key components of the HRA defined in the SRAM that are different than in the two SB990 alternatives, and therefore noteworthy in this discussion, are:

- The use of typical residential exposures that include dermal contact, ingestion and inhalation of soil and ambient and indoor inhalation of vapors. Baseline human health risks for consumption of homegrown fruits and vegetables and ecological risks are calculated but considered separately when evaluating remediation areas (see Section 2.1.3.4).

- Both 95% upper confidence limits (UCL) of the mean and the mean (average) are calculated using area-weighting across the RFI site, and are inclusive of background risks for chemicals of potential concern. These calculated concentrations are termed EPCs in the risk assessment.

2.1.3 Remediation Decision Criteria for Identification of Remediation Areas

After the completion of the HRA, the risk results are interpreted and two types of areas are identified for remediation purposes. These are:

- Areas recommended for further evaluation in the CMS and potentially subject to remediation in the CMI. These are called CMS Areas. Not all CMS Areas are included in the Base Case remedial estimates as described below in Section 2.1.3.4.

- Areas that qualify for no further action or consideration in subsequent RCRA steps. These are called no further action (NFA) Areas.

The following subsections describe the process used and the decision criteria applied to the identification of CMS and NFA areas.

2.1.3.1 Identification of Risk Drivers and Assumed Acceptable Risk Levels

The first step in identifying estimated remediation areas is to review the results of the HHRA and determine if total human health risk (either ILCR or non-cancer HI) are over acceptable levels. For the purposes of the Base Case, a total human ILCR of 1 x 10^{-6} and HI of 1.0 for the SRAM resident exposures were used as guides. Note that these risk criteria are for the purposes of conservatively estimating remediation areas in the Base Case, and the final ILCR and HI used for cleanup at the SSFL may different than these values. If unacceptable total risk levels calculated using the UCL of the mean for the EPCs result, then individual chemicals that are contributors to any risk exceedance are identified. These chemicals are identified by their chemical-specific ILCR being above approximately 0.2 x 10^{-6} or their non-cancer Hazard Quotient (HQ) above 0.2. Any chemical meeting these criteria is selected as a risk driver or contributor. The use of the lower criteria accounts for the potential for more than one risk driver being present in site soils.

2.1.3.2 Mapping of Chemical Concentrations

The second step to develop estimated remediation areas is to identify sample locations where the chemical risk drivers/contributors are present at concentrations above their RBSL at each RFI site. For the Base Case, the RBSL is a soil concentration for each chemical that is equivalent to an ILCR of 1 x 10^{-6} or HQ of 1.0 for the SRAM resident. The SRAM-based RBSLs used for each of the four example RFI sites is provided in the risk assessment appendix attached to the Group RFI reports. SRAM RBSLs used for the RFI Group Reports have been recently updated to reflect current risk assessment toxicological information. Updated SRAM-based RBSLs used for the Base Case presented in this technical memorandum for human health risk drivers/contributors are presented in Table 2, with calculation details presented in Attachment 2. The human health SRAM RBSLs are the lowest of the hypothetical child or adult resident values calculated using dermal contact, ingestion and inhalation of soil, and indoor inhalation of vapor exposures.

By identifying on maps the locations where the risk drivers/contributors are present above their RBSL, the unique identifier (i.e., sample number) associated with those samples can be determined and those samples included in an estimated remediation area. In addition to human health risks, the Base Case evaluation includes evaluation of ecological HQs to identify risk contributors. The spatial distribution of ecological risk drivers and contributors is evaluated to determine overlap of these sample concentrations with the samples identified contributing to unacceptable human risk. If there are separate areas of ecological-only unacceptable risks, then additional remediation areas are added using the sample process outlined above where areas of ecological risk drivers are identified by comparison to ecological RBSLs.

For the Base Case, the human health risks, ecological risks, and the resultant CMS Areas are identified for the four example RFI sites in the RFI site reports (Attachment 1). Mapping of estimated remediation areas also considered additional criteria as described below.

2.1.3.3 Additional Criteria Used to Estimate Remediation Areas

In addition to the sample concentrations and their comparison to RBSLs, other features of the site and analytical criteria were considered when estimating remediation areas. One consideration was topography. The type of land (flat, sloping, steep, rocky, or drainage) was considered when determining the extent of areas to include in remediation areas. Another consideration was the surrounding sample concentrations, which provide an indication of the extent of migration. When considering these surrounding samples, non-detect samples and their respective analytical reporting limits (RLs) are considered. In some cases, application of these criteria results in expanding remediation areas (e.g., when surrounding data are non-detect with RLs above RBSLs). In other cases, application of these additional criteria results in restricting remediation areas (e.g., when drainage over-bank deposits are constrained by bedrock). Finally, in some cases, where risk assessment indicates unacceptable risks solely due to estimated or extrapolated data, or elevated RLs, then remedial estimates may not be not made pending further sampling results (i.e., a CMS Area is not included as a CMI Area).

For the Base Case, there were a few CMS Areas at the four example sites where contaminant concentrations were estimated to be above the RBSL due to extrapolated or elevated RL non detect data. These CMS Areas were not included as remediation CMI Areas since it was assumed additional RFI sampling data would be collected to eliminate these uncertainties. Thus, a few CMS Areas identified in the RFI Site Reports are not included in the Base Case estimated remediation areas shown in Figure 3.

2.1.3.4 Residual Risk Evaluation

In order to determine if the cleanup of a proposed remediation area would be acceptable, post-cleanup risks were qualitatively evaluated by reviewing both the planned 'removed' concentrations (those samples included in the estimated remediation areas) and the remaining residual concentrations (those samples not included in the estimated remediation areas). The residual human health risks were estimated to be at or below the acceptable risk criteria for each of the four RFI example sites.

For post-remediation ecological HQs, a qualitative process was followed as described above. Sample concentrations of ecological risk drivers that were either removed or remain after remediation were identified and post-cleanup ecological HQs estimated. It was determined that for ecological risks at each RFI site, post-remediation HQs of up to 10 would be acceptable based on conservative assumptions that are used in the ERA.

For post-remediation home-garden risks, a similar qualitative process was used to determine if residual risks were acceptable. This evaluation was done by comparing the net reduction in total HRA baseline risks and applying that same net reduction to the estimated 'pre-remediation' risks for the home-garden pathway. At each of the four example site cases, post-remediation home-garden estimated risks were less than 1x10-4 and HIs near 1.

2.1.3.5 Estimating Remediation Volumes

The final step in the definition of estimated remediation is the calculation of soil volumes. In this step the 2-dimensional estimated remediation area is combined with information on both total soil depth and the vertical profile of chemical concentrations. In this process, at each area identified for remediation, the total depth of soil (to bedrock) is estimated and an average depth across the remediation area is assumed. If there is sufficient characterization information to suggest that a decrease of concentrations with soil depth is present such that deeper soil could remain and not cause an exceedance of acceptable human or ecological risks, than a depth less than total soil thickness was used for remedial volume estimates. The remediation area multiplied by the depth calculates the total in-place remediation volume. When multiple remediation areas are recommended for a given RFI site, then the total remediation volume for that RFI site is calculated as the sum of the volumes from the individual areas.

2.2 BASE CASE REMEDIATION SCOPE

For the remediation areas proposed under the Base Case, four RFI sites are used as examples. For each of the four estimated remediation scopes, the following criteria were met:

- Site was sufficiently characterized for preliminary remedial estimates.
- HHRA and ERA risks were above preliminary ILCR of 1 x 10^{-6} and HI or HQ of 1.0.
- Samples of identified risk drivers/contributors with concentrations above their SRAM RBSLs were identified and considered in estimating the remediation areas.
- Post-remediation risks from home-grown fruits and vegetables and post-remediation ecological risks were acceptable.
- A remediation soil volume could be calculated.

2.2.1 Remediation Volumes for Four Example RFI Sites

Figure 3 and Table 3 provide the estimated remediation areas and remediation volumes, respectively, for the four example RFI sites. These sites serve as detailed examples of the application of the Base Case methodology and the resultant estimated remedial cleanup that is protective of future residential site use and ecological receptors. The total estimated soil remediation volumes are provided in Table 3. Calculations of estimated remediation soil volumes are provided in Attachment 2.

2.2.2 Estimated SSFL-wide Remediation Soil Volume under Base Case

Using this process for the remaining RFI sites at the SSFL, preliminary remediation volumes have been estimated based on the site data and risk assessment findings. At RFI sites where risk assessments have not yet been performed, sampling results were evaluated using SRAM RBSLs adjusted downwards to target a 0.2 x 10^{-6} ILCR and a HI value of 0.2 to account for potentially collocated contaminants. It is recognized that the Base Case soil remediation volumes will likely change as additional sampling is performed and each RFI site report and risk assessment is completed (using current DTSC-approved methods). These RFI Reports serve as the best estimator of potential remediation areas. When the Base Case methodology is applied to the entire SSFL, it is estimated that 180,000 cubic yards (cy) of soil will be evaluated in the CMS and subject to potential remediation in the CMI. This site-wide Base Case soil remediation volume is also compared to the volumes of the two SB990 alternative cases in Table 3.

2.3 ENVIRONMENTAL IMPACTS SUMMARY

In anticipation of potential onsite and offsite impacts of the estimated Base Case remediation at SSFL, preliminary estimates of specific environmental impacts have been developed. These impacts have not been used in estimating soil remediation volumes but provide an indication of the types of criteria under which the Base Case remediation will be evaluated in an Environmental Impact Report (EIR) under the California Environmental Quality Act (CEQA).

The environmental impact study includes the evaluation of the following issues:

- Emission Footprints (heavy equipment operation)
- Natural Capacity Conservation and Restoration (ecological impacts)
- Resource Conservation and Usage (fuel use)
- Community Impacts (truck trips/durations)

A summary of these issues as they relate to the Base Case is presented in Table 4. This table presents the total impact of the estimated cleanup under this scenario and compares it to the SB990 alternatives presented in Sections 3 and 4 of this technical memorandum. This comparison shows that the Base Case remedial scenario creates the least impact on the environment, and is the most desirable from that perspective. Based on an evaluation scoring system, described in more detail in Attachment 6, the Base Case scores the best and highest (17) of the three remedial cases presented in this document.

3.0 DEFAULT SB990 RURAL RESIDENTIAL ALTERNATIVE

This section describes the process to implement SB990 for chemical risk assessment using default exposure pathways defined for the rural residential radiological risk assessment, and then identify the resultant estimated chemical remediation areas. This default alternative is compliant with requirements of SB990. For the purposes of this technical memorandum, the default SB990 rural residential alternative is termed the "Default SB990 Alternative".

The Default SB990 Alternative is defined as the characterization of contamination, evaluation of human health and ecological risk, and estimation of the extent of remediation to meet the most conservative (i.e., no SSFL site-specific considerations) interpretation of rural residential (agricultural) land use. The Default SB990 Alternative is not defined in the current, DTSC-approved RFI risk assessment process for the SSFL (MWH, 2005).

It is noteworthy that there is no regulatory document that defines the rural residential scenario for the evaluation of potential chemical risk and exposure. For this evaluation, the Default SB990 Alternative has been based using default exposure parameters from the online USEPA PRG calculator for radionuclides and the online Risk Assessment Information System (RAIS) calculation tool (USEPA 2008, RAIS 2005). It is also worth noting that certain exposure parameter information is not well defined for the default pathways, so several assumptions have been made for this evaluation as described in Attachment 3. As such, significantly more time might be required for this approach prior to implementation to allow for additional research, and agency review and approval. Finally, since the goal of the HHRA and ERA is to accurately, yet conservatively, predict potential exposures and adverse effects, the rural residential land use scenario has not previously been considered in SSFL risk assessment methodology because rural residential is not a future anticipated land use of the site.

The Default SB990 Alternative represents the upper end of estimated remediation that would be required under a hypothetical future rural residential use of the SSFL. The exposure assumptions (pathways and parameters) for the Default SB990 Alternative are presented and contrasted with that of the Base Case and a SSFL-site specific SB990 Alternative (discussed in Sections 2.0 and 4.0, respectively). Potential environmental impacts associated with the remediation effort under the Default SB990 Alternative (e.g., volume of soil to be addressed, duration of cleanup, number of hauling trucks), as well as other environmental and community impacts, have been evaluated to facilitate decisions regarding how to implement an SB990-compliant remediation at SSFL.

3.1 PROCESS FOLLOWED IN DEFAULT SB990 ALTERNATIVE

The process followed in the Default SB990 Alternative evaluation is described below. Some aspects of the current RFI process, as defined in numerous SSFL documents including the SRAM, the RFI Program Report, and RFI Group Reports (MWH, 2004, 2005, 2006, 2007a, and 2007b), served as the basis for developing the Default SB990 Alternative. For the purpose of comparing the Default SB990 Alternative with the Base Case and the SSFL SB990 Alternative, this discussion focuses on characterization, risk assessment methodology, and remediation decision criteria.

3.1.1 Site Characterization

The purpose of site characterization is to determine the nature (i.e., what chemicals are present) and extent (i.e., the concentrations and their spatial distribution) of contamination. There are many inputs into site characterization. A few of the key inputs are:

- Site history and operations
- Site physical characteristics
- Characteristics of chemicals and their release
- Background concentrations of selected chemicals
- Analytical reporting limits and RBSLs
- Sample analytical results

Each of these inputs is used to guide the site characterization. However, there are some differences that would be expected between the Base Case and the Default SB990 Alternative. The first difference is that the Default SB990 RR_d RBSLs are lower than those based on the SRAM. The difference is due to the use of additional exposure pathways and assumptions. Based on the calculations presented in this technical memorandum, the RBSLs decrease by approximately 100-fold for all chemicals evaluated. The second difference is the data quality requirements for analytical RLs for sampling data would also be lowered to achieve the lower RR_d RBSL. For some chemicals, the current analytical methods do not allow for measurement of concentrations as low as the Default RR_d RBSLs. In many cases, the existing sample data RLs are generally higher than the Default RR_d RBSLs. The effect of this is that since the RR_d RBSLs are one of the criteria used to determine the extent of chemical contamination, the current RFI data may be insufficient to meet SB990 risk assessment or cleanup requirements.

For the purposes of this evaluation of the Default SB990 Alternative, additional sampling has not been performed. Therefore, the current process of site characterization, as represented by data collected for RFI reporting, serves as the basis for the evaluation of the Default SB990

Alternative. As described in Section 2.1.1, four RFI sites (OCY, FSDF, ESADA, and Coca) have been selected as representative of SSFL site conditions and chemical contamination and used in this Default SB990 Alternative evaluation. It is acknowledged that there will be additional sampling and risk assessment as a result of these submittals to DTSC and the ongoing data gap assessment at the site. However, since additional characterization has not yet been performed, these four RFI reports represent the level of effort to date. Because of this limitation, certain assumptions have been made regarding use of RLs as presented in Section 3.1.3.3.

As in the description of the Base Case, an aspect of the SSFL RFI characterization that should be considered when making decisions based on the characterization data is the type of sampling strategy employed. There are generally two categories of environmental sampling: judgmental (biased) and probabilistic or statistical-based (unbiased or random). Regulatory agencies recommend that in order to make sound risk assessment and risk management decisions, a certain amount of statistical-based sampling is necessary in the characterization (USEPA, 2002). Statistical-based sampling is characterized by random sampling across the potential exposure areas in order to obtain a non-biased estimate of exposure point concentrations. Judgmental sampling is a biased sampling approach that targets source areas and therefore provides only biased (higher) EPCs.

As described for the Base Case, the RFI characterization of the SSFL has been primarily judgmental in nature. Although some statistical-based sampling has been performed at SSFL, a biased sampling approach has been predominantly used based on the knowledge of potential sources and historical operations, and in consideration of geographic and topographic conditions at the SSFL. While this judgmental sampling strategy does provide good information about the nature and extent of the contamination, it also provides EPCs that are biased high. This bias should be considered in evaluating the alternatives presented in this document.

3.1.2 Risk Assessment

The purpose of the HRA, which contains both the HHRA and ERA, is to estimate the potential for adverse effects on human and ecological receptors. For the purposes of the Default SB990 Alternative, the HRAs have been completed according to an abbreviated process that has allowed expedited completion of the risk assessments.

The risk assessment step for the evaluation of the Default SB990 Alternative has initially focused on human health risks and has used default RR_d RBSLs as the basis for evaluating risk. As described previously, the RBSLs are the soil concentrations for a particular chemical that is associated with a specified ILCR and HI. By calculating the ratio of a soil concentration of a chemical to its RBSL, the resulting value gives an indication of whether that sample concentration is above or below the RBSL and how it contributes to total human health risk. Neither ILCRs or HIs were calculated in this evaluation due to time constraints. Instead, a sample-by-sample comparison of the sample concentrations to the RR_d RBSLs was performed.

The calculation of the Default SB990 Alternative RR_d RBSLs is presented in Attachment 3.

Several of the key components of this Default SB990 Alternative evaluation that should be compared to the HHRA defined in the SRAM (Base Case) or in the SSFL SB990 Alternative are listed below.

- The exposure pathways and assumptions are based on the pathways and parameters presented in the USEPA PRG calculator and RAIS calculation tools (USEPA 2008; RAIS 2005). The Default SB990 Alternative rural residential exposures include the typical residential exposures (dermal contact, ingestion and inhalation of soil, and indoor inhalation of vapors) plus the agricultural pathways of consumption of homegrown fruits and vegetables, consumption of home-raised beef, milk, poultry, eggs, and swine. Consumption of pond-raised fish was not included because this evaluation used soil media only for comparison purposes between sites. If required, the fish consumption pathway could be evaluated at the limited RFI sites assuming perennial ponds exist and are large enough to sustain a fish population.

- Instead of calculating an EPC, the Default SB990 Alternative consists of a sample-by-sample comparison of sample concentrations to RR_d RBSLs. This calculation is provided in Attachment 3.

3.1.3 Remediation Decision Criteria for Identification of Remediation Areas

After comparison of a sample concentration to the RR_d RBSLs, the resulting recommendations fall into two types of areas identified for remediation purposes. These are:

- Areas recommended for further evaluation in the CMS and are assumed to be subject to remediation in the CMI for this Alternative. These are called CMI Areas.

- Areas that qualify for no further action or consideration in subsequent RCRA steps. These are called NFA Areas.

The following subsections describe the process used and the decision criteria applied to the identification of CMI and NFA areas.

3.1.3.1 Identification of Risk Drivers and Assumed Acceptable Risk Levels

The first step in identifying remediation areas is to identify those chemicals with ratios of the sample concentration to RR_d RBSL ratio above the value of 1.0 (process described above). For the purposes of the Default SB990 Alternative, a total human ILCR of 1 x 10^{-6} and HI of 1.0 for the rural resident were used as guides. Specifically, any identified sample with a concentration above its RR_d RBSL is considered a contributor to unacceptable ILCR risks or HI.

In order to complete this Default SB990 Alternative evaluation in a timely manner, a short-list of chemicals were selected for inclusion in the evaluation. These chemicals were selected since they are the major risk drivers and/or contributors identified in the Base Case at the four example RFI sites. These are also generally considered the primary chemical contaminants and potential risk drivers/contributors across the SSFL. These selected chemicals are listed in Table 2. This list includes several metals, VOCs, polynuclear aromatic hydrocarbons (PAHs), polychlorinated dibenzo-p-dioxins and furans (dioxins), and polychlorinated biphenyls (PCBs). The assumption that these selected chemicals accounted for the majority of the risk was confirmed by re-estimating the Base Case human health risks for just these chemicals and comparing those risks to the total risk published in the four RFI site reports. This comparison was done for the SSFL SB990 Alternative (see Section 4.0 and Attachment 4), but the conclusion from that evaluation would apply to the Default SB990 Alternative as well.

The result of using this sample-by-sample approach to identify estimated remediation areas is that if all samples with concentrations above their RR_d RBSLs are removed, then the remaining (post-remediation) concentrations will all be below the RR_d RBSLs and both average and UCL-based EPCs will result in human health risks below the initial target risks (in this case of ILCR at 1 x 10^{-6} or HI of 1.0). Combined with the conservative impact of the judgmental sampling strategy, the final risk estimates from this Default SB990 Alternative will be biased high.

3.1.3.2 Mapping of Chemical Concentrations

The second step to develop estimated remediation areas is to map the locations where sample concentrations are above their RR_d RBSL at the RFI site. By identifying on maps the locations where the risk drivers/contributors are present above their RR_d RBSL, the unique identifier (i.e., sample number) associated with those samples can be determined and those samples included in an estimated remediation area.

3.1.3.3 Additional Criteria Used to Estimate Remediation Areas

In addition to the sample concentrations and their comparison to RBSLs, other features of the site were considered when estimating remediation areas. One consideration was topography. The type of land (flat, sloping, steep, rocky, or drainage) was considered when determining the extent of areas to include in remediation areas. Another consideration was the surrounding sample concentrations, which provide an indication of the extent of migration. When considering these surrounding samples, non-detect samples and their respective analytical RLs are considered. In some cases, application of these criteria results in expanding remediation areas (e.g., when surrounding data are non-detect with RLs above RBSLs). In other cases, application of these other criteria results in restricting remediation areas (e.g., when drainage over-bank deposits are constrained by bedrock). Finally, in some cases, where risk assessment indicates unacceptable risks solely due to estimated or extrapolated data, or elevated RLs, then remedial estimates may not be made pending further sampling results (i.e., a CMS Area is not included as a CMI Area).

For the Default SB990 Alternative, estimated remediation areas do include locations where unacceptable risks are solely associated with non detect data when compared to the RR_d RBSL since screening levels for this alternative are much lower than current data quality objectives. Non detected data above RBSLs were sometimes included in the Default SB990 Alternative remediation areas identified if near potential sources to conservatively address the issue of current RLs being above many Default RR_d RBSLs. The estimated remediation areas for the Default SB990 Alternative are provided in Figure 4.

3.1.3.4 Residual Risk Evaluation

In order to determine if the cleanup of a proposed remediation area would be acceptable, post-remediation risks were qualitatively evaluated by reviewing both the removed concentrations (those samples included in the proposed remediation areas) and the remaining concentrations (those samples not included in the proposed remediation areas). The residual human risks were estimated to be at or below the acceptable risk criteria for each of the four RFI example sites.

For post-remediation ecological HQs, a qualitative process was followed as described above. Sample concentrations of ecological risk drivers that were either removed or remain after remediation were identified and post-cleanup ecological HQs estimated. It was determined that for ecological risks at each RFI site, acceptable post-remediation HQs of up to 10 would be acceptable considering the conservative assumptions used in the ERA.

3.1.3.5 Estimating Remediation Volumes

The final step in the definition of estimated remediation is the calculation of soil volumes. In this step the 2-dimensional estimated remediation area is combined with information on both total soil depth and the vertical profile of chemical concentrations. In this process, at each area identified for remediation, the total depth of soil (to bedrock) is estimated and an average depth across the remediation area is assumed. If there is sufficient characterization information to suggest that a decrease of concentrations with soil depth is present such that deeper soil could remain and not cause an exceedance of acceptable human or ecological risks, than a depth less than total soil thickness was used for remedial volume estimates. The remediation area multiplied by the depth calculates the total in-place remediation volume. When multiple remediation areas are recommended for a given RFI site, then the total remediation volume for that RFI site is calculated as the sum of the volumes from the individual areas.

3.2 DEFAULT SB990 ALTERNATIVE REMEDIATION SCOPE

For the remediation areas proposed under the Default Alternative, four RFI sites are used as examples. For each of the four estimated remediation scopes, the following criteria were assumed:

- Site was sufficiently characterized for preliminary remedial estimates.
- HHRA and ERA risks were above preliminary ILCR of 1 x 10^{-6} and HI or HQ of 1.0 for the Default SB990 Alternative rural residential scenario.
- Samples with concentrations above their RR_d RBSLs were identified and considered in estimating the remediation areas.
- A remediation soil volume could be calculated.

3.2.1 Remediation Volumes for Four Example RFI Sites

Figure 4 and Table 3 provide the estimated remediation areas and remediation volumes, respectively, for the four example RFI sites. These sites serve as detailed examples of the application of the Default SB990 Alternative methodology and the resultant estimated remedial cleanup that would be protective of future default rural residential site use and ecological receptors. The total estimated soil remediation volumes are provided in Table 3. Calculations of estimated soil volumes are provided in Attachment 3.

3.2.2 Estimated SSFL-wide Remediation Soil Volume under Default Alternative

In order to understand the total potential scope of cleanup at SSFL under the Default SB990 Alternative, the change in estimated remedial cleanup volumes for the four example RFI sites has been scaled-up to include all RFI sites at the SSFL. As noted above in Section 2.1.2, these four sites represent a range in site conditions and chemical contamination at the SSFL. To develop this site-wide remediation estimate, a factor of 4 was used to represent the increase in estimated remedial volumes for the Default SB990 Alternative compared to the Base Case. In terms of estimated remedial volumes, this equates to an estimated 720,000 cy of soil that would require cleanup. This Default SB990 Alternative soil remediation volume is compared to the estimated volumes of the Base Case and SSFL SB990 Alternative in Table 3.

A factor of 4 (400%) was used in this evaluation since it is representative of the variation in the calculated remediation increases for the four RFI sites evaluated. It is considered that this value is under estimated since there are factors that are not accounted for this evaluation (e.g., how background for some metals, including aluminum, is determined, or inclusion of the fish consumption pathway) that would result in increased remediation volumes.

3.3 ENVIRONMENTAL IMPACTS SUMMARY

In anticipation of potential onsite and offsite impacts of the estimated Default SB990 Alternative remediation at SSFL, preliminary estimates of specific environmental impacts have been developed. These impacts have not been used in estimating soil remediation volumes, but provide an indication of the types of criteria under which the Default SB990 Alternative remediation would be evaluated in an EIR under CEQA.

The environmental impacts study includes the evaluation of the following issues:

- Emission Footprints (heavy equipment operation)
- Natural Capacity Conservation and Restoration (ecological impacts)
- Resource Conservation and Usage (fuel use)
- Community Impacts (truck trips/durations)

A summary of these issues as they relate to the Default SB990 Alternative is presented in Table 4. This table presents the total impact of the estimated cleanup under this scenario and compares it to the Base Case and SSFL SB990 Alternatives presented in Sections 2 and 4 of this technical memorandum. This comparison shows that the Default SB990 Alternative remedial scenario clearly creates the most impact on the environment, and is the least desirable from that perspective. Based on an evaluation scoring system, described in more detail in Attachment 6, the Default SB990 Alternative scores the lowest (6.2) of the three remedial cases presented in this document.

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4.0 SSFL SB990 RURAL RESIDENTIAL ALTERNATIVE

This section describes the process to implement SB990 for chemical risk assessment using SSFL site-specific exposure pathways and then identify the resultant estimated chemical remediation areas. The SSFL site-specific alternative is compliant with requirements of SB990. For the purposes of this technical memorandum, the SSFL site-specific SB990 rural residential alternative is termed the "SSFL SB990 Alternative".

The SSFL SB990 Alternative is defined as the characterization of contamination, evaluation of human health and ecological risk, and estimation of the extent of remediation to meet the conservative and site-specific (i.e., use of SSFL site-specific parameters) interpretation of rural residential (agricultural) land use. The SSFL SB990 Alternative is not defined in the current, DTSC-approved RFI risk assessment process for the SSFL (MWH, 2005).

It is noteworthy that there is no regulatory document that defines the rural residential scenario for the evaluation of potential chemical risk and exposure. For this evaluation, the SSFL SB990 Alternative has been based using default exposure parameters from the online USEPA PRGs calculator for radionuclides and the online Risk Assessment Information System (RAIS) (USEPA 2008; RAIS2005), and modified in light of SSFL characteristics. Since the goal of the HHRA and ERA is to accurately, yet conservatively, predict potential exposures and adverse effects, the rural residential land use scenario has not previously been considered in SSFL risk assessment methodology because rural residential is not a future anticipated land use of the site.

The SSFL SB990 Alternative represents a reasonable extent of remediation that would be required under a hypothetical future rural residential use of the SSFL. The exposure assumptions (pathways and parameters) for the SSFL SB990 Alternative are presented and contrasted with that of the Base Case and Default SB990 Alternative (discussed in Sections 2.0 and 3.0, respectively). Potential environmental impacts associated with the remediation effort under the SSFL SB990 Alternative (e.g., volume of soil to be addressed, duration of cleanup, number of hauling trucks), as well as environmental and community impacts, have been evaluated to facilitate decisions regarding how to implement an SB990-compliant remediation at SSFL.

4.1 PROCESS FOLLOWED IN SSFL SB990 ALTERNATIVE

The process followed in the SSFL SB990 Alternative evaluation is described below. Some aspects of the current RFI process, as defined in numerous SSFL documents including the

SRAM, the RFI Program Report and RFI Group Reports (MWH, 2004, 2005, 2006, 2007a, and 2007b), served as the basis for developing the SSFL SB990 Alternative. For the purpose of comparing the SSFL Alternative with the Base Case and Default SB990 Alternative, this discussion focuses on characterization, risk assessment methodology, and remediation decision criteria.

4.1.1 Site Characterization

The purpose of site characterization is to determine the nature (i.e., what chemicals are present) and extent (i.e., the concentrations and their spatial distribution) of contamination. There are many inputs into site characterization. A few of the key inputs are:

- Site history and operations
- Site physical characteristics
- Characteristics of chemicals and their release
- Background concentrations of selected chemicals
- Analytical reporting limits and RBSLs
- Sample analytical results

Each of these inputs is used to guide the site characterization. However, there are some differences that would be expected between the Base Case and the SSFL SB990 Alternative. The first difference is that the SSFL site-specific RR_s RBSLs for all non-carcinogenic chemicals are lower for this alternative relative to the Base Case. The difference is due to additional exposure pathways and assumptions. Based on the calculations presented in this technical memorandum, these RBSLs decrease by approximately 10-fold for the chemicals evaluated. For carcinogenic chemicals, the RR_s RBSLs are comparable to the Base Case SRAM RBSLs. This is because although additional exposure pathways are included, a higher allowable risk of 1×10^{-4} is used.

The second difference is the data quality requirements for analytical RLs would also be lowered to achieve the lower RR_s RBSL. Similar to the Default SB990 Alternative, some current analytical methods can not detect concentrations at levels as low as the RR_s RBSLs. In some cases, the existing sample data RLs are higher than the site-specific RR_s RBSLs. The effect of this is that since the RR_s RBSLs are one of the criteria used to determine the extent of chemical contamination, the current RFI data may be insufficient to meet SB990 risk assessment or cleanup requirements without additional sampling (although to a lesser extent than the Default SB990 Alternative).

For the purposes of this evaluation of the SSFL SB990 Alternative, additional sampling has not been performed. Therefore, the current process of site characterization, as represented by data collected for RFI reporting, serves as the basis for the evaluation of the SSFL SB990 Alternative. As described in Section 2.1.1, four RFI sites (OCY, FSDF, ESADA, and Coca) have been selected as representative of SSFL site conditions and chemical contamination and used in this SSFL SB990 Alternative evaluation. It is acknowledged that there will be additional sampling and risk assessment as a result of these submittals to DTSC and the ongoing data gap assessment at the site. However, since additional characterization has not yet been performed, these four RFI reports represent the level of effort to date. Because of this limitation, certain assumptions have been made regarding use of RLs as presented in Section 4.1.3.3.

As in the description of the Base Case and Default SB990 Alternative, an aspect of the SSFL RFI characterization that should be considered when making decisions based on the characterization data is the type of sampling strategy employed. There are generally two categories of environmental sampling: judgmental (biased) and probabilistic or statistical-based (unbiased or random). Regulatory agencies recommend that in order to make sound risk assessment and risk management decisions, a certain amount of statistical based sampling is necessary in the characterization (USEPA, 2002). Statistical-based sampling is characterized by random sampling across the potential exposure areas in order to obtain a non-biased estimate of exposure point concentrations. Judgmental sampling is a biased sampling approach that targets source areas and therefore provides only biased (high) EPCs.

As described for the Base Case, the RFI characterization of the SSFL has been primarily judgmental in nature. Although some statistical-based sampling has been performed at SSFL, a biased sampling approach has been predominantly used based on the knowledge of potential sources and historical operations, and in consideration of geographic and topographic conditions at the SSFL. While this judgmental sampling strategy does provide good information about the nature and extent of the contamination, it provides EPCs that are biased high. This bias should be considered in evaluating the alternatives presented in this document.

4.1.2 Risk Assessment

The purpose of the HRA, which contains both the HHRA and ERA, is to estimate the potential for adverse effects on humans and ecological receptors. For the purposes of the SSFL SB990 Alternative, the HRAs have been completed according to a streamlined process that has allowed expedited completion of the risk assessments.

The risk assessment step for the evaluation of the SSFL SB990 Alternative has initially focused on human health risks and has used site-specific RR_s RBSLs as the basis for estimating risk. As described previously, the RBSLs are the soil concentrations for a particular chemical that is associated with a specified ILCR and HI. By calculating the ratio of a soil concentration of a chemical to its RBSL, the resulting value gives an indication of whether that sample concentration is above or below the RBSL and how it contributes to total human health risk.

The calculation of the SSFL SB990 Alternative RR_s RBSLs is presented in Attachment 4. The risk drivers/contributors used for the Default and SSFL SB990 Alternatives are those identified in the Base Case. The calculated RR_s RBSLs for the SSFL SB990 Alternative are presented in Table 2.

For the SSFL SB990 Alternative, both ILCRs and HIs were calculated. Instead of the sample-by-sample comparison of the sample concentrations to the Default SB990 Alternative RBSLs that was performed for the Default SB990 Alternative, risks were calculated using a sum-of-fractions methodology. This sum-of-fractions approach provides good estimates of total RFI site risks. A comparison of total risks using the sum-of-fractions approach to the risks published in the RFI reports was completed and there was good agreement between the two (this comparison is presented in Attachment 4). Based on this comparison, it was concluded that this expedited approach was appropriate to use in the evaluation of the SSFL SB990 Alternative.

In order to complete this SSFL SB990 Alternative evaluation in a timely manner, a short-list of chemicals were selected for inclusion in the evaluation. These chemicals were selected since they are the major risk drivers and/or contributors identified in the Base Case at the four example RFI sites. These are also generally considered the primary chemical contaminants and potential risk drivers/contributors across the SSFL. These selected chemicals are listed Table 2. This list is the same for the Base Case, Default and SSFL SB990 Alternatives.

The sum-of-fractions approach is based on the ratio of the EPC to the RBSL. In the approach used to evaluate the SSFL SB990 Alternative, RFI site EPCs for each of the chemicals included in this evaluation were compared to their SSFL SB990 Alternative RR_s RBSLs. The EPC to RBSL ratio for each chemical is then used to determine its ILCR or HQ contribution to total site ILCR or HI. Total ILCR and HI for the RFI site was estimated by summing these individual chemical contributions. The calculation work books that were used to estimate total RFI site risk for the SSFL Alternative based on the EPC:RBSL sum-of-fractions approach are presented in Attachment 4.

Several of the key components of this SSFL SB990 Alternative evaluation that should be compared to the HHRA defined in the SRAM (the Base Case) or in the Default SB990 Alternative are listed below.

- The exposure pathways and assumptions are based using the parameters from the online USEPA PRG calculator for radionuclides and the online RAIS calculation tool (USEPA2008, RAIS 2005). The SSFL SB990 Alternative rural residential exposures include the typical residential exposures (dermal contact, ingestion and inhalation of soil, and indoor inhalation of vapors) plus the agricultural pathways of consumption of homegrown fruits and vegetables, consumption of home-raised beef, poultry, and eggs. Consumption of home-raised milk and swine was not included because these pathways were not considered practical in conjunction with land use for beef cattle and poultry given site-specific topographic, bedrock, and forage constraints. Pond-raised fish consumption was not included since this evaluation used soil media for comparison. It is worth noting, however, that there are only a few SSFL sites that may have a perennial pond that could sustain a fish population. Rationale for inclusion and exclusion of pathways for the SSFL SB990 Alternative is provided in Attachment 4.

- The mean (average) area-weighted contaminant concentrations, inclusive of background concentrations, were used as the EPCs. This calculation is provided in Attachment 4.

4.1.3 Remediation Decision Criteria for Identification of Remediation Areas

After estimating total human health risks based on the EPC to RR_s RBSL sum-of-fractions approach, the risks were used to make recommendations for estimating remediation areas. The resulting recommendations fall into two types of areas identified for remediation purposes. These are:

- Areas recommended for further evaluation in the CMS and potentially subject to remediation in the CMI. These are called CMS Areas. For the SSFL SB990 Alternative, all CMS areas are included in the remedial area estimates.

- Areas that qualify for no further action or consideration in subsequent RCRA steps. These are called NFA Areas.

The following subsections describe the process used and the decision criteria applied to the identification of CMS and NFA areas.

4.1.3.1 Identification of Risk Drivers and Assumed Acceptable Risk Levels

The first step in identifying remediation areas is to review the results of the HHRA and determine if total human health risk (either ILCR or non-cancer HI) are over acceptable levels. For the purposes of the SSFL SB990 Alternative, the total human ILCR of 1×10^{-4} and HI of 1.0 for the rural resident were used as guides. If unacceptable total risk levels are indicated, then chemicals that are contributors to any risk exceedance are identified. These chemicals are identified by their ILCR generally being above 0.2×10^{-4} or their non-cancer HQ above 0.2. Any chemical meeting these criteria are selected as risk drivers or contributors.

4.1.3.2 Mapping of Chemical Concentrations

The second step to develop estimated remediation areas is to map the locations where sample concentrations are above their SSFL SB990 Alternative RR_s RBSL at the RFI site. By identifying on maps the locations where the risk drivers/contributors are present above their RR_s RBSL, the unique identifier (i.e., sample number) associated with those samples can be determined and those samples included within the estimated remediation area. Estimated remediation areas for the SSFL SB990 Alternative were drawn to include identified sample results significantly above the RR_s RBSL where contributing to total risk. Non detect data were sometimes included in this case if above the RR_s RBSL as described below in Section 3.1.3.4.

4.1.3.3 Additional Criteria Used to Estimate Remediation Areas

In addition to the sample concentrations and their comparison to RBSLs, other features of the site were considered when estimating remediation areas. One consideration was topography. The type of land (flat, sloping, steep, rocky, or drainage) was considered when determining the extent of areas to include in remediation areas. Another consideration was the surrounding sample concentrations, which provide an indication of the extent of migration. When considering these surrounding samples, non-detect samples and their respective analytical RLs are considered. In some cases, application of these criteria results in expanding remediation areas (e.g., when surrounding data are non-detect with RLs above RBSLs). In other cases, application of these other criteria results in restricting remediation areas (e.g., when drainage over-bank deposits are constrained by bedrock). Finally, in some cases, where risk assessment indicates unacceptable risks solely due to estimated or extrapolated data, or elevated RLs, then remedial estimates may not be made pending further sampling results (i.e., a CMS Area is not included as a CMI Area).

For the SSFL SB990 Alternative, estimated remediation areas may include locations of unacceptable risks associated with non detect data since some screening levels for this alternative are lower than current data quality objectives. Similar to the Default SB990 Alternative, non detect data is sometimes included in estimated remediation areas if near source areas.

4.1.3.4 Residual Risk Evaluation

In order to determine if the cleanup of a proposed remediation area would be acceptable, post-remediation risks were qualitatively evaluated by reviewing both the planned ‘removed’ concentrations (those samples included in the estimated remediation areas, and the remaining residual concentrations (those samples not included in the estimated remediation areas). The residual human risks were estimated to be at or below the acceptable risk criteria for each of the four RFI example sites.

For post-remediation ecological HQs, a qualitative process was followed as described above. Sample concentrations of ecological risk drivers that were either removed or remain after remediation were identified and post-cleanup ecological HQs estimated. It was determined that for ecological risks at each RFI site, acceptable post-remediation HQs of up to 10 would be acceptable considering conservative assumptions used in the ERA.

4.1.3.5 Estimating Remediation Volumes

The final step in the definition of estimated remediation is the calculation of soil volumes. In this step the 2-dimensional estimated remediation area is combined with information on both total soil depth and the vertical profile of chemical concentrations. In this process, at each area identified for remediation, the total depth of soil (to bedrock) is estimated and an average depth across the remediation area is assumed. If there is sufficient characterization information to suggest that a decrease of concentrations with soil depth is present such that deeper soil could remain and not cause an exceedance of acceptable human or ecological risks, than a depth less than total soil thickness was used for remedial volume estimates. The remediation area multiplied by the depth calculates the total in-place remediation volume. When multiple remediation areas are recommended for a given RFI site, then the total remediation volume for that RFI site is calculated as the sum of the volumes from the individual areas.

4.2 SSFL SB990 ALTERNATIVE REMEDIATION SCOPE

For the remediation areas proposed under the SSFL Alternative, four RFI sites are used as examples. For each of the four estimated remediation scopes, the following criteria were assumed:

- Site was sufficiently characterized for preliminary remedial estimates.
- HHRA and ERA risks were above preliminary ILCR of 1×10^{-4} and HI or HQ of 1.0 for the SSFL SB990 Alternative rural residential scenario.
- Samples with concentrations above their RBSLs were identified and considered in estimating the remediation areas.
- A remediation soil volume could be calculated.

4.2.1 Remediation Volumes for Four Example RFI Sites

Figure 5 and Table 3 provide the estimated remediation areas and remediation volumes, respectively, for the four example RFI sites. These sites serve as detailed examples of the application of the SSFL SB990 Alternative methodology and the resultant estimated remedial cleanup would be protective of future rural residential site use and protective of ecological receptors. The total estimated soil remediation volumes are provided in Table 3. Calculations of soil volumes are provided in Attachment 4.

4.2.2 Estimated SSFL-wide Remediation Soil Volume under SSFL SB990 Alternative

In order to understand the total potential scope of cleanup at SSFL under the SSFL SB990 Alternative, the change in estimated remedial cleanup volumes for the four example RFI sites has been scaled-up to include all RFI sites at the SSFL. As noted in Section 2.1.2, these four sites represent a range of site conditions and chemical contamination at the SSFL. To develop this site-wide remediation estimate, a factor of 1.15 was used to represent the increase in estimated remedial volumes for the SSFL SB990 Alternative compared to the Base Case (a 15% increase). In terms of estimated remedial volumes, this equates to an estimated 207,000 cy of soil that would require cleanup. This SSFL SB990 Alternative soil remediation volume is compared to the estimated volumes of the Base Case and Default SB990 Alternative in Table 3.

The average increase for the SSFL SB990 Alternative at the four example sites was about a factor of 1.1 (110%). A conservative factor of 1.15 (115%) was used for site-wide impacts since only 4 of 57 sites were used in this analysis. It is considered that this value is underestimated since there are factors that are not accounted for this evaluation (e.g., how background for some metals, including aluminum, is determined, or inclusion of the fish consumption pathway) that would result in increased remediation volumes.

4.3 ENVIRONMENTAL IMPACTS SUMMARY

In anticipation of potential onsite and offsite impacts of the estimated SSFL SB990 Alternative remediation at SSFL, preliminary estimates of specific environmental impacts have been developed. These impacts have not been used in the estimation of soil remediation volumes, but provide an indication of the types of criteria under which the SSFL SB990 Alternative remediation would be evaluated in an EIR under CEQA.

The environmental impacts study includes the evaluation of the following issues:

- Emission Footprints (heavy equipment operation)
- Natural Capacity Conservation and Restoration (ecological impacts)
- Resource Conservation and Usage (fuel use)
- Community Impacts (truck trips/durations)

A summary of these issues as they relate to the SSFL SB990 Alternative is presented in Table 4. This table presents the total impact of the estimated cleanup under this scenario and compares it to the Base Case and Default SB990 Alternative presented in Sections 2 and 3 of this technical memorandum. This comparison shows that the SSFL SB990 Alternative remedial scenario creates only slightly more impact on the environment than the Base Case scenario, and is the second-most desirable from that perspective. Based on an evaluation scoring system, described in more detail in Attachment 6, the SSFL SB990 Alternative (16.3) scores almost as high as the Base Case (17).

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5.0 SUMMARY AND RECOMMENDATIONS

This technical memorandum presents an analysis of two SB990 implementation alternatives (Default and SSFL site-specific) and compares the resultant estimated remedial volumes associated with each of these alternatives to a current planning estimate (Base Case) developed using DTSC-approved risk assessment methodologies for the site. This analysis is for comparing these alternatives only. Remedial estimates presented herein are for comparison of alternatives and should not be construed as surrogates for baseline risk assessment results nor formal CMS or CMI recommendations for agency review or approval.

SB990 does not specifically define critical risk assessment elements, or how risk assessments are to be used to set cleanup requirements, and as such, is subject to interpretation. The implementation alternatives presented in this document each meet SB990 requirements since regulatory guidance is also absent on important chemical risk assessment components for the rural residential (i.e., agricultural) land use exposure pathway and parameter assumptions. The alternatives were developed in consideration of SB990 requirements with the Default SB990 Alternative providing an upper bound, maximum estimate and the SSFL SB990 Alternative providing a realistic, reasonable maximum scenario. Both alternatives are based on the rural residential land use which is currently not planned for the SSFL.

In summary, the analysis performed for the SB990 alternatives indicates significant differences in the remedial cleanup estimates, and ensuing environmental impacts associated with these cleanups. A comparison of significant differences in the two SB990 implementation alternatives considered includes:

Default SB990 Alternative	**SSFL SB990 Alternative**
Uses all exposure pathways following radiological risk assessment PRG calculations, including home-grown fruits and vegetables, beef, dairy, poultry, eggs, and swine (fish not included). To implement risk calculations, significant assumptions were made since exposure pathways, default parameters, and toxicological inputs are not defined for the chemical risk assessment.	Uses agricultural exposure pathways for SSFL considering topographic and geopmorphic constraints, including exposures to home-grown fruits and vegetables, beef, poultry, and eggs. To implement risk calculations, significant assumptions were made but for fewer pathways and parameters than in the Default Alternative.

Default SB990 Alternative	**SSFL SB990 Alternative**
Uses a sample by sample cleanup approach, essentially setting a SSFL-wide cleanup level. The effect of this approach is additional remedial areas identified for cleanup, and an increase in environmental impacts without a net benefit to the end users of the site (recreators).	Uses an area-weighted cleanup approach to achieve a target risk level (based on RFI site size). This approach does not set a specific cleanup level for each chemical on a SSFL-basis. The effect of this approach is fewer remedial cleanup areas without a reduction in protectiveness to the end users of the site, while still meeting SB990 requirements.
Uses a target ILCR of 10^{-6} and a HI = 1 for the hypothetical rural resident to identify estimated remediation areas (for each sample result).	Uses a target ILCR of 10^{-4} and a HI = 1 for the hypothetical rural resident to identify estimated remediation areas (for composite sample areas contributing to unacceptable risk).
Results in 100-fold reduction in RBSLs. The effect of this is that many current sampling results may be inadequate for site characterization and additional sampling will be required.	Results in 10-fold reduction in RBSLs. The effect of this is that some current sampling results may be inadequate for site characterization and additional sampling will be required (but less than for Default Alternative).
Estimated to result in significant, negative impacts to the environment, including: • 10 years of truck haulage (Base Case, 3 years) • 97,000,000 pounds of CO_2 equivalents produced (Base Case, 24,000,000 pounds of CO_2) • 4,270,000 gallons of diesel and 133,000 gallons of gasoline consumed (Base Case, 1,070,000 and 33,000 gallons)	Estimated to results in environmental impacts slightly greater than estimated Base Case cleanup impacts, including: • 3.5 years of truck haulage (Base Case, 3 years) • 28,000,000 pounds of CO_2 equivalents produced (Base Case 24,000,000 pounds of CO_2) • 1,230,000 gallons of diesel and 38,000 gallons of gasoline consumed (Base Case, 1,070,000 and 33,000 gallons)

Based on this comparative analysis, implementation of the SSFL SB990 Alternative is recommended since it:

1) is compliant with SB990 requirements and follows approved regulatory risk assessment practice;

2) can be defined more quickly and definitely than the Default SB990 Alternative, and would allow faster site characterization and finalization of proposed remedial cleanup areas;

3) results in less significant negative environmental or community impacts; and,

4) provides a protective and extremely conservative cleanup for the end land use of the SSFL (open space for recreational use).

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6.0 REFERENCES

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TABLES

TABLE 1
SB990 Risk Assessment and Site Cleanup Requirements

SB990 TEXT (key element # inserted in parentheses)	KEY ELEMENT	ISSUES
"In calculating risk (1), the cumulative risk (2) from radiological and chemical contaminants at the site shall be summed, and the land use assumption shall be either suburban residential or rural residential (3) (agricultural), whichever produces the lower permissible residual concentration (4) for each contaminant. In the case of radioactive contamination, the department shall use as its risk range point of departure (5) the concentrations in the PRGs issued by United States Environmental Protection Agency in effect as of January 1, 2007."	1. This text addresses risk calculations.	• Text does not specifically state a requirement to set cleanup levels. • Text could apply to either or both baseline risk assessment or calculation of residual risk assessment. • Text does not state whether risks should be considered incrementally above background.
	2. Cumulative risk from chemicals and radionuclides are to both be considered in cleanup.	• Text does not state non-cancer risks will be considered additive.
	3. Exposure assumption as either suburban residential or rural residential (agricultural) based on risk assessment results.	• Text does not specify which exposure pathways are to be included in these land use assumptions. Although default radiological risk assessment exposure pathways are defined by USEPA, these are not defined for chemical risk assessments. Also, regulatory guidance encourages exposure pathways to be defined for each site subject to risk assessment. • Text does not state that both suburban and rural residential risk assessments need to be performed. If exposure assumptions for common pathways are the same, rural residential will always result in higher estimated risks than suburban since more exposure pathways are included.
	4. "lower permissible residual concentration"	• Text does not define this term. Permissible residual concentration can vary from cleanup area to cleanup area if a remediation goal is set to a target risk level (i.e., 1×10^{-6}).
	5. If a risk range point of departure is exceeded, then remedial action is considered.	• Text does not define risk range point of departure for chemicals. • Text does not define acceptable cancer or non-cancer risk range.

Table 2
SOIL SCREENING LEVELS AND SSFL RBSLs
(Page 1 of 1)

Selected Chemicals for SB990 RBSL Evaluation	Typical Analytical Reporting Limit (mg/kg)	Maximum SSFL Background Concentration in Soil (mg/kg)	Human Health RBSLs				
			CHHSLs Residential (mg/kg)	ORNL Regional Screening Level [a] (mg/kg)	Base Case Residential SRAM RBSL[b] (mg/kg)	Default SB990 Rural Residential Cumulative RBSL [c] (RR_d) (mg/kg)	SSFL SB990 Site-specific Rural Residential Cumulative RBSL [d] (RR_s) (mg/kg)
Metals (select metals only)							
Aluminum	10	20,000	--	77,000	75,000	6,271	8,423
Antimony	1	8.7	30	31	30	3.1	3.3
Arsenic	0.5	15	0.07	0.39	0.095	0.0032	0.0038
Cadmium	0.2	1	1.7	70	39	1.3	5.3
Lead	0.4	34	150	400	150	120 - estimated [e\]	120 - estimated [e]
Mercury	0.01	0.09	18	23	23	0.39	1.2
Perchlorate	.004	--	--	55	9.1	9.1	9.1
Selenium	1	2.1	380	390	380	0.73	22.2
Thallium	0.2	0.46	5	5.1	6.1	0.13	0.63
Zinc	5	110	23000	23000	22817	30	1,117
VOCs							
1,1-DCE	0.005	--	--	250	0.023	0.023	0.023
Benzene	0.002	--	--	1.1	0.00013	0.00013	0.00013
Cis-1,2-Dichloroethene	0.002	--	--	780	0.014	0.014	0.014
Methylene chloride	0.005	--	--	11	0.004	0.0040	0.0040
PCE	0.002	--	--	0.57	0.00043	0.00042	0.00043
TCE	0.002	--	--	2.8	0.0022	0.0022	0.0022
Vinyl chloride	0.002	--	--	0.06	0.000010	0.0000096	0.000010
SVOCs							
Benzo(a)anthracene	0.02	--	--	0.15	0.60	0.0075	0.028
Benzo(a)pyrene	0.02	--	0.038	0.015	0.060	0.00045	0.0025
Benzo(b)fluoranthene	0.02	--	--	0.15	0.60	0.0045	0.025
Benzo(k)fluoranthene	0.02	--	--	1.5	0.60	0.0010	0.015
Dibenz(a,h)anthracene	0.02	--	--	0.015	0.17	0.00029	0.0043
Phenanthrene	0.02	--	--	--	1720	111	231
PCBs		--					
Aroclor 1248	0.02	--	0.089	0.22	0.35	0.0051	0.017
Aroclor 1254	0.02	--	0.089	0.22	0.35	0.0033	0.016
Aroclor 1260	0.02	--	0.089	0.22	0.35	0.00030	0.0060
Dioxins/Furans [f]							
2,3,7,8-TCDD	1.0×10^{-6}	8.7×10^{-7}	4.6×10^{-6}	4.5×10^{-6}	6.9×10^{-6}	9.1E-09	1.4E-07
1,2,3,7,8-PeCDD	5.0×10^{-6}	1.8×10^{-7}	4.6×10^{-6}	4.5×10^{-6}	6.9×10^{-6}	1.8E-08	1.9E-07
1,2,3,4,7,8-HxCDD	5.0×10^{-6}	3.4×10^{-7}	4.6×10^{-5}	4.5×10^{-5}	6.9×10^{-5}	9.4E-09	2.4E-07
1,2,3,6,7,8-HxCDD	5.0×10^{-6}	9.5×10^{-7}	4.6×10^{-5}	4.5×10^{-5}	6.9×10^{-5}	2.9E-08	6.5E-07
1,2,3,7,8,9-HxCDD	5.0×10^{-6}	1.1×10^{-6}	4.6×10^{-5}	4.5×10^{-5}	6.9×10^{-5}	2.9E-08	6.5E-07
1,2,3,4,6,7,8-HpCDD	5.0×10^{-6}	1.3×10^{-5}	4.6×10^{-4}	4.5×10^{-4}	6.9×10^{-4}	9.4E-08	1.6E-06
OCDD	1.0×10^{-5}	1.4×10^{-4}	1.5×10^{-2}	1.5×10^{-2}	2.3×10^{-2}	3.3E-07	9.2E-06
2,3,7,8-TCDF	1.0×10^{-6}	1.8×10^{-6}	4.6×10^{-5}	4.5×10^{-5}	6.9×10^{-5}	6.2E-07	2.6E-06
1,2,3,7,8-PeCDF	5.0×10^{-6}	5.9×10^{-7}	1.5×10^{-4}	1.5×10^{-4}	2.3×10^{-4}	3.1E-07	4.7E-06
2,3,4,7,8-PeCDF	5.0×10^{-6}	6.4×10^{-7}	1.5×10^{-5}	1.5×10^{-5}	2.3×10^{-5}	2.3E-08	3.9E-07
1,2,3,4,7,8-HxCDF	5.0×10^{-6}	7.3×10^{-7}	4.6×10^{-5}	4.5×10^{-5}	6.9×10^{-5}	5.8E-08	1.1E-06
1,2,3,6,7,8-HxCDF	5.0×10^{-6}	3.0×10^{-7}	4.6×10^{-5}	4.5×10^{-5}	6.9×10^{-5}	5.8E-08	1.1E-06
2,3,4,6,7,8-HxCDF	5.0×10^{-6}	4.5×10^{-7}	4.6×10^{-5}	4.5×10^{-5}	6.9×10^{-5}	5.8E-08	1.1E-06
1,2,3,7,8,9-HxCDF	5.0×10^{-6}	4.3×10^{-7}	4.6×10^{-5}	4.5×10^{-5}	6.9×10^{-5}	5.8E-08	1.1E-06
1,2,3,4,6,7,8-HpCDF	5.0×10^{-6}	2.5×10^{-6}	4.6×10^{-4}	4.5×10^{-4}	6.9×10^{-4}	2.3E-07	5.4E-06
1,2,3,4,7,8,9-HpCDF	5.0×10^{-6}	1.9×10^{-7}	4.6×10^{-4}	4.5×10^{-4}	6.9×10^{-4}	2.3E-07	5.4E-06
OCDF	1.0×10^{-5}	8.1×10^{-6}	1.5×10^{-2}	1.5×10^{-2}	2.3×10^{-2}	5.0E-07	1.4E-05

Notes:

[a] The ORNL Regional Screening Levels, which have replaced the Region IX PRGs, are based on urban residential and do not include inhalation of vapors or ingestion of

[b] Includes direct contact exposure to soil via ingestion and dermal contact, inhalation of nonvolatile chemicals in fugitive dust, and inhalation of volatile chemicals in indoor and ambient air. The RBSLs are based on an incremental lifetime cancer risk of 1×10^{-6} or a hazard index of 1.

[c] The Default SB990 Rural Residential RBSLs presented in this table are based on a 5-acre site since zoning for the area is rural agriculture, 5-acre minimum lot size. These RBSLs include cumulative risk for most sensitive receptor (child res) from the following pathways: ingestion of soil, dermal contact with soil, inhalation of dust, inhalation of vapors from soil, ingestion of fruits/vegetables, ingestion of beef, ingestion of poultry, ingestion of milk, ingestion of swine, and ingestion of eggs. Some values do not include all pathways since uptake/tox information is not available for all chemicals (esp. metals). The RBSLs are based on an incremental lifetime cancer risk of 1×10^{-6} or a hazard index of 1.

[d] The SSFL SB990 Site-Specific Rural Residential RBSLs presented in this table are based on a 5-acre site since zoning for the area is rural agriculture, 5-acre minimum lot size. These RBSLs include cumulative risk for most sensitive receptor (child res) from the following pathways: ingestion of soil, dermal contact with soil, inhalation of dust, inhalation of vapors from soil, ingestion of fruits/vegetables, ingestion of beef, ingestion of poultry, and ingestion of eggs. Some values do not include all pathways since uptake/tox information is not available for all chemicals (esp. metals). The RBSLs are based on an incremental lifetime cancer risk of 1×10^{-6} or a hazard index of 1.

[e] Leadspread model has modest homegrown vegetables. The RBSL for rural residents was assumed to be approximately 20% less than RBSL for SRAM residents due to increased produce consumption. No estimate for animal products.

[f] Values for dioxins/furans other than 2,3,7,8-TCDD are calculated based on 2,3,7,8-TCDD and 2005 WHO TEFs.

Table 3 - Summary of Estimated Remedial Volumes for Base Case and SB990 Alternatives
(Page 1 of 1)

EXAMPLE RFI SITES	Base Case Estimated CMI Volume ($yards^3$)	SSFL SB990 Alternative Estimated CMI Volume ($yards^3$)	Default SB990 Alternative Estimated CMI Volume ($yards^3$)
Old Conservation Yard RFI Site			
Total	9,912	10,889	21,552
Increase Factor	--	1.1	2.2
Coca Area RFI Site			
Total	23,679	28,961	38,047
Increase Factor	--	1.2	1.6
FSDF RFI Site			
Total	2,126	2,126	13,460
Increase Factor	--	1.0	6.3
ESADA RFI Site			
Total	1,231	1,231	7,626
Increase Factor	--	1.0	6.2
Total Volume for 4 Sites	36,947	43,207	80,685
Site Weighted Average Increase Factor for 4 Sites (a)		1.08	4.1
ESTIMATES FOR ENTIRE SSFL			
Total Volume Estimated for Entire SSFL	180,000	207,000	720,000
Site-Wide Average Increase Factor Used (b)		1.15	4.0

Notes:

a) An average of the four sites was used since volumes at selected example RFI sites may not be representative of remedial volumes elsewhere at SSFL. These sites were selected because they represented the general types of conditions and contaminant suites at the SSFL, not because they represented typical remedial volumes.

b) Site-wide increase factors selected based on uncertainties in estimates. For the SSFL SB990 Alternative, a conservative value of 1.15 (115%) was used since only 4 of 57 sites were used in this analysis. For the Default SB990 Alternative, a factor of 4 (400%) was selected as it is representative of the variation in the calculated remediation increases for the four RFI sites evaluated. It is considered that these values are under-estimated since there are factors that are not accounted for this evaluation (e.g., how background for some metals, including aluminum, is determined, or inclusion of the fish consumption pathway) that would result in increased remediation volumes.

TABLE 4

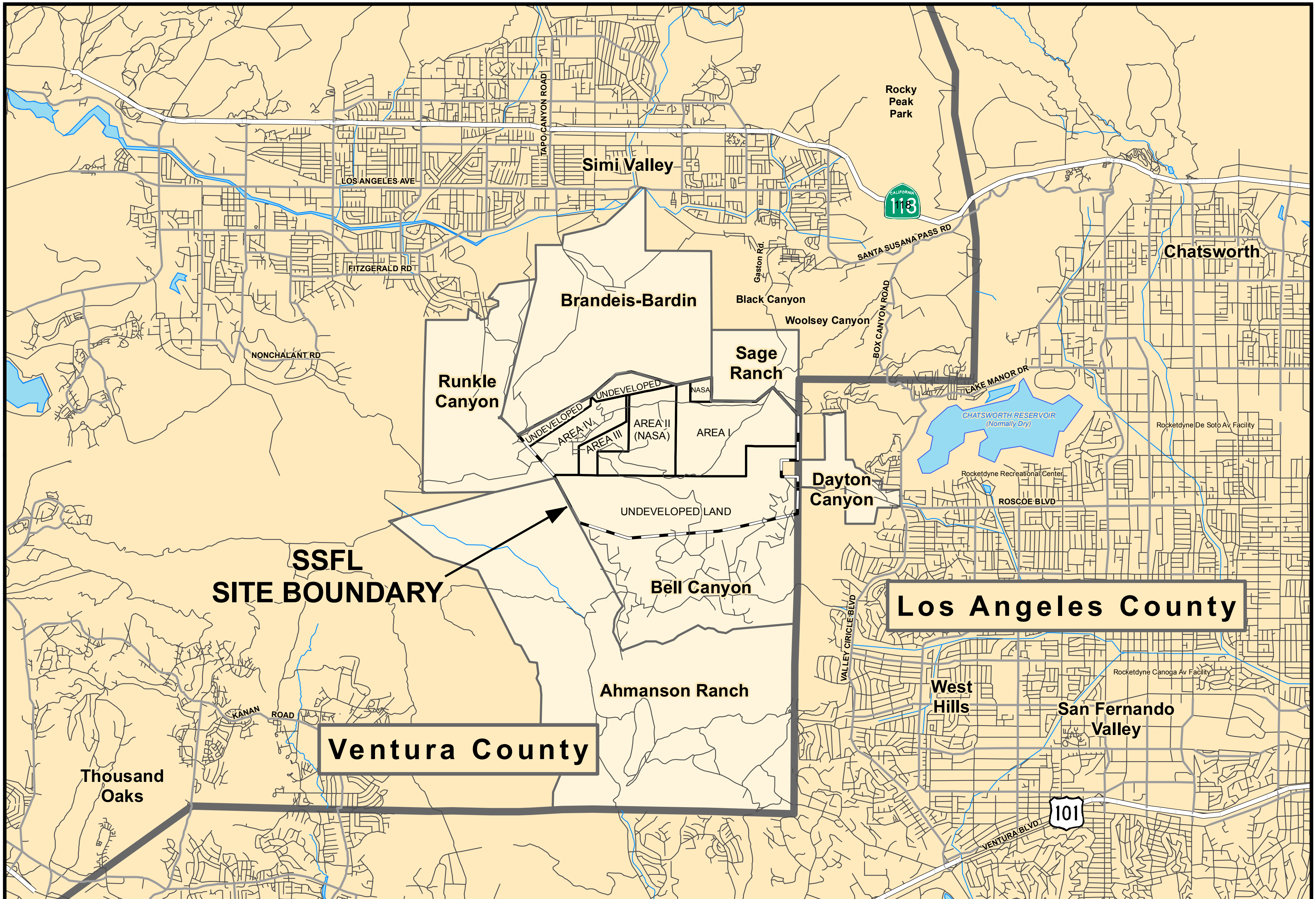
ENVIRONMENTAL IMPACT ANALYSIS SUMMARY FOR REMEDIAL CLEANUP ALTERNATIVES
SANTA SUSANA FIELD LABORATORY

(PAGE 1 OF 1)

	Alternative I: Base Case	Alternative II: Default SB990	Alternative III: SSFL SB990	Units
Project Metrics				
Soil Excavated	180,000	720,000	207,000	cy
Truckloads Hauled	12,000	48,000	13,800	loads
Estimated Project Duration	750 / 3	3,000 / 10	860 / 3½	workdays / years
Emissions Footprint				
CO_2	24,000,000	97,000,000	28,000,000	*lb*
CO	240,000	961,000	276,000	*lb*
VOC	47,000	188,000	54,000	*lb*
NO_x	504,000	2,017,000	580,000	*lb*
SO_x	8,000	31,000	9,000	*lb*
PM-10 Dust	106,000	426,000	122,000	*lb*
GHG Units[1]	24,000,000	97,000,000	28,000,000	*lb of CO2 Equivalents*
Fuel Consumption				
Diesel	1,070,000	4,270,000	1,230,000	*gallons*
Gasoline	33,000	133,000	38,000	*gallons*
Sustainability Score	**17**	**6.2**	**16.3**	***Out of 20***

[1] Note that one pound of greenhouse gas (GHG) unit is equivalent to one lb of CO_2 or 1/8 lb of methane spanning the lifetime of the gas. Also referred to as greenhouse gas potential.

FIGURES



1 inch = 1.5 miles

0 | 1.5 | 3 Miles

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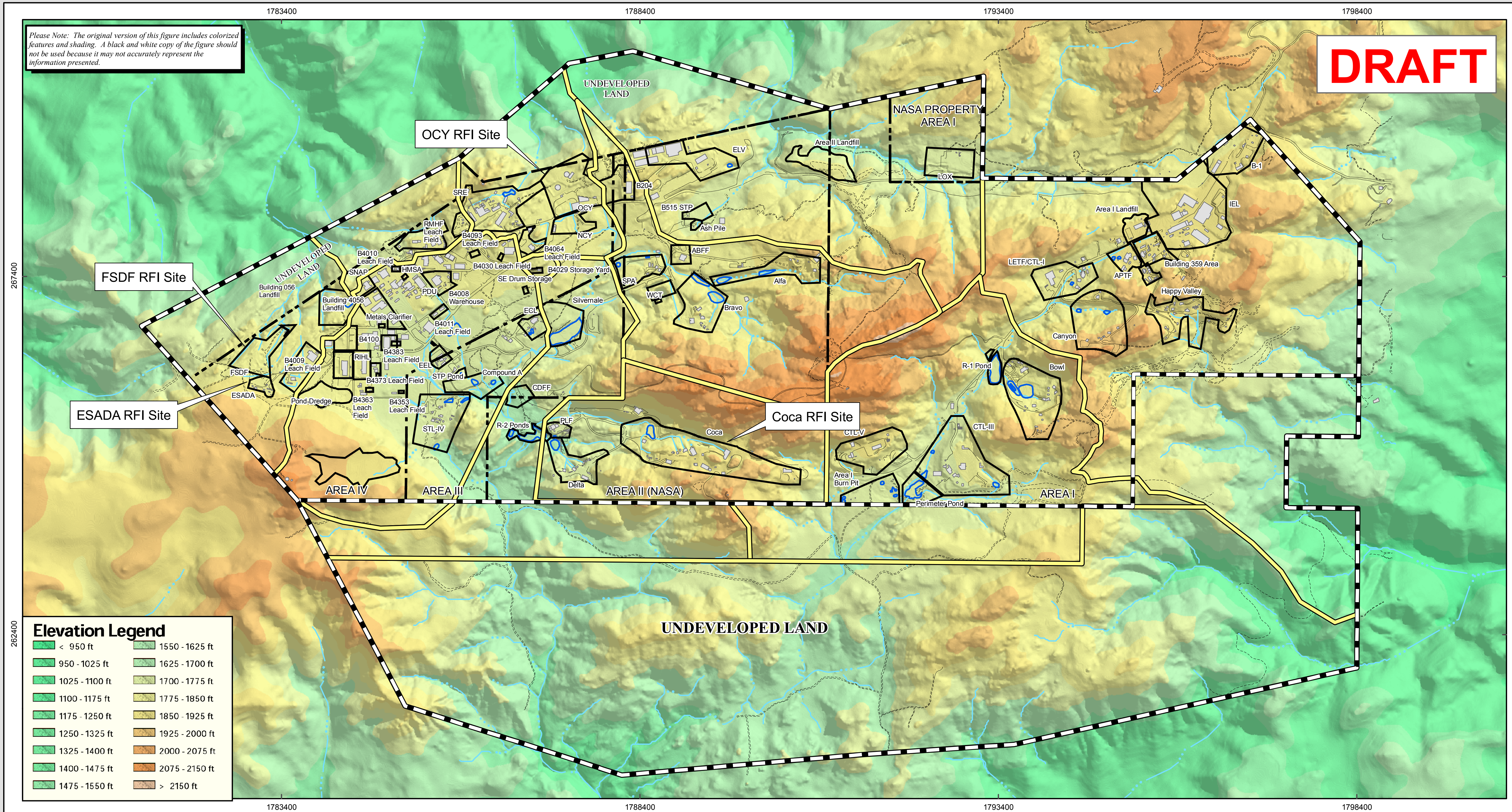
SANTA SUSANA FIELD LABORATORY

Document: Misc-CMS_RegionalMap.mxd

Date: Sep 10, 2008

Regional Map

FIGURE 1



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0 1,300 FEET

MAP COORDINATES IN STATEPLANE, NAD 27, ZONE V

RFI SITES (Chemical Investigation Area)

AREA I

- SWMU 4.1 - B-1 Area
- SWMU 4.2 - Area I Landfill
- SWMUs 4.3, 4.4 and AOC - Instrument and Equipment Laboratories (IEL)
- SWMU 4.5, 4.6 - LOX Plant Former Sump/Clarifier and Drum Disposal Area
- SWMU 4.7 - Component Test Laboratory III (CTL-III) Area
- SWMU 4.8 - Area I Burn Pit
- SWMU 4.9, AOC - Advanced Propulstion Test Facility (APTF) Area
- SWMU 4.12 - Laser Engineering Test Facility (LETF)/Component Test Lab I (CTL-I) Area
- SWMU 4.14 - Canyon Area
- SWMU 4.15 and AOC - Bowl Area and Building 901 Leachfield
- SWMU 4.16 - Area I Reservoir (R-1 Pond)
- SWMU 4.17 - Perimeter Pond
- AOC - Building 359 Sump
- AOC - Happy Valley Area

AREA II

- SWMU 5.1 - Area II Landfill
- SWMU 5.2 - ELV Final Assembly, Building 206
- SWMU 5.5 and AOC - Building 204 Area
- SWMU 5.6 - Former Incinerator Ash Pile
- SWMU 5.7 - Hazardous Waste Storage Area Waste Coolant Tank (WCT)
- SWMU 5.9, 5.10, 5.11 - Alfa Area
- SWMU 5.12, 5.13, 5.14, 5.15 - Alfa/Bravo Skim Pond and Bravo Area
- SWMU 5.18, 5.19 - Coca Area
- SWMU 5.20, 5.21, 5.22 - Propellant Load Facility (PLF)
- SWMU 5.23 - Delta Area
- SWMU 5.26 - R-2A and R-2B Ponds
- AOC - Building 515 Sewage Treatment Plant
- AOC - Storable Propellant Area (SPA)
- AOC - Alfa/Bravo Fuel Farm
- AOC - Coca/Delta Fuel Farm
- AOC - Building 224 Leach Field

AREA III

- SWMUs 6.1, 6.3, AOC - Engineering Chemistry Laboratory (ECL) Area
- SWMU 6.4 Compound A Facility
- SWMU 6.5 Systems Test Laboratory IV (STL-IV) Area
- SWMU 6.8 - Silvernale Reservoir
- SWMU 6.9 - Environmental Effects Laboratory (EEL)
- AOC - Sewage Treatment Plant (STP) Pond Area

AREA IV

- SWMU 7.1 - Building 56 Landfill
- SWMU 7.3 - Former Sodium Disposal Facility (FSDF)
- SWMU 7.4 - Old Conservation Yard (OCY)
- SWMU 7.5 - Building 100 Trench
- SWMU 7.6 - Radioactive Materials Handling Facility (RMHF)

AREA IV (cont)

- SWMU 7.7 - Rockwell International Hot Laboratory (RIHL)
- SWMU 7.8 - New Conservation Yard (NCY)
- SWMU 7.9 - ESADA Chemical Storage Area
- SWMU 7.10 - Former Coal Gasification PDU
- AOC - Former Hazardous Materials Storage Area (HMSA)
- AOC - Chemistry Laboratory Metals Clarifier
- AOC - Pond Dredge Area
- AOC - Sodium Reactor Experiment (SRE) Area
- AOC - SE Drum Storage Yard
- AOC - SNAP Facility
- AOC - Boeing Area IV Leach Fields
- AOC - DOE Area IV Leach Fields

Legend

- SSFL Property Boundary
- Administrative Boundary
- Report Group Boundary
- RFI Site Boundary
- Building
- Pond
- Drainage
- Dirt Road
- Road

SSFL RFI Site Location Map

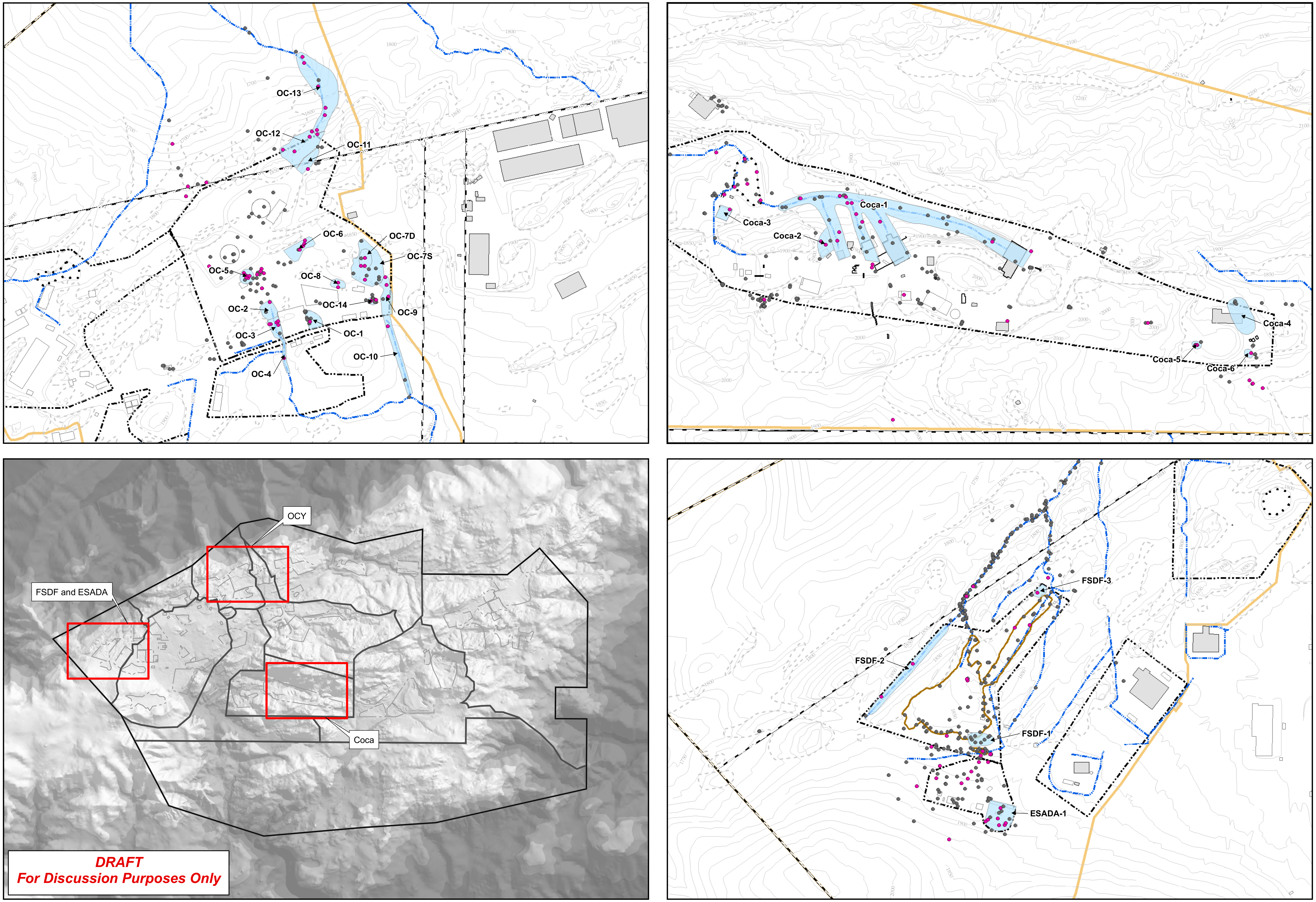
SANTA SUSANA FIELD LABORATORY

Date: Sep 10, 2008

Document: Misc-CMS_RFILocation_11x17.mxd

MWH

FIGURE 2



Base Case Remediation Estimates for Four Example Sites

SANTA SUSANA FIELD LABORATORY

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Report Group Boundary
- Existing Building
- Removed Building
- Ponds
- Drainage
- Bedrock Outcrop
- Elevation Contour

Base Case CMI Areas

- FSDF, ESADA, OCY, and Coca Base Case (CMI) Areas

Sample Locations

- Detect Above SRAM RBSLs
- All Other Samples

Figure Notes:
1. SRAM RBSLs based on SRAM resident exposure pathways for ILCR = 1 x 10-6 and HI = 1.
2. Estimated remediation areas rationale provided in Table A2-1.
3. Other samples include detections below SRAM RBSLs and non detects.

Document: Misc-CMS-BaseCase_Areas.mxd

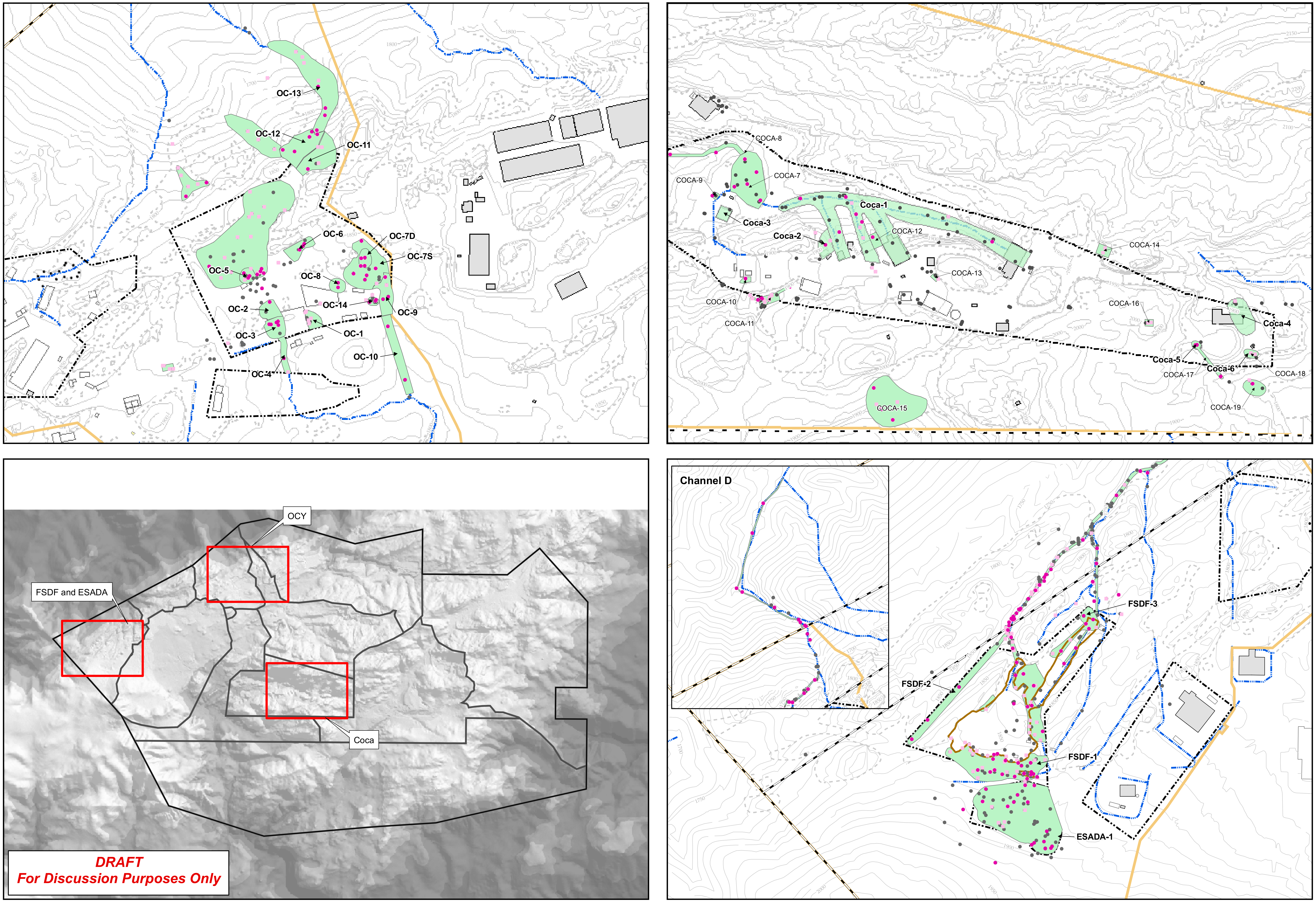
Date: Sep 11, 2008

1 inch = 250 feet

0 250 500 Feet

MWH

Figure 3



Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Report Group Boundary
- Existing Building
- Removed Building
- Ponds
- Drainage
- Bedrock Outcrop
- Elevation Contour

Default SB990 CMI Areas

- FSDF, ESADA, OCY, and Coca Default SB990 (CMI) Areas

Sample Locations

- Detects above Default RBSLs
- Non Detects above Default RBSLs
- All Other Samples

Figure Notes:
1) Default SB990 RBSLs based on default rural resident exposure pathways for ILCR = 1 x 10-6 and HI = 1.
2) Estimated remediation areas rationale provided in Table A3-4.
3) Other samples include detects or non detects below Default SB990 RBSLs and sample results for chemicals not included in this evaluation.

Document: Figure4_Default4Sites.mxd

Date: Sep 11, 2008

1 inch = 250 feet

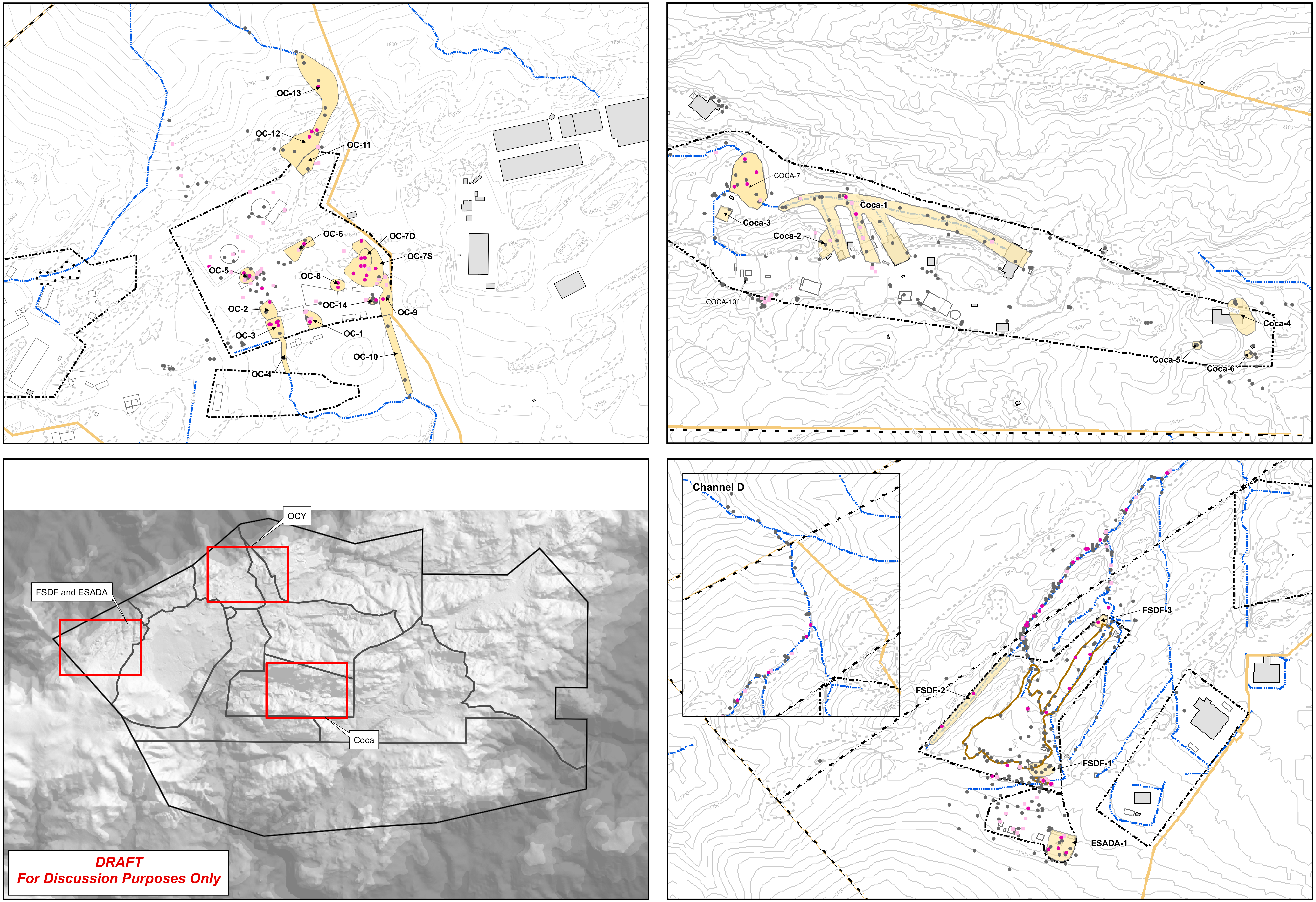
0 250 500 Feet

Default SB990 Alternative Remediation Estimates for Four Example Sites

SANTA SUSANA FIELD LABORATORY

MWH

Figure 4



SSFL SB990 Alternative Remediation Estimates for Four Example Sites

SANTA SUSANA FIELD LABORATORY

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Report Group Boundary
- Existing Building
- Removed Building
- Ponds
- Drainage
- Bedrock Outcrop
- Elevation Contour

SSFL SB990 CMI Areas

- FSDF, ESADA, OCY, and Coca SSFL SB990 (CMI) Areas

Sample Locations

- Detects above SSFL SB990 RBSLs
- Non Detects above SSFL SB990 RBSLs
- All Other Samples

Figure Notes:
1. SSFL SB990 RBSLs based on site-specific rural resident exposure pathways for ILCR = 1 x 10-4 and HI = 1.
2. Estimated remediation areas rationale provided in Table A4-4.
3. Other samples include detects or non detects below SSFL B990 RBSLs and sample results for chemicals not included in this evaluation.

Document: Figure5_SSFLSB990_4Sites.mxd

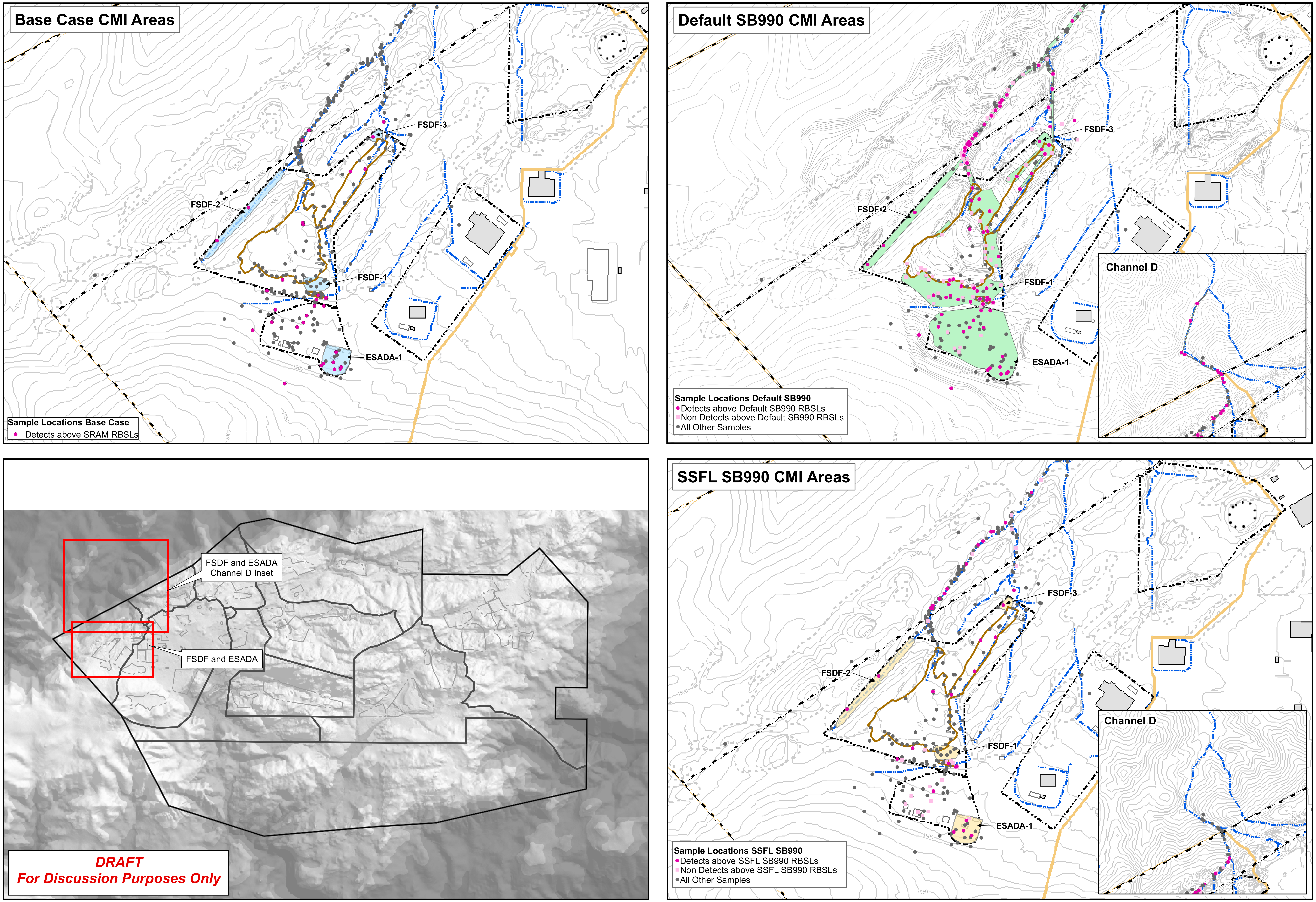
Date: Sep 11, 2008

1 inch = 250 feet

0 250 500 Feet

MWH

Figure 5



Summary of Remedial Alternative Estimates for FSDF and ESADA RFI Sites

SANTA SUSANA FIELD LABORATORY

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Report Group Boundary
- Existing Building
- Removed Building
- Ponds
- Drainage
- Bedrock Outcrop
- Elevation Contour
- Interim Measure (IM) Excavation

Base Case CMI Areas

- FSDF and ESADA Base Case (CMI) Areas

Default SB990 CMI Areas

- FSDF and ESADA Default SB990 (CMI) Areas

SSFL SB990 CMI Areas

- FSDF and ESADA SSFL SB990 (CMI) Areas

Note: See Explanatory Notes on Figures 4, 5, and 6.

Document: Figure6_SummaryFSDFESADA.mxd

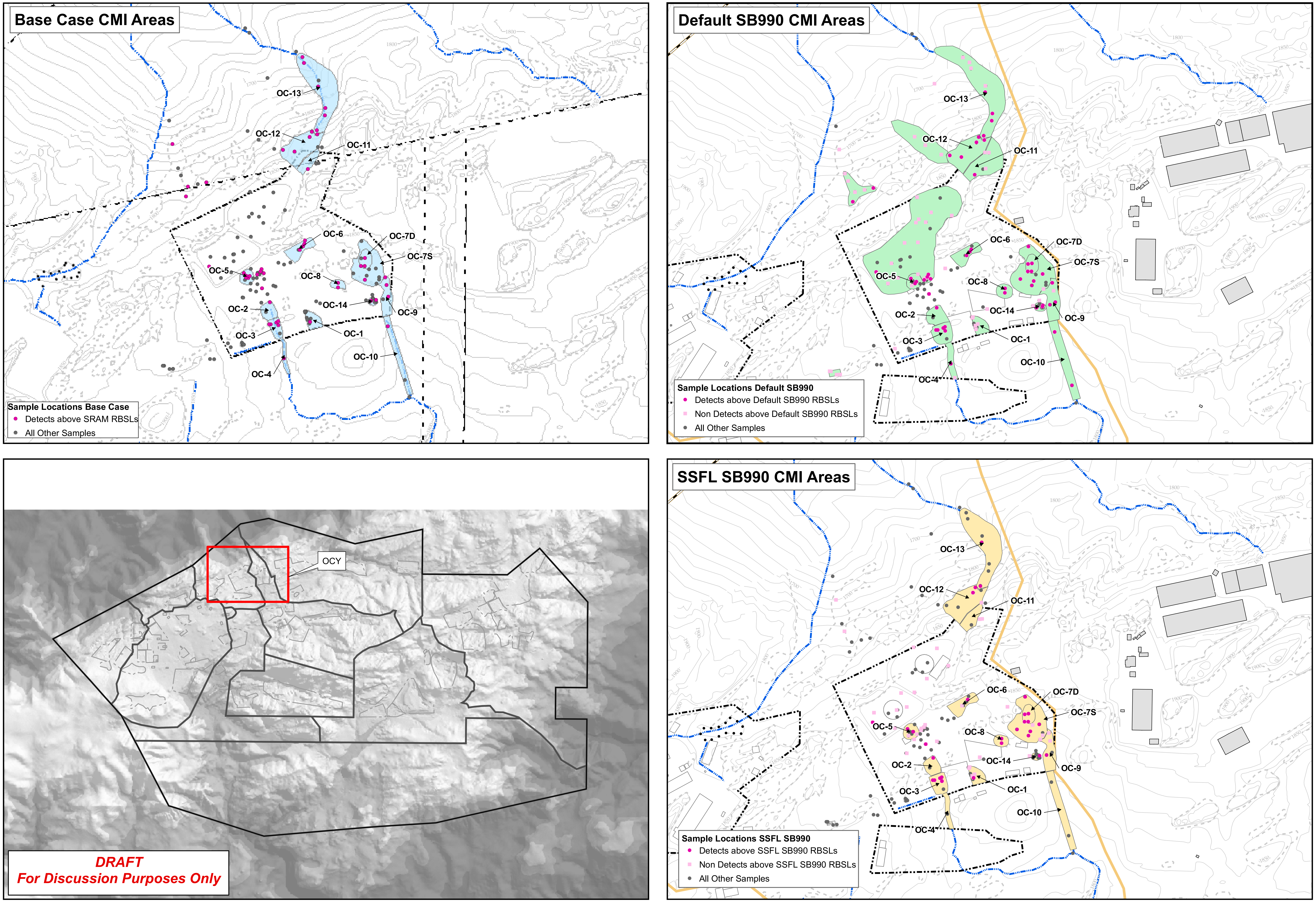
Date: Sep 11, 2008

1 inch = 250 feet

0 250 500 Feet

MWH

Figure 6



Summary of Remedial Alternative Estimates for OCY RFI Site

SANTA SUSANA FIELD LABORATORY

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Report Group Boundary
- Existing Building
- Removed Building
- Ponds
- Drainage
- Bedrock Outcrop
- Elevation Contour

Base Case CMI Areas

- OCY Base Case (CMI) Areas

Default SB990 CMI Areas

- OCY Default SB990 (CMI) Areas

SSFL SB990 CMI Areas

- OCY SSFL SB990 (CMI) Areas

Note: See Explanatory Notes on Figures 4, 5, and 6.

Document: Figure7_SummaryOCY.mxd

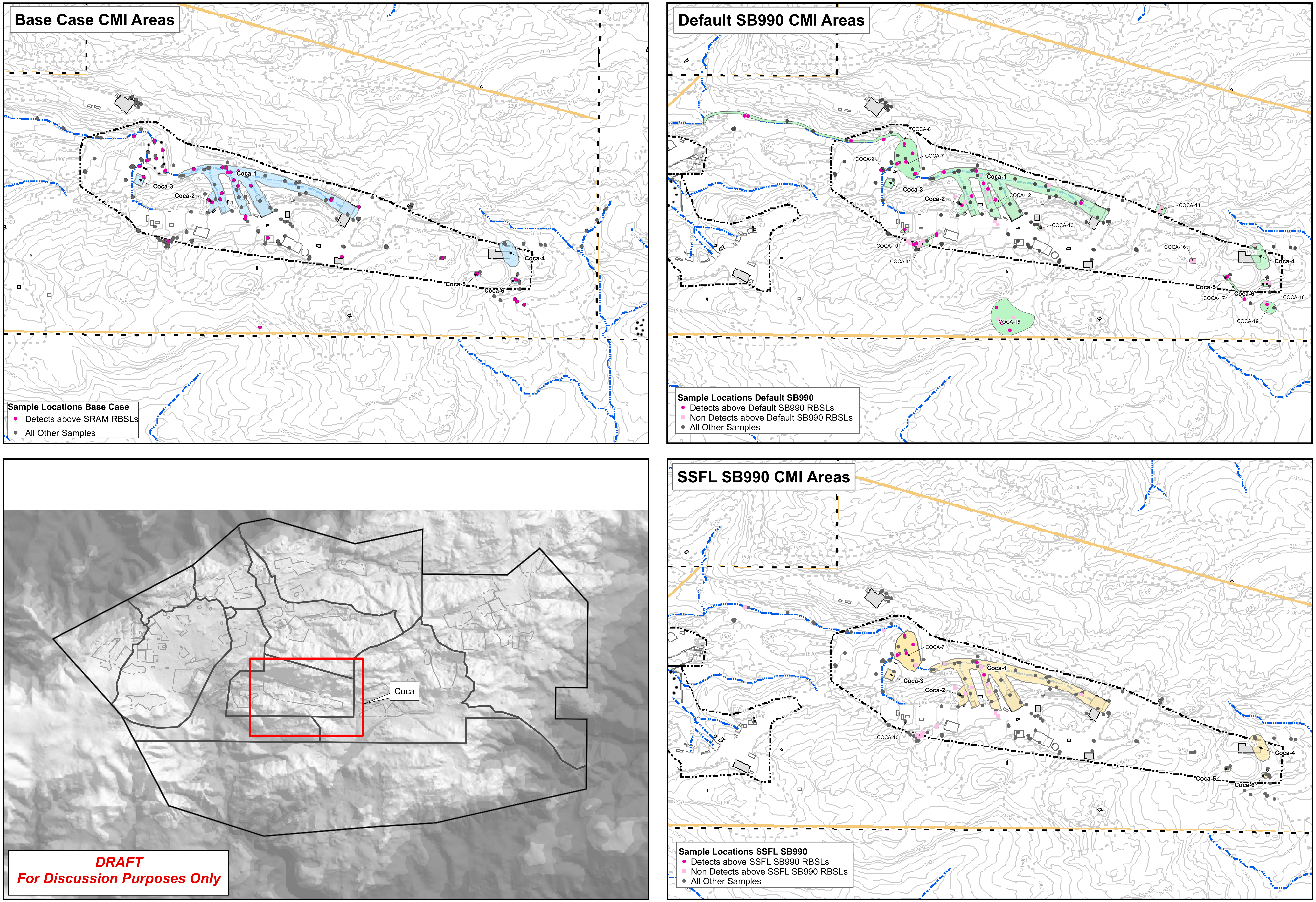
Date: Sep 11, 2008

1 inch = 250 feet

0 250 500 Feet

MWH

Figure 7



Summary of Remedial Alternative Estimates for Coca RFI Site

SANTA SUSANA FIELD LABORATORY

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Report Group Boundary
- Existing Building
- Removed Building
- Ponds
- Drainage
- Bedrock Outcrop
- Elevation Contour

Base Case CMI Areas

Coca Base Case (CMI) Areas

Default SB990 CMI Areas

Coca Default SB990 (CMI) Areas

SSFL SB990 CMI Areas

Coca SSFL SB990 (CMI) Areas

Note: See Explanatory Notes on Figures 4, 5, and 6.

Document: Figure8_SummaryCoca.mxd

Date: Sep 11, 2008

1 inch = 350 feet

0 350 700 Feet

MWH

Figure 8

ATTACHMENT 1

PREVIOUSLY PUBLISHED RFI DOCUMENTS USED FOR SB990 ALTERNATIVE ANALYSIS

ATTACHMENT 2

BASE CASE ASSUMPTION AND CALCULATION DETAILS

ATTACHMENT 2
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2.2 POTENTIAL EXPOSURE PATHWAYS FOR SOIL A2-1
3 RBSL QUANTIFICATION A2-2
4 ESTIMATED REMEDIATION EVALUATION A2-3
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A2-2 OCY RFI Site Base Case Remediation Areas
A2-3 Coca RFI Site Base Case Remediation Areas

LIST OF ELECTRONIC ATTACHMENTS

File No.

File A2-1 SRAM RBSL Calculations

ATTACHMENT 2

BASE CASE ASSUMPTION AND CALCULATION DETAILS

1 INTRODUCTION

This attachment presents the Base Case residential risk-based screening levels (RBSLs) for soil, and details associated with estimated remedial volumes for the Base Case.

Updated SSFL Standardized Risk Assessment Methodology-based RBSLs (SRAM RBSLs) used for the Base Case are presented in Table 2 included in the main body of this technical memorandum. Calculation summary tables for the Base Case are presented in File A2-1. The human health SRAM RBSLs are the lowest (i.e., most protective) of the hypothetical child or adult resident values calculated for the following exposure pathways: ingestion of soil, dermal contact with soil, inhalation of soil particulates and volatile organic compounds (VOCs) in outdoor air, and inhalation of VOCs in indoor air through the vapor intrusion pathway.

2 EXPOSURE ASSUMPTIONS

2.1 CONCEPTUAL MODEL

A generalized human health conceptual site model (CSM) for the Base Case is provided on Figure 4-2 of the Standardized Risk Assessment Methodology (SRAM) Work Plan (MWH, 2005).

2.2 POTENTIAL EXPOSURE PATHWAYS FOR SOIL

The following pathways were included in the Base Case residential evaluation:

- Incidental ingestion of soil and weathered bedrock
- Dermal contact with soil
- Inhalation of soil particulates and VOCs in outdoor air
- Inhalation of VOCs in indoor air through the vapor intrusion pathway

A detail explanation of why the above exposure pathways are potentially complete is provided in Section 4.1.2 of the SRAM (MWH, 2005).

Potential Base Case residents may be exposed to chemicals in soil and weathered bedrock via direct contact pathways (ingestion and dermal exposures). These pathways are therefore considered potentially complete. Potential exposure to VOCs migrating from soil vapor to outdoor and/or indoor air is also considered a potentially complete pathway, but only for chemicals that meet the Department of Toxic Substance Control (DTSC) definition of a volatile chemical. Potential future rural residential exposure via inhalation of nonvolatile chemicals in fugitive dust is also considered to be a potentially complete exposure pathway.

3 RBSL QUANTIFICATION

The SRAM RBSLs for ingestion of soil, dermal contact with soil, inhalation of dust, and inhalation of vapors from soil are based on the DTSC-approved risk assessment work plan (MWH, 2005) and are provided in Table 2 of the main text of this technical memorandum. Base Case residential RBSLs were estimated in the SRAM separately for adults and children for both carcinogenic and non-carcinogenic effects. Workbooks used for the Base Case RBSL calculations are equivalent to the workbooks used in Attachment 1 and were created based on equations provided in Section 5 and Section 8 of the SRAM (MWH, 2005). Exposure parameter values for each exposure pathway for adults and children used in the Base Case residential RBSL calculations are provided in Table 5-2 and Table 5-3 of the SRAM (MWH, 2005).

Toxicity values for the Base Case RBSL calculations were obtained from the following hierarchy of sources, as specified in the SRAM (MWH, 2005). Toxicity values originally provided in Table 7-1 and 7-2 of the SRAM (MWH, 2005) have been updated, when available, for the SRAM RBSL used in the Base Case.

1. OEHHA (http://www.oehha.ca.gov/risk/chemicalDB/index.asp)
2. Integrated Risk Information System (IRIS; USEPA 2005a)
3. Health Effects Assessment Summary Table (HEAST; USEPA 1997c)
4. USEPA criteria documents
5. Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles
6. Environmental Criteria and Assessment Office (ECAO)
7. Other sources

4 ESTIMATED REMEDIATION EVALUATION

The process for estimating remediation areas and volumes associated with the Base Case is described in Section 2.0 of this technical memorandum. This attachment provides details regarding site-specific application of the process described in the main body of this document.

Table A2-4 summarizes the remedial estimates when baseline risk assessment results and site data are interpreted spatially using back-calculated RBSLs Base Case SRAM RBSLs at the four example RFI sites. Figures A2-1 through A2-3 present Base Case estimated remediation areas for the examples used. The data sets used for this analysis for each site are provided in Attachment 5.

5 REFERENCES

California Environmental Protection Agency (Cal-EPA), 2008. Toxicity Criteria Database. January 25, 2008.

MWH Americas, Inc. (MWH). 2005. Standardized Risk Assessment Methodology (SRAM) Work Plan, Santa Susana Field Laboratory, Ventura County, CA. Revision 2 – Final. September.

United States Environmental Protection Agency (USEPA). 2008. Integrated Risk Information System (IRIS) Database. U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency (USEPA). 1997b. Health Effects Summary Tables. FY 1997 Update. Office of Solid Waste and Emergency Response. July. EPA-540-R-97-036.

DRAFT For Review and Discusion

Table A2-1. Summary of Base Case Estimated Remedial Volumes

Description	CMI NAME	AREA (Sq. Ft)	Depth (ft)	Volume (cubic Yds)	Chemical Drivers
Old Conservation Yard RFI Site					
Rocketdyne Cons Yard Spill (SW Corner)	OC-1	3,605	3	401	PAHs
SRE Pond Discharge Pipeline	OC-2	3,815	4	565	Dioxins, metals, PCBs
OCY Low Spot	OC-3	3,315	4	491	PAHs, PCBs, Dioxins, Metals
Asphalt Drainage South of Low Spot	OC-4	2,084	3	232	PAHs, PCBs, Dioxins, Metals
Transformer	OC-5	2,672	6	594	PCBs
AI Conservation Yard	OC-6	5,436	3	604	PAHs, PCBs
OCY N/S Debris Areas (deep)	OC-7D	3,163	6	703	PAHs, PCBs, Dioxins, Metals
OCY N/S Debris Areas (sfc.)	OC-7S	13,584	2	1,006	PAHs, PCBs, Dioxins, Metals
Telephone Pole Storage Area	OC-8	1,736	3	193	Dioxins
Soil Downslope of N/S Debris Area	OC-9	5,851	2	433	PCBs, Dioxins, Metals
Southeast Drainage	OC-10	7,845	3	872	Dioxins, Metals
N. Slope Storage Area	OC-11	3,879	3	431	PAHs, PCBs
N. Slope Storage - Downslope	OC-12	13,654	3	1,517	PAHs, PCBs
N. Slope Debris Area "A"	OC-13	24,011	2	1,779	PCBs
Transformer	OC-14	836	3	93	PCBs
				9,912	**Estimated Volume**
Coca Area RFI Site					
Spilways and test stands	Coca-1	98,368	6	21,860	TCE, cis-1,2-DCE, trans-1,2-DCE, vinyl chloride, Cadmium, Lead, Selenium, Zinc
Lubricant Oil Area	Coca-2	4,894	1	181	Aroclor-1254, Aroclor-1260, Cadmium, Lead
Bulk Test Facility	Coca-3	2,579	3	287	Lead, Zinc
Hydrogen Compressor Area Buildings	Coca-4	10,914	3	1,213	Freon-113
Hydrogen Compressor Bleed-off Valve Area	Coca-5	944	2	70	PAHs, Aroclor-1254
Hydrogen Compressor Building 933 Discharge Area	Coca-6	928	2	69	PAHs
				23,679	**Estimated Volume**
FSDF RFI Site					
Concrete Pool Area/Southern FSDF	FSDF-1	4,794	6	1,065	Perchlorate
Drainage/Drum Debris Area	FSDF-2	12,521	2	928	Mercury
FSDF Pistol Range	FSDF-3	1,793	2	133	Lead
				2,126	**Estimated Volume**
ESADA RFI Site					
ESADA Former Storage Yard	ESADA-1	11,076	3	1,231	Antimony, Arsenic, Lead, Selenium
				1,231	**Estimated Volume**

FSDF and ESADA RFI Site Base Case

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Report Group Boundary
- Existing Building
- Removed Building
- Ponds
- Drainage
- Bedrock Outcrop
- Elevation Contour
- Interim Measure (IM) Excavation

ESADA and FSDF Base Case (CMI) Areas

Sample Locations

- Detect Above SRAM RBSLs
- All Other Samples

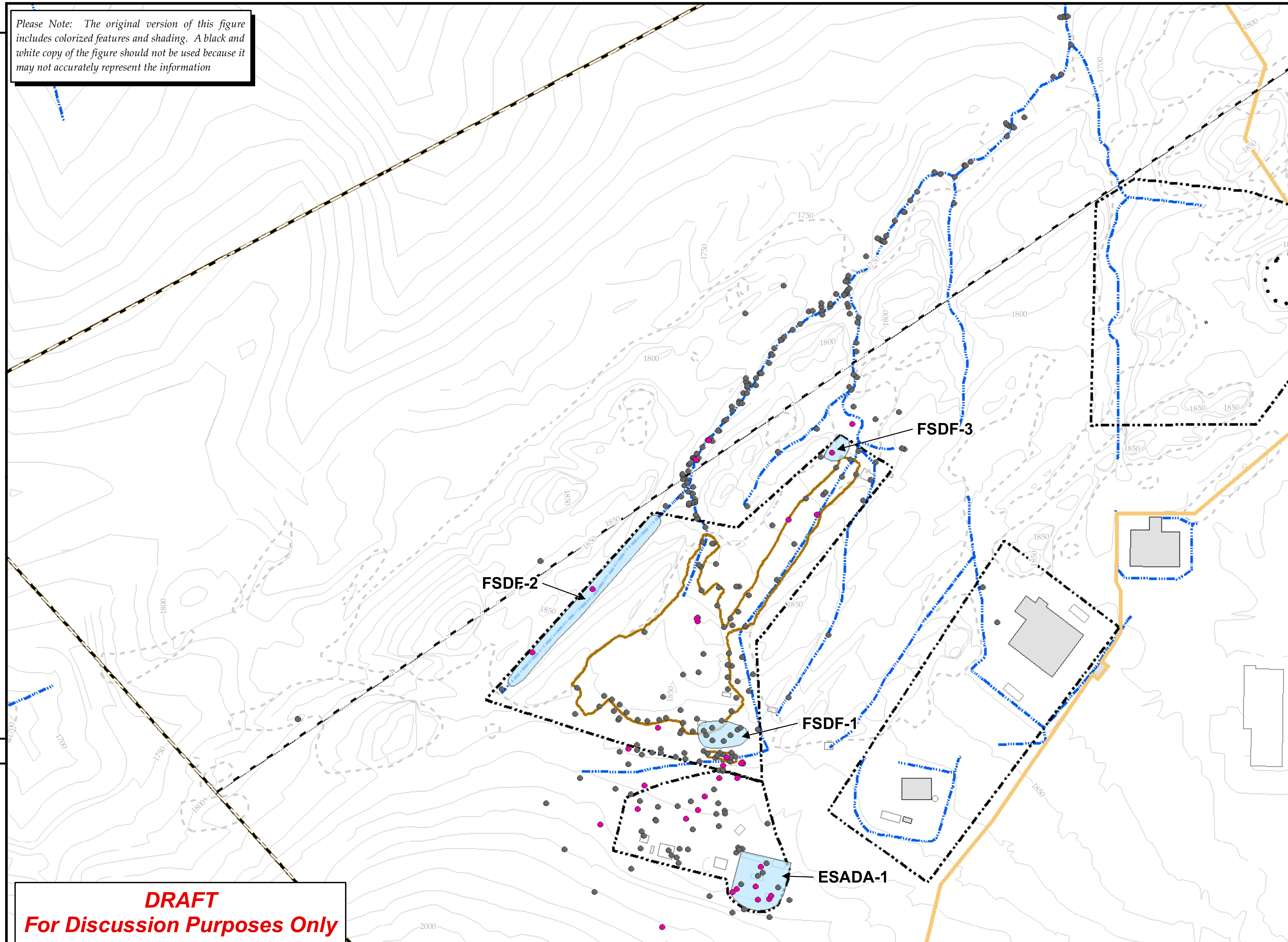


Figure Notes:
1. SRAM RBSLs based on SRAM resident exposure pathways for ILCR = 1 x 10-6 and HI = 1.
2. Estimated remediation areas rationale provided in Table A2-1.
3. Other samples include detections below SRAM RBSLs and non detects.

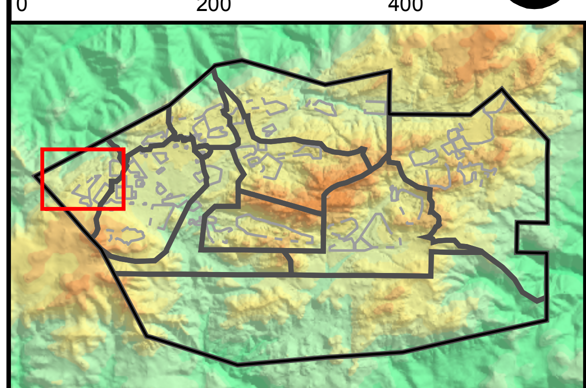
Document: Misc-CMS-Group8_Areas.mxd

Date: Sep 11, 2008

1 inch = 200 feet

Feet: 0, 200, 400

N



MWH

S A N T A S U S A N A F I E L D L A B O R A T O R Y

Figure A2-1

OCY RFI Site Base Case

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Report Group Boundary
- Existing Building
- Removed Building
- Ponds
- Drainage
- Bedrock Outcrop
- Elevation Contour

OCY Base Case (CMI) Areas

Sample Locations

- Detect Above SRAM RBSLs
- All Other Samples

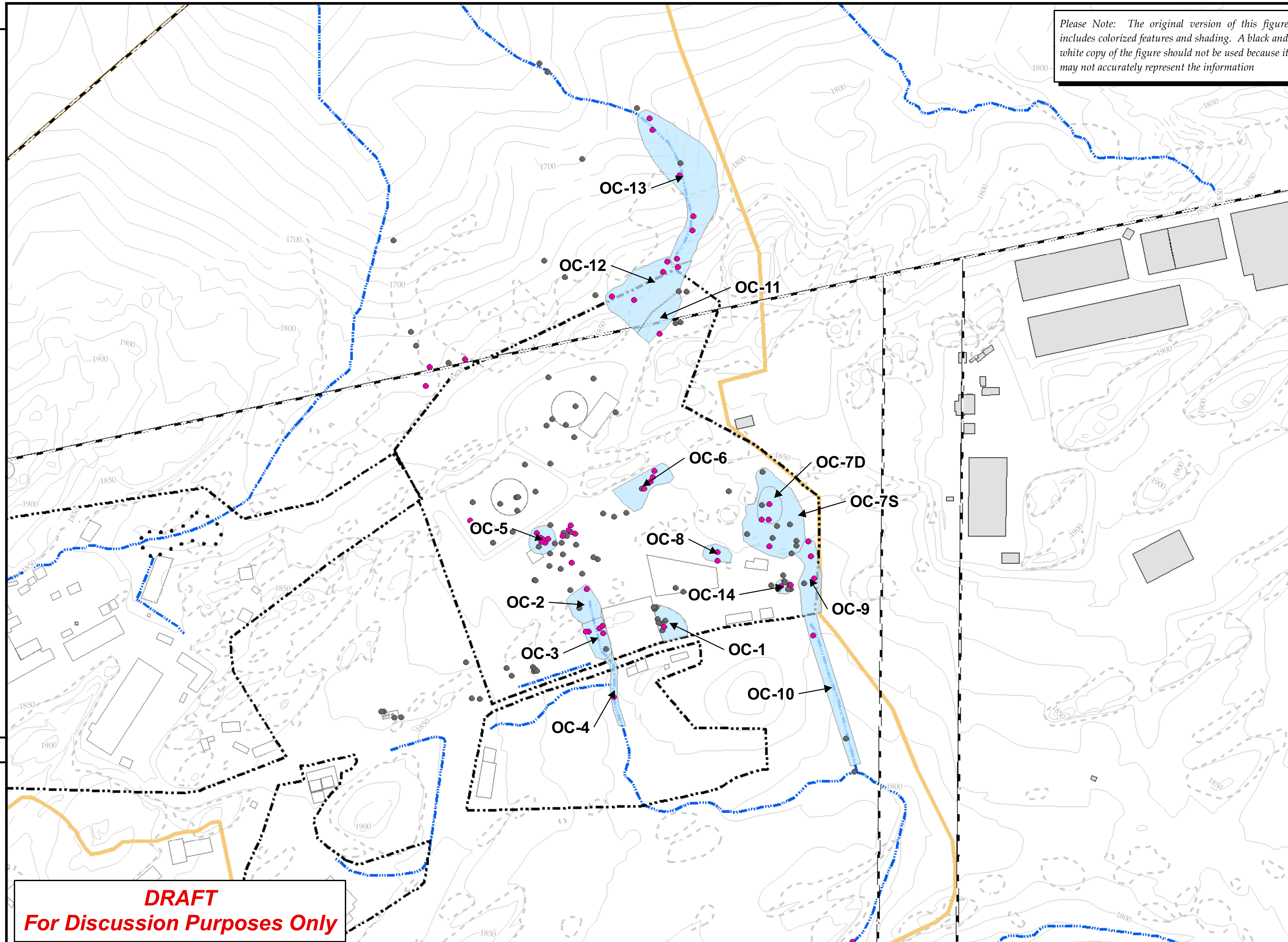
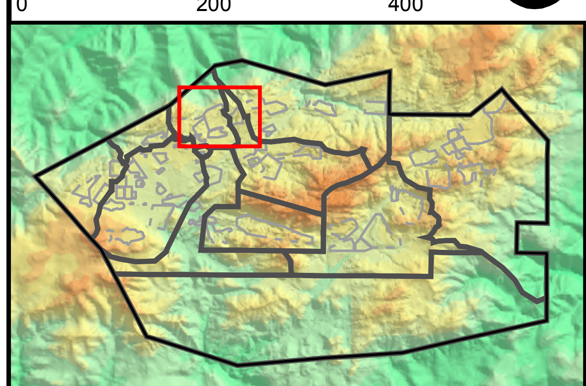


Figure Notes:
1. SRAM RBSLs based on SRAM resident exposure pathways for ILCR = 1 x 10-6 and HI = 1.
2. Estimated remediation areas rationale provided in Table A2-1.
3. Other samples include detections below SRAM RBSLs and non detects.

Document: Misc-CMS-Group6_Areas.mxd   Date: Sep 11, 2008

1 inch = 200 feet

Feet: 0, 200, 400



MWH

SANTA SUSANA FIELD LABORATORY

Figure A2-2

Coca RFI Site Base Case

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Report Group Boundary
- Existing Building
- Removed Building
- Ponds
- Drainage
- Bedrock Outcrop
- Elevation Contour

Coca Base Case (CMI) Areas

Sample Locations

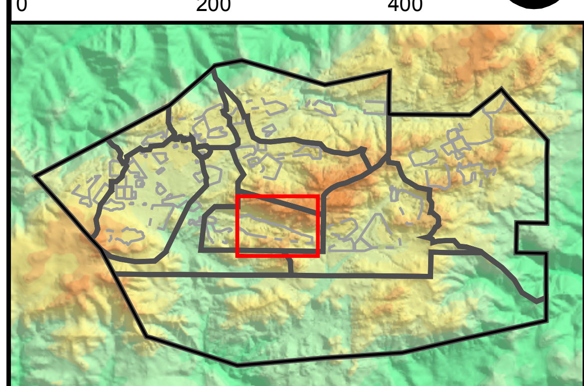
- Detect Above SRAM RBSLs
- All Other Samples

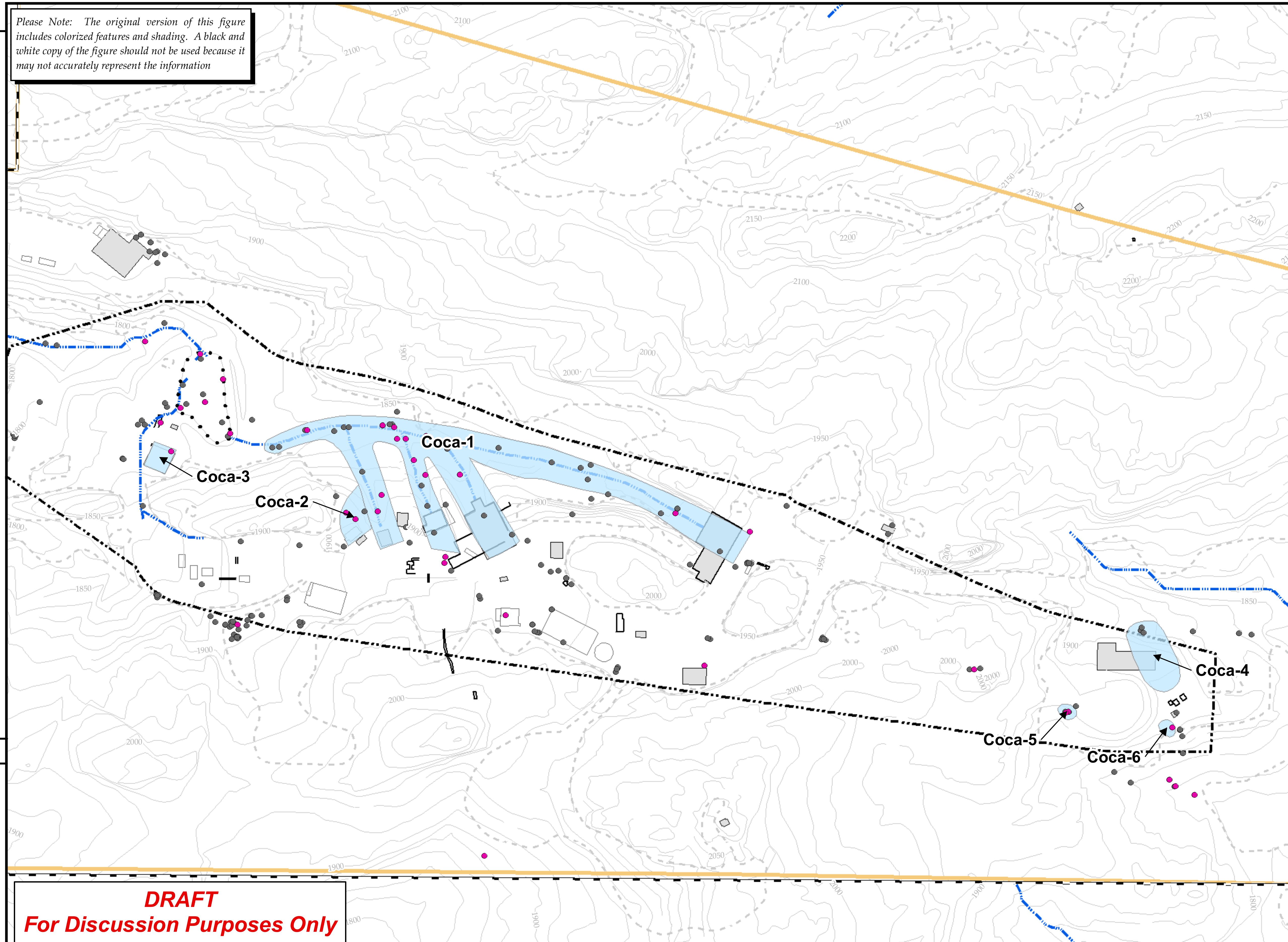
Figure Notes:
1. SRAM RBSLs based on SRAM resident exposure pathways for ILCR = 1 x 10-6 and HI = 1.
2. Estimated remediation areas rationale provided in Table A2-1.
3. Other samples include detections below SRAM RBSLs and non detects.

Document: Misc-CMS-Group4_Areas.mxd | Date: Sep 11, 2008

1 inch = 200 feet

Feet: 0 200 400





MWH

S A N T A S U S A N A F I E L D L A B O R A T O R Y

Figure A2-3

ATTACHMENT 3

DEFAULT SB990 ALTERNATIVE ASSUMPTION AND CALCULATION DETAILS

ATTACHMENT 3
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A3-3 OCY RFI Site Default SB990 Alternative Remediation Areas

A3-4 Coca RFI Site Default SB990 Alternative Remediation Areas

LIST OF ELECTRONIC ATTACHMENTS

File No.

File A3-1 RBSL Calculations

ATTACHMENT 3

DEFAULT SB990 ALTERNATIVE ASSUMPTION AND CALCULATION DETAILS

1 INTRODUCTION

This attachment presents the exposure assumptions and equations used to develop default rural residential risk-based screening levels (RBSLs $_{RRd}$) for soil, and details associated with estimated remedial volumes for the default SB990 alternative (herein referred to as the Default SB990 Alternative).

In order to complete this Default SB990 Alternative evaluation in a timely manner, a short-list of chemicals was selected for inclusion in the evaluation. Chemicals included in this evaluation were selected because they are the major risk drivers and/or contributors identified in the Base Case for the four example RCRA Facility Investigation (RFI) sites (see Section 2 of the main text of this technical memorandum). These chemicals are also generally considered the primary chemical contaminants and potential risk drivers/contributors across the SSFL. The selected chemicals are listed in tables A3-2 and A3-3 of this attachment.

2 EXPOSURE ASSUMPTIONS

2.1 CONCEPTUAL MODEL

A conceptual site model (CSM) for the default potential future rural residential/agricultural pathways has been developed for the four example RFI sites. Soil-based default rural residential exposure pathways described in Section 2.2 were considered to be "potentially complete". Exposure pathways for other site media (i.e., groundwater, surface water, and sediment) are not included, as this evaluation focuses on comparing soil remediation alternatives. The CSM for the Default SB990 Alternative is shown on Figure A3-1. Onsite rural residents are considered potential future human receptors for this evaluation. Potentially complete default exposure pathways for these receptors include direct contact with soil, weathered bedrock, and air, as well as indirect exposure to chemicals in soil via uptake into plants, beef cattle, chickens, milk, swine and eggs.

2.2 Potential Exposure Pathways For Soil

The following pathways were included in the default potential future rural residential evaluation:

- Direct inhalation of vapors and particles
- Incidental ingestion of soil and weathered bedrock
- Ingestion of homegrown produce (i.e., fruits and vegetables)
- Ingestion of home-raised beef
- Ingestion of milk from home-raised cows
- Ingestion of home-raised poultry
- Ingestion of eggs from home-raised poultry
- Ingestion of home-raised swine

The above default potential rural residential exposure pathways were evaluated because they are included in USEPA Preliminary Remediation Goal (PRG) calculator for radionuclides (USEPA, 2008). Not all of these pathways are practical pathways under a rural residential scenario at the SSFL, as described as Attachment 4. In addition to the pathways presented above, ingestion of fish is also included as a possible exposure pathway in USEPA PRG calculator for radionuclides. However, the fish consumption pathway was not included as a default rural residential pathway because this evaluation used soil media only for comparison purposes between sites. If required, the fish consumption pathway could be evaluated at the limited RFI sites which have perennial ponds large enough to sustain a fish population. USEPA (2005a) indicated that the ingestion of fish exposure pathway for the farmer exposure scenario is usually not recommended unless site-specific exposure setting characteristics such as the presence of ponds are identified.

3 RBSL QUANTIFICATION

The SSFL Standardized Risk Assessment Methodology (SRAM) Residential RBSLs for ingestion of soil, dermal contact with soil, inhalation of dust, and inhalation of vapors from soil are based on the DTSC-approved risk assessment work plan (MWH, 2005) and are provided in Table 2 of the main text of this technical memorandum. Default rural residential RBSLs for homegrown fruits and vegetables, beef, milk, poultry, eggs, and swine were calculated using risk assessment procedures and equations provided on the online Risk Assessment Information

System (RAIS, http://rais.ornl.gov/homepage/tm/for_ag.shtml). These equations are based on guidance in *Risk Assessment Guidance for Superfund: Volume 1, Human Health Evaluation Manual (Part A - Baseline Risk Assessment)* (RAGS, Part A; USEPA, 1989) and *Risk Assessment Guidance for Superfund: Volume 1, Human Health Evaluation Manual (Part B - Development of Risk-based Preliminary Remediation Goals)* (RAGS, Part B; USEPA, 1991). Default rural residential RBSLs were estimated separately for adults and children for both carcinogenic and non-carcinogenic effects using the equations presented in the following sections.

3.1 INGESTION OF FRUITS AND VEGETABLES

The default rural residential soil RBSLs for the fruits and vegetables pathway were estimated using the following equations:

$$RBSL_{fv} = \frac{C_{fv}}{Bv_{wet} + MLF}\text{; where}$$

$$C_{fv} = \frac{T \times BW \times AT}{TV \times \left(IR_f + IR_v\right) \times CPF \times EF \times ED}$$

And where:

RBSLfv = default rural residential Soil RBSL for fruits and vegetables pathway (mg/kg)

C_{fv} = target chemical concentration in fruits and vegetables (mg/kg)

Bv_{wet} = soil to plant uptake wet weight (kg/kg)

MLF = plant mass loading factor (unitless)

AT = averaging time (yr x day/yr)

BW = body weight (kg)

ED = exposure duration (yr)

EF = exposure frequency (day/yr)

CPF = contaminated plant fraction (unitless)

IRf = fruit ingestion rate (kg/day)

IRv = vegetable ingestion rate (kg/day)

T = target cancer risk of 1 x 10^{-6} or target hazard index of 1 (unitless)

TV = oral toxicity value (SFo or 1/RFDo)

where:

SFo = oral cancer slope factor $(mg/kg\text{-}day)^{-1}$

RfDo = oral chronic reference dose (mg/kg-day)

3.2 Ingestion of Beef

The default rural residential soil RBSLs for the beef pathway were estimated using the following equations:

$$RBSL_b = \frac{C_b}{F_b \times \left[\left(Qp_b \times fp_b \times fs_b \times \left(Bv_{dry} + MLF_b\right)\right) + \left(Qs_b \times fp_b\right)\right]} \text{; where}$$

$$C_b = \frac{T \times BW \times AT}{TV \times IR_b \times FI_b \times EF \times ED}$$

And where:

$RBSL_b$ = default rural residential Soil RBSL for beef pathway (mg/kg)

C_b = target chemical concentration in beef (mg/kg)

Bv_{dry} = soil to plant uptake dry weight (kg/kg)

fp_b = fraction of year animal is on site – beef cattle (unitless)

fs_b = fraction of animal's food is from site – beef cattle (unitless)

F_b = beef transfer coefficient (day/kg)

MLF_b = plant mass loading factor –beef pasture (unitless)

Qp_b = quantity of pasture ingested – beef cattle (kg/day)

Qs_b = quantity of soil ingested – beef cattle (kg/day)

AT = averaging time (yr x day/yr)

BW = body weight (kg)

ED = exposure duration (yr)

EF = exposure frequency (day/yr)

FI_b = fraction ingested (unitless)

IR_b = beef ingestion rate (kg/day)

T = target cancer risk of 1 x 10^{-6} or target hazard index of 1 (unitless)

TV = oral toxicity value (SFo or 1/RFDo)

where:

SFo = oral cancer slope factor $(mg/kg\text{-}day)^{-1}$

RfDo = oral chronic reference dose (mg/kg-day)

3.3 Ingestion of Milk

The default rural residential soil RBSLs for the milk pathway were estimated using the following equations:

$$RBSL_m = \frac{C_m}{F_m \times \left[\left(Qp_m \times fp_m \times fs_m \times \left(Bv_{dry} + MLF_m\right)\right) + \left(Qs_m \times fp_m\right)\right]}\text{; where}$$

$$C_m = \frac{T \times BW \times AT}{TV \times IR_m \times FI_m \times EF \times ED}$$

And where:

$RBSL_m$= default rural residential Soil RBSL for milk pathway (mg/kg)

C_m = target chemical concentration in milk (mg/kg)

Bv_{dry} = soil to plant uptake dry weight (kg/kg)

fp_m = fraction of year animal is on site – dairy cattle (unitless)

fs_m = fraction of animal's food is from site – dairy cattle (unitless)

F_m = milk transfer coefficient (day/kg)

MLF_m = plant mass loading factor –dairy pasture (unitless)

Qp_m = quantity of pasture ingested – dairy cattle (kg/day)

Qs_m = quantity of soil ingested – dairy cattle (kg/day)

AT = averaging time (yr x day/yr)

BW = body weight (kg)

ED = exposure duration (yr)

EF = exposure frequency (day/yr)

FI_m = fraction ingested – milk (unitless)

IF_m = milk ingestion rate (kg/day)

T = target cancer risk of 1 x 10^{-6} or target hazard index of 1 (unitless)

TV = oral toxicity value (SFo or 1/RFDo)

where:

SFo = oral cancer slope factor $(mg/kg\text{-}day)^{-1}$

RfDo = oral chronic reference dose (mg/kg-day)

3.4 INGESTION OF POULTRY

The default rural residential soil RBSLs for the poultry pathway were estimated using the following equations:

$$RBSL_p = \frac{C_p}{F_p \times \left[\left(Qp_p \times fp_p \times fs_p \times \left(Bv_{dry} + MLF_p\right)\right) + \left(Qs_p \times fp_p\right)\right]}; \text{ where}$$

$$C_p = \frac{T \times BW \times AT}{TV \times IR_p \times FI_p \times EF \times ED}$$

And where:

$RBSL_p$ = default rural residential Soil RBSL for poultry pathway (mg/kg)

C_p = target chemical concentration in poultry (mg/kg)

Bv_{dry} = soil to plant uptake dry weight (kg/kg)

fp_p = fraction of year animal is on site – poultry (unitless)

fs_p = fraction of animal's food is from site – poultry (unitless)

F_p = poultry transfer coefficient (day/kg)

MLF_p = plant mass loading factor – poultry pasture (unitless)

Qp_p = quantity of fodder ingested – poultry (kg/day)

Qs_p = quantity of soil ingested – poultry (kg/day)

AT = averaging time (yr x day/yr)

BW = body weight (kg)

ED = exposure duration (yr)

EF = exposure frequency (day/yr)

FI_p = fraction ingested (unitless)

IR_p = poultry ingestion rate (kg/day)

T = target cancer risk of 1 x 10^{-6} or target hazard index of 1 (unitless)

TV = oral toxicity value (SFo or 1/RFDo)

where:

SFo = oral cancer slope factor $(mg/kg\text{-}day)^{-1}$

RfDo = oral chronic reference dose (mg/kg-day)

3.5 Ingestion of Eggs

The default rural residential soil RBSLs for the egg pathway were estimated using the following equations:

$$RBSL_e = \frac{C_e}{F_e \times \left[\left(Qp_p \times fp_p \times fs_p \times \left(Bv_{dry} + MLF_p\right)\right) + \left(Qs_p \times fp_p\right)\right]}$$; where

$$C_e = \frac{T \times BW \times AT}{TV \times IR_e \times FI_e \times EF \times ED}$$

And where:

$RBSL_e$ = default rural residential Soil RBSL for egg pathway (mg/kg)

C_e = target chemical concentration in egg (mg/kg)

Bv_{dry} = soil to plant uptake dry weight (kg/kg)

fp_p = fraction of year animal is on site – poultry (unitless)

fs_p = fraction of animal's food is from site – poultry (unitless)

F_e = egg transfer coefficient (day/kg)

MLF_p = plant mass loading factor – poultry pasture (unitless)

Qp_p = quantity of pasture ingested – poultry (kg/day)

Qs_p = quantity of soil ingested – poultry (kg/day)

AT = averaging time (yr x day/yr)

BW = body weight (kg)

ED = exposure duration (yr)

EF = exposure frequency (day/yr)

FI_e = fraction ingested (unitless)

IR_e = egg ingestion rate (kg/day)

T = target cancer risk of 1 x 10^{-6} or target hazard index of 1 (unitless)

TV = oral toxicity value (SFo or 1/RFDo)

where:

SFo = oral cancer slope factor $(mg/kg\text{-}day)^{-1}$

RfDo = oral chronic reference dose (mg/kg-day)

3.6 INGESTION OF SWINE

The default rural residential soil RBSLs for the swine pathway were estimated using the following equations:

$$RBSL_s = \frac{C_s}{F_s \times \left[\left(Qp_s \times fp_s \times fs_s \times \left(Bv_{dry} + MLF_s\right)\right) + \left(Qs_s \times fp_s\right)\right]}$$; where

$$C_s = \frac{T \times BW \times AT}{TV \times IR_s \times FI_s \times EF \times ED}$$

And where:

$RBSL_s$ = default rural residential Soil RBSL for swine pathway (mg/kg)

C_s = target chemical concentration in swine (mg/kg)

Bv_{dry} = soil to plant uptake dry weight (kg/kg)

fp_s = fraction of year animal is on site – swine (unitless)

fs_s = fraction of animal's food is from site – swine (unitless)

F_s = swine transfer coefficient – swine (day/kg)

MLF_s = plant mass loading factor – swine pasture (unitless)

Qp_s = quantity of pasture ingested – swine (kg/day)

Qs_s = quantity of soil ingested – swine (kg/day)

AT = averaging time (yr x day/yr)

BW = adult body weight (kg)

ED = exposure duration (yr)

EF = exposure frequency (day/yr)

FI_s = fraction ingested (unitless)

IR_s = swine ingestion rate (kg/day)

T = target cancer risk of 1 x 10^{-6} or target hazard index of 1 (unitless)

TV = oral toxicity value (SFo or 1/RFDo) where:

SFo = oral cancer slope factor $(mg/kg\text{-}day)^{-1}$

RfDo = oral chronic reference dose (mg/kg-day)

3.7 CUMULATIVE RBSL EQUATION

The cumulative rural residential RBSLs for soil were estimated using the following equations:

$$SUM = \left(\frac{USC}{RBSL_{res}}\right) + \left(\frac{USC}{RBSL_{fv}}\right) + \left(\frac{USC}{RBSL_{b}}\right) + \left(\frac{USC}{RBSL_{p}}\right) + \left(\frac{USC}{RBSL_{e}}\right) + \left(\frac{USC}{RBSL_{s}}\right) + \left(\frac{USC}{RBSL_{m}}\right); \text{ and}$$

$$RBSL_{RRd} = \frac{USC}{SUM}$$

Where:

$RBSL_{res}$ = SRAM residential RBSL (mg/kg)

$RBSL_{fv}$ = default rural residential Soil RBSL for fruit and vegetable pathway (mg/kg)

$RBSL_{b}$ = default rural residential Soil RBSL for beef pathway (mg/kg)

$RBSL_{p}$ = default rural residential Soil RBSL for poultry pathway (mg/kg)

$RBSL_{e}$ = default rural residential Soil RBSL for egg pathway (mg/kg)

$RBSL_{s}$ = default rural residential Soil RBSL for swine pathway (mg/kg)

$RBSL_{m}$ = default rural residential Soil RBSL for milk pathway (mg/kg)

SUM = sum of USC/pathway-specific RBSLs

USC = unit soil concentration (mg/kg)

$RBSL_{RRd}$ = default cumulative rural residential RBSL (mg/kg)

The exposure parameters and rationale for the default rural residential pathway are presented in Table A3-1. Chemical-specific parameters are presented in Table A3-2.

Toxicity values for the RBSL calculations were obtained from the following hierarchy of sources, as specified in the SRAM (MWH, 2005):

1. OEHHA (http://www.oehha.ca.gov/risk/chemicalDB/index.asp)
2. Integrated Risk Information System (IRIS; USEPA 2008)
3. Health Effects Assessment Summary Table (HEAST; USEPA 1997a)
4. USEPA criteria documents
5. Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles
6. Environmental Criteria and Assessment Office (ECAO)
7. Other sources

The toxicity values used in the RBSL calculations are presented in Table A3-3.

4 ESTIMATED REMEDIATION EVALUATION

The process for estimating remediation areas and volumes associated with the Default SB990 Alternative is described in Section 3.0 of this technical memorandum. This attachment provides details regarding site-specific application of the process described in the main body of this document.

Table A3-4 summarizes the remedial estimate changes from Base Case when Default SB990 Alternative Soil RBSLs (i.e., default rural residential Soil RBSLs $_{RRd}$) are compared to soil concentrations on a sample-by-sample basis for the four example RFI sites. Rationale for changes in or additions to the Base Case remedial areas / volumes are described in these tables. Figures A3-2 through A3-4 depict the extent of estimated remediation areas (called CMI Areas) for the Default SB990 Alternative; Base Case estimated remediation areas are shown in figures included in Attachment 2 for reference. Included on these figures are the sampling data screened against Default SB990 Alternative RBSLs $_{RRd}$, with results exceeding RBSLs $_{RRd}$ shown in red. The data sets used for this analysis for each site are provided in Attachment 5.

5 REFERENCES

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Table A3-1

Exposure Parameters and Rationale for Default Rural Residential Risk-Based Screening Level Calculations

Parameter	Units	RME Default Rural Residential Receptor		Rationale
		Adult	Child	
General				
CS = soil/sediment/dust concentration	mg/kg	site-specific	site-specific	site-specific
BW = body weight	kg	70	15	(a)
ED = exposure duration	years	24	6	(a)
EF = exposure frequency	days/year	350	350	(a)
ATc = averaging time for carcinogens	year x days/year	25550	25550	= 70 * 365
ATn = averaging time for non-carcinogens	year x days/year	8760	2190	= ED * 365
Ingestion of Fruits and Vegetables				
CPF = contaminated plant fraction	unitless	0.25	0.25	(a)
IR_f = fruit ingestion rate	kg/day	0.0562	0.0148	(a)
IR_v = vegetable ingestion rate	kg/day	0.0285	0.0104	(a)
MLF = plant mass-loading factor	unitless	0.26	0.26	(a)
Ingestion of Beef				
fp_b = fraction of year animal is on site - beef cattle	unitless	1	1	(a)
fs_b = fraction of animal's food is on site - beef cattle	unitless	1	1	(a)
FI_b = ingestion fraction - beef	unitless	1	1	(a)
IR_b = beef ingestion rate	kg/day	0.138	0.0129	(a)
MLF_b = plant mass-loading factor - beef pasture	unitless	0.25	0.25	(a)
Qp_b = quantity of pasture ingested - beef cattle	kg/day	11.77	11.77	(a)
Qs_b = quantity of soil ingested - beef cattle	kg/day	0.39	0.39	(a)
Ingestion of Milk				
fp_m = fraction of year animal is on site	unitless	1	1	(a)
fs_m = fraction of animal's food is on site	unitless	1	1	(a)
FI_m = ingestion fraction	unitless	1	1	(a)
IR_m = milk ingestion rate	kg/day	0.265	0.614	(a)
MLF_m = plant mass-loading factor - pasture	unitless	0.25	0.25	(a)
Qp_m = quantity of pasture ingested - dairy cattle	kg/day	16.9	16.9	(a)
Qs_m = quantity of soil ingested - dairy cattle	kg/day	0.41	0.41	(a)

Table A3-1

Exposure Parameters and Rationale for Default Rural Residential Risk-Based Screening Level Calculations

Parameter	Units	RME Default Rural Residential Receptor Adult	Child	Rationale
Ingestion of Swine				
fp_s = fraction of year animal is on site	unitless	1	1	(a)
fs_s = fraction of animal's food is on site	unitless	1	1	(a)
FI_s = ingestion fraction	unitless	1	1	(a)
IR_s = pork ingestion rate	kg/day	0.0759	0.0123	(b)
MLF_s = plant mass-loading factor - pasture	unitless	0.25	0.25	(a)
Qp_s = quantity of pasture ingested - swine	kg/day	4.7	4.7	(b)
Qs_s = quantity of soil ingested - swine	kg/day	0.37	0.37	(b)
Ingestion of Poultry				
fp_p = fraction of year animal is on site - poultry	unitless	1	1	(a)
fs_p = fraction of animal's food is on site - poultry	unitless	1	1	(a)
FI_p = ingestion fraction - poultry	unitless	1	1	(a)
IR_p = poultry ingestion rate	kg/day	0.098	0.014	(b)
MLF_p = plant mass-loading factor - poultry pasture	unitless	0.25	0.25	(a)
Qp_p = quantity of pasture ingested - poultry	kg/day	0.2	0.2	(b)
Qs_p = quantity of soil ingested - poultry	kg/day	0.022	0.022	(b)
Ingestion of Eggs				
FI_e = ingestion fraction - eggs	unitless	1	1	(a)
IR_e = egg ingestion rate	kg/day	0.041	0.0063	(b)

Notes:

kg - kilogram(s)
mg - milligram(s)
NA - not applicable

(a) Online RAIS (http://rais.ornl.gov/cgi-bin/prg/PRG_search) default parameter.
(b) EPA Online PRG calculator for radionuclides (http://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search) default parameter.

Table A3-2

Chemical-Specific Factors Used in the Default Rural Residential Risk-Based Screening Level Calculations

Analyte	Log of [a] Octanol-Water Partition Coefficient log(Kow)	Soil to Plant [b] Uptake Wet Weight Bv_{wet} (kg/kg)	Soil to Plant [b] Uptake Dry Weight Bv_{dry} (kg/kg)	Beef [b] Transfer Coefficient F_b (day/kg)	Milk [b] Transfer Coefficient F_m (day/kg)	Poultry [a] Transfer Coefficient F_p (day/kg)	Egg [a] Transfer Coefficient F_e (day/kg)	Swine [a] Transfer Coefficient F_s (day/kg)
Inorganic Compounds								
Aluminum	NA	1.0E-03	4.0E-03	1.5E-03	2.0E-04	na	na	na
Antimony	NA	1.0E-02	5.0E-02	4.0E-05	2.5E-05	na	na	na
Arsenic	NA	1.0E-02	4.0E-02	2.0E-03	6.0E-05	na	na	na
Cadmium	NA	1.4E-01	5.5E-01	4.0E-04	1.0E-03	1.1E-01	2.5E-03	1.9E-04
Lead	NA	7.6E-04	9.0E-02	4.0E-04	3.0E-04	na	na	na
Mercury	NA	3.0E-01	1.0E+00	1.0E-02	4.7E-04	na	na	na
Perchlorate	NA	na	na	na	na	na	na	na
Selenium	NA	1.0E-01	5.0E-01	1.0E-01	1.0E-02	1.1E+00	1.1E+00	1.9E-01
Thallium	NA	1.0E-03	4.0E-03	4.0E-02	2.0E-03	na	na	na
Zinc	NA	2.6E-01	9.9E-01	1.0E-01	1.0E-02	8.8E-03	8.8E-03	1.3E-04
Volatile Organic Compounds								
1,1-Dichloroethene	NA	7.0E-01	3.4E+00	1.6E-06	5.0E-07	2.5E-03	1.4E-03	4.1E-03
Benzene	NA	4.7E-01	2.3E+00	3.1E-06	9.9E-07	2.5E-03	1.4E-03	4.1E-03
cis-1,2-Dichloroethene	NA	6.1E-01	3.0E+00	2.0E-06	6.3E-07	1.8E-03	1.0E-03	3.0E-03
Methylene chloride	NA	1.4E+00	6.7E+00	5.0E-07	1.6E-07	6.5E-04	3.7E-04	1.1E-03
Tetrachloroethene	NA	2.4E-01	1.2E+00	1.0E-05	3.1E-06	1.2E-02	6.9E-03	2.0E-02
Trichloroethene	NA	3.1E-01	1.5E+00	6.3E-06	2.0E-06	3.8E-03	2.2E-03	6.3E-03
Vinyl Chloride	NA	1.2E+00	5.9E+00	6.3E-07	2.0E-07	7.8E-04	4.4E-04	1.3E-03
Semi-Volatile Organic Compounds								
Benzo(a)anthracene	NA	3.8E-03	1.9E-02	1.3E-02	4.0E-03	2.9E-02	1.7E-02	4.8E-02
Benzo(a)pyrene	NA	2.2E-03	1.1E-02	3.1E-02	9.9E-03	2.8E-02	1.6E-02	4.5E-02
Benzo(b)fluoranthene	NA	2.2E-03	1.1E-02	3.1E-02	9.9E-03	2.7E-02	1.5E-02	4.4E-02
Benzo(k)fluoranthene	NA	8.8E-04	4.3E-03	1.6E-01	5.0E-02	2.7E-02	1.5E-02	4.4E-02
Dibenz(a,h)anthracene	NA	8.8E-04	4.3E-03	1.6E-01	5.0E-02	2.3E-02	1.3E-02	3.7E-02
Phenanthrene	NA	1.7E-02	8.2E-02	1.0E-03	3.1E-04	2.5E-02	1.4E-02	4.1E-02
PCDD/PCDFs								
2,3,7,8-TCDD	NA	8.8E-04	4.3E-03	1.6E-01	5.0E-02	1.9E-02	1.1E-02	3.2E-02
1,2,3,7,8-PeCDD	NA	1.3E-03	6.5E-03	7.9E-02	2.5E-02	2.1E-02	1.2E-02	3.5E-02
1,2,3,4,7,8-HxCDD	7.8E+00	2.3E-04 [c]	1.1E-03 [d]	1.6E+00 [e]	5.0E-01 [f]	8.1E-03	4.6E-03	1.3E-02
1,2,3,6,7,8-HxCDD	7.3E+00	4.5E-04 [c]	2.2E-03 [d]	5.0E-01 [e]	1.6E-01 [f]	1.3E-02	7.6E-03	2.2E-02
1,2,3,7,8,9-HxCDD	7.3E+00	4.5E-04 [c]	2.2E-03 [d]	5.0E-01 [e]	1.6E-01 [f]	1.3E-02	7.6E-03	2.2E-02
1,2,3,4,6,7,8-HpCDD	8.0E+00	1.8E-04 [c]	8.7E-04 [d]	2.5E+00 [e]	4.8E-01	6.5E-03	3.7E-03	1.1E-02
OCDD	NA	6.2E-05	3.1E-04	1.5E+01	4.8E+00	5.1E-03	2.9E-03	8.3E-03
2,3,7,8-TCDF	NA	3.2E-03	1.6E-02	1.7E-02	5.2E-03	2.7E-02	1.5E-02	4.4E-02
1,2,3,7,8-PeCDF	NA	8.9E-04	4.4E-03	1.5E-01	4.9E-02	1.9E-02	1.1E-02	3.2E-02
2,3,4,7,8-PeCDF	NA	7.5E-04	3.7E-03	2.1E-01	6.6E-02	2.3E-02	1.3E-02	3.7E-02
1,2,3,4,7,8-HxCDF	7.0E+00	6.7E-04 [c]	3.3E-03 [d]	2.5E-01 [e]	7.9E-02 [f]	1.7E-02	9.6E-03	2.8E-02
1,2,3,6,7,8-HxCDF	7.0E+00	6.7E-04 [c]	3.3E-03 [d]	2.5E-01 [e]	7.9E-02 [f]	1.7E-02	9.6E-03	2.8E-02
2,3,4,6,7,8-HxCDF	7.0E+00	6.7E-04 [c]	3.3E-03 [d]	2.5E-01 [e]	7.9E-02 [f]	1.7E-02	9.6E-03	2.8E-02
1,2,3,7,8,9-HxCDF	7.0E+00	6.7E-04 [c]	3.3E-03 [d]	2.5E-01 [e]	7.9E-02 [f]	1.7E-02	9.6E-03	2.8E-02
1,2,3,4,6,7,8-HpCDF	7.4E+00	3.9E-04 [c]	1.9E-03 [d]	6.3E-01 [e]	2.0E-01 [f]	1.2E-02	6.9E-03	2.0E-02
1,2,3,4,7,8,9-HpCDF	7.4E+00	3.9E-04 [c]	1.9E-03 [d]	6.3E-01 [e]	2.0E-01 [f]	1.2E-02	6.9E-03	2.0E-02
OCDF	NA	7.9E-05	3.9E-04	1.0E+01	3.1E+00	6.5E-03	3.7E-03	1.1E-02

Table A3-2

Chemical-Specific Factors Used in the Default Rural Residential Risk-Based Screening Level Calculations

Analyte	Log of [a] Octanol-Water Partition Coefficient log(Kow)	Soil to Plant [b] Uptake Wet Weight Bv_{wet} (kg/kg)	Soil to Plant [b] Uptake Dry Weight Bv_{dry} (kg/kg)	Beef [b] Transfer Coefficient F_b (day/kg)	Milk [b] Transfer Coefficient F_m (day/kg)	Poultry [a] Transfer Coefficient F_p (day/kg)	Egg [a] Transfer Coefficient F_e (day/kg)	Swine [a] Transfer Coefficient F_s (day/kg)
Polychlorinated Biphenyls (PCBs)								
Aroclor-1248	NA	3.3E-03	1.6E-02	1.6E-02	5.0E-03	2.5E-02	1.4E-02	na
Aroclor-1254	NA	2.5E-03	1.3E-02	2.5E-02	7.9E-03	2.3E-02	1.3E-02	3.7E-02
Aroclor-1260	NA	5.9E-04	2.9E-03	3.1E-01	9.9E-02	5.1E-03	2.9E-03	na

Notes:
NA - not applicable in the calculations of rural residential human health risks
na - not available

[a] Unless otherwise noted, values are obtained from Human Health Risk Assessment Protocol Companion Database, 2005.
[b] Unless otherwise noted, values are obtained from online RAIS (http://rais.ornl.gov/cgi-bin/tox/TOX_select?select=csf) chemical-specific factors.
[c] Calculated using equation ($7.7*Kow^{-0.58}$): McKone, T. E. 1994. Uncertainty and variability in human exposures to soil contaminants through home-grown food: a Monte Carlo assessment. Risk Anal. 14(4):449-463.
[d] Calculated using equation (38*Kow-0.58): McKone, T. E. 1994. Uncertainty and variability in human exposures to soil contaminants through home-grown food: a Monte Carlo assessment. Risk Anal. 14(4):449-463.
[e] Calculated using equation (2.5*10-8*Kow): McKone, T. E. 1994. Uncertainty and variability in human exposures to soil contaminants through home-grown food: a Monte Carlo assessment. Risk Anal. 14(4):449-463.
[f] Calculated using equation (7.9*10-9*Kow): McKone, T. E. 1994. Uncertainty and variability in human exposures to soil contaminants through home-grown food: a Monte Carlo assessment. Risk Anal. 14(4):449-463.

Table A3-3

Toxicity Values Used in Rural Residential Risk-Based Screening Level Calculations

	Cancer Slope Factor - CSF $(mg/kg\text{-}d)^{-1}$						Reference Dose - RfD (mg/kg-d)					
Analyte	**Oral**		**Dermal**		**Inhalation**		**Oral**		**Dermal**		**Inhalation**	
Inorganic Compounds												
Aluminum	NTV		NTV		NTV		1.0E+00	P	1.0E+00	R	1.4E-03	P
Antimony	NTV		NTV		NTV		4.0E-04	I	4.0E-04	R	NTV	
Arsenic	9.5E+00	C	9.5E+00	R	1.2E+01	C	3.0E-04	I	3.0E-04	R	8.6E-06	C
Cadmium	NTV		NTV		NTV		1.0E-03	I	1.0E-03	R	5.7E-06	C
Lead	NTV		NTV		NTV		NTV		NTV		NTV	
Mercury [a]	NTV		NTV		NTV		3.0E-04	I	3.0E-04	R	2.6E-05	C
Perchlorate	NTV		NTV		NTV		1.2E-04	C	1.2E-04	R	1.2E-04	C
Selenium	NTV		NTV		NTV		5.0E-03	I	5.0E-03	R	5.7E-03	C
Thallium	NTV		NTV		NTV		8.0E-05	I	8.0E-05	R	NTV	
VOCs												
1,1-Dichloroethene	NTV		NTV		NTV		5.0E-02	I	5.0E-02	R	2.0E-02	C
Benzene	1.0E-01	C	1.0E-01	R	1.0E-01	C	4.0E-03	I	4.0E-03	R	8.6E-03	I
Methylene chloride	1.4E-02	C	1.4E-02	R	3.5E-03	C	6.0E-02	I	6.0E-02	R	1.1E-01	C
Tetrachloroethene	5.4E-01	C	5.4E-01	R	2.1E-02	C	1.0E-02	I	1.0E-02	R	1.0E-02	C
Trichloroethene	1.3E-02	C	1.3E-02	R	7.0E-03	C	3.0E-04	I	3.0E-04	R	1.7E-01	C
SVOCs												
Benzo(a)anthracene	1.2E+00	C	1.2E+00	R	3.9E-01	C	NTV		NTV		NTV	
Benzo(a)pyrene	1.2E+01	C	1.2E+01	R	3.9E+00	C	NTV		NTV		NTV	
Benzo(b)fluoranthene	1.2E+00	C	1.2E+00	R	3.9E-01	C	NTV		NTV		NTV	
Benzo(k)fluoranthene	1.2E+00	C	1.2E+00	R	3.9E-01	C	NTV		NTV		NTV	
Dibenz(a,h)anthracene	4.1E+00	C	4.1E+00	R	4.1E+00	C	NTV		NTV		NTV	
PCDD/PCDFs [b]												
2,3,7,8-TCDD	1.3E+05	C	1.3E+05	R	1.3E+05	C	NTV		NTV		NTV	
1,2,3,7,8-PeCDD	1.3E+05	C	1.3E+05	R	1.3E+05	C	NTV		NTV		NTV	
1,2,3,4,7,8-HxCDD	1.3E+04	C	1.3E+04	R	1.3E+04	C	NTV		NTV		NTV	
1,2,3,6,7,8-HxCDD	1.3E+04	C	1.3E+04	R	1.3E+04	C	NTV		NTV		NTV	
1,2,3,7,8,9-HxCDD	1.3E+04	C	1.3E+04	R	1.3E+04	C	NTV		NTV		NTV	
1,2,3,4,6,7,8-HpCDD	1.3E+03	C	1.3E+03	R	1.3E+03	C	NTV		NTV		NTV	
OCDD	3.9E+01	C	3.9E+01	R	3.9E+01	C	NTV		NTV		NTV	
2,3,7,8-TCDF	1.3E+04	C	1.3E+04	R	1.3E+04	C	NTV		NTV		NTV	
1,2,3,7,8-PeCDF	3.9E+03	C	3.9E+03	R	3.9E+03	C	NTV		NTV		NTV	
2,3,4,7,8-PeCDF	3.9E+04	C	3.9E+04	R	3.9E+04	C	NTV		NTV		NTV	
1,2,3,4,7,8-HxCDF	1.3E+04	C	1.3E+04	R	1.3E+04	C	NTV		NTV		NTV	
1,2,3,6,7,8-HxCDF	1.3E+04	C	1.3E+04	R	1.3E+04	C	NTV		NTV		NTV	
2,3,4,6,7,8-HxCDF	1.3E+04	C	1.3E+04	R	1.3E+04	C	NTV		NTV		NTV	
1,2,3,7,8,9-HxCDF	1.3E+04	C	1.3E+04	R	1.3E+04	C	NTV		NTV		NTV	
1,2,3,4,6,7,8-HpCDF	1.3E+03	C	1.3E+03	R	1.3E+03	C	NTV		NTV		NTV	
1,2,3,4,7,8,9-HpCDF	1.3E+03	C	1.3E+03	R	1.3E+03	C	NTV		NTV		NTV	
OCDF	3.9E+01	C	3.9E+01	R	3.9E+01	C	NTV		NTV		NTV	
PCBs												
Aroclor-1248	2.0E+00	I	2.0E+00	R	2.0E+00	I	NTV		NTV		NTV	
Aroclor-1254	2.0E+00	I	2.0E+00	R	2.0E+00	I	2.0E-05	I	2.0E-05	R	2.0E-05	R
Aroclor-1260	2.0E+00	I	2.0E+00	R	2.0E+00	I	NTV		NTV		NTV	

Note:
CSF - Cancer slope factor
mg/kg-d - Milligram per kilogram per day
RfD - Reference dose
NTV - no toxicity value
WHO TEF = World Health Organization Toxicity Equivalency Factor

[a] Mercuric chloride used as a surrogate.

[b] Toxicity values are based on Cal-EPA's 2,3,7,8-TCDD toxicity values and 2005 WHO TEFs.

Source Data:
C California EPA (Cal-EPA)
I Integrated Risk Information System (IRIS) Database (USEPA)
P Provisional Peer Reviewed Toxicity Values (PPRTV)
R Route extrapolation

DRAFT For Review and Discussion

Table A3-4. Comparison of Base Case and Default SB990 Alternative Estimated Remedial Volumes

(Page 1 of 2)

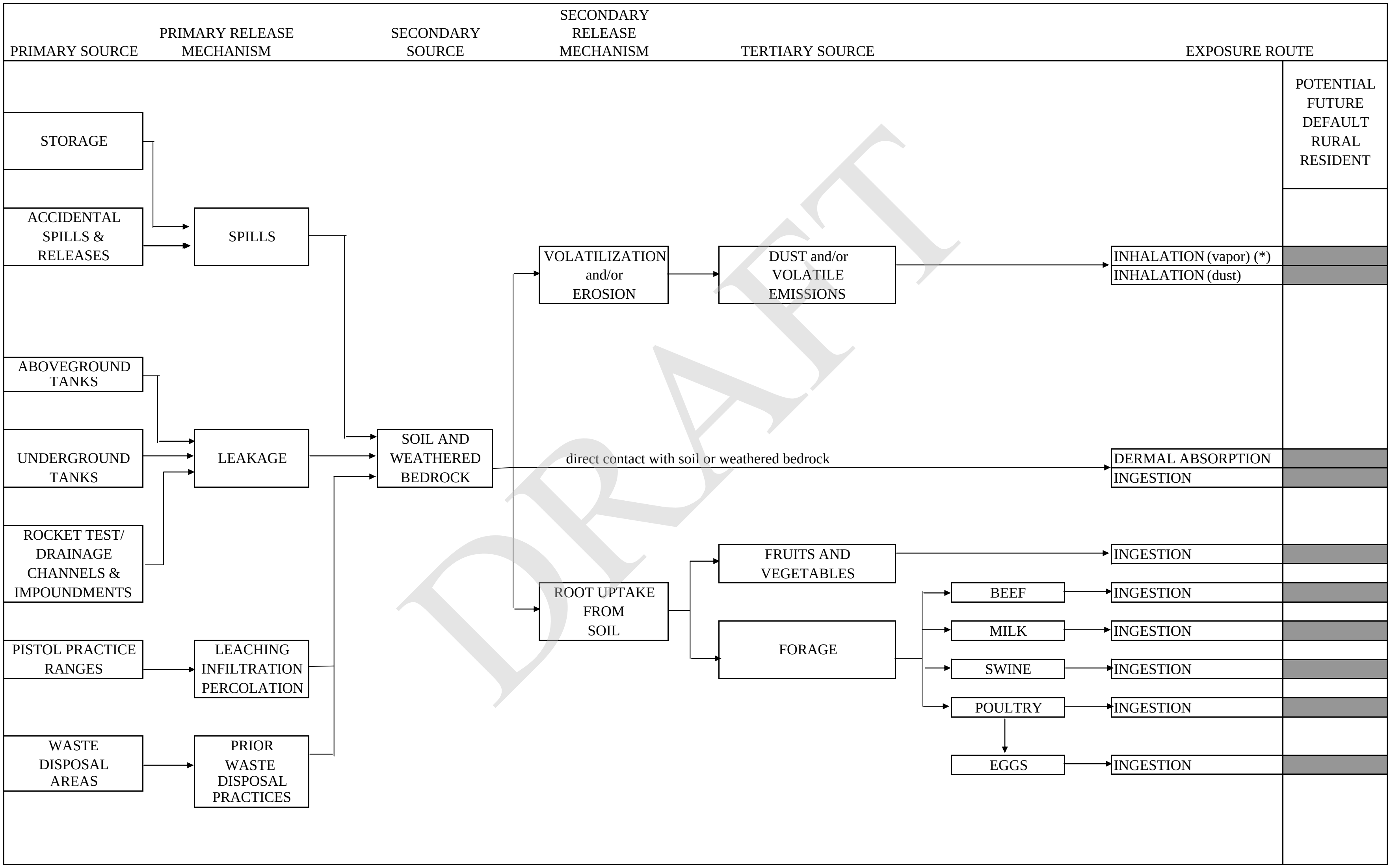
	Base Case Estimates	Default SB990 Alternative Estimates				
Description	**CMI Volume (cubic yds)**	**CMI NAME**	**AREA (Sq. Ft)**	**Depth (ft)**	**Volume (cubic Yds)**	**Basis for Potential Additional Cleanup**
Old Conservation Yard RFI Site						
Rocketdyne Cons Yard	401	OC-1	3,605	3	401	-----------
SRE Pond Discharge Pipeline	**565**	**OC-2**	**4,921**	**4**	**729**	**CMI area widened for detected PCBs, dioxins, metals based on lower RBSLs; extent based on topography and concentrations relative to RBSLs**
OCY Low Spot	**491**	**OC-3**	**5,955**	**4**	**882**	**CMI area widened for detected PCBs, PAHs, dioxins, metals based on lower RBSLs; extent based on topography and concentrations relative to RBSLs**
Asphalt Drainage South of Low Spot	**232**	**OC-4**	**3,559**	**3**	**395**	**CMI area widened approximately 10 feet for detected PCBs based on lower RBSLs (assumed wider impacts in drainage)**
Transformer (central)	**594**	**OC-5**	**3,128**	**6**	**695**	**CMI area expanded for detected PCBs near source based on lower RBSLs; area extended 5 to 8 feet on east side (highest concentrations).**
AI Conservation Yard	604	OC-6	5,436	3	604	-----------
OCY N/S Debris Areas (deep)	703	OC-7D	3,163	6	703	-----------
OCY N/S Debris Areas (sfc.)	**1,006**	**OC-7S**	**23,034**	**2**	**1,706**	**CMI area expanded to west, south & east for detected thallium and dioxins; extent based on topography, concentrations, bedrock and debris extent.**
Telephone Pole Storage Area	**193**	**OC-8**	**3,052**	**3**	**339**	**CMI area expanded for detected Dioxins based on lower RBSLs (assumed cleanup to background)**
Soil Downslope of N/S Debris Area	**433**	**OC-9**	**7,928**	**2**	**587**	**CMI area expanded for detected Dioxins and thallium DLs based on lower RBSLs (assumed cleanup to background)**
Southeast Drainage	**872**	**OC-10**	**11,258**	**3**	**1,251**	**CMI area widened approximately 10 feet for detected Dioxins based on lower RBSLs (assumed cleanup to background and wider impacts in drainage)**
North Storage Area	**431**	**OC-11**	**13,469**	**3**	**1,497**	**CMI area extended for PCB DLs near source area and PAH DLs and lower RBSLs; extent based on DLs relative to RBSLs, historical storage and bedrock.**
North Storage - Downslope	1,517	OC-12	13,654	3	1,517	-----------
North Storage - Downslope drainage	**--**	**OC-12B**	**16,774**	**2**	**1,243**	**PAHs, PCBs DLs above lower RBSLs downslope from source area**
North Slope Debris Area "A"	**1,779**	**OC-13**	**30,982**	**2**	**2,295**	**CMI Area extended downslope from source area for PCB DLs and lower RBSLs; extent 100 feet past last elevated DL.**
Transformer (southeast)	**93**	**OC-14**	**1,294**	**3**	**144**	**CMI area expanded for detected PCBs near source based on lower RBSLs;**
North Slope Debris Area "B"	--	OC-15	6,769	2	501	**CMI area added based on PCB Detection Limits (DLs) and detected PAHs; extent based on extent of debris and potential concentrations relative to DLs**
Transformer (west)	--	OC-16	1,067	3	119	**Added to CMI based on PCB DLs (up to 51 µg/kg) near potential source and lower RBSLs; extent based on transformer pad and sample locations.**
Tank Area Soils	--	OC-17	80,253	2	5,945	**Added to CMI Based on PAH DLs (approximately 30 µg/kg up to 3,200 µg/kg)**
	9,912				**21,552**	**Estimated Volume**
Coca Area RFI Site						
Spilways and test stands	21,860	Coca-1	98,368	6	21,860	-----------
Lubricant Oil Area	181	Coca-2	4,894	1	181	-----------
Bulk Test Facility	287	Coca-3	2,579	3	287	-----------
Hydrogen Compressor Area Buildings	1,213	Coca-4	10,914	3	1,213	-----------
Hydrogen Compressor Bleed-off Valve Area	70	Coca-5	944	2	70	-----------
Hydrogen Compressor Building 933 Discharge Area	69	Coca-6	1,658	2	123	**(Area labelled "Coca-18) CMI area extended 25 feet downslope based on PCB DLs (up to 120 µg/kg) relative to lower RBSLs**
Coca Skim Pond	**--**	**Coca-7**	**23,848**	**6**	**5,300**	**Area added based on detected dioxins and lower RBSLs; extent based on pond size**
Drainage below Coca Skim Pond	**--**	**Coca-8**	**15,441**	**6**	**3,431**	**Area added based on detected dioxins and lower RBSLs; extent based on assumed drainage width of 15 feet to confluence with tributary downstream**
Transformer area west of Coca Skim Pond	**--**	**Coca-9**	**524**	**3**	**58**	**Area added for PCBs up to 73 µg/kg, well above RBSLs; extent based on general pad area.**
Pump Shed Area	**--**	**Coca-10**	**882**	**2**	**65**	**Area added for PCBs up to 240 µg/kg, well above RBSL; extent based on exposed soil up to paved surface.**
B222 Leach Field & Transformer	**--**	**Coca-11**	**3,728**	**6**	**828**	**Area added for PCBs at transformer up to 120 µg/kg, well above RBSL; leachfield added to CMI based on PAHs (detected and DLs); extent based on leachfield area and transformer data**
Soil between Coca 2 and Coca 3 Test Stands	**--**	**Coca-12**	**2,033**	**2**	**151**	**CMI area added based on PCB DLs (up to 52 µg/kg) and lower RBSLs; extent based on soil in proximity to test stand (limited area)**
Transformer area south of B240	**--**	**Coca-13**	**532**	**2**	**39**	**CMI area added based on PCB DLs (up to 52 µg/kg) and lower RBSLs; extent based on transformer pad and sample locations**
Transformer area east of B919	**--**	**Coca-14**	**2,213**	**2**	**164**	**CMI area added based on PCB DLs (up to 51 µg/kg) and lower RBSLs; extent based on transformer pad and sample locations**
Debris Area (south of Building 234)	**--**	**Coca-15**	**32,459**	**3**	**3,607**	**CMI area added based on detected PAHs and DLs, thallium, selenium in debris area; extent based on mapped debris extent.**
V99 Bleed-off Valves Vent Stack (oil spray)	**--**	**Coca-16**	**908**	**2**	**67**	**CMI area added based on PCB DLs in suspected oil spraying area where maximum lubricant oil range TPH detected; extent based on area of likely influence.**
V99 Bleed-off Valves pipeline oil stained soil locations	**--**	**Coca-17**	**2,723**	**1**	**101**	**CMI area added based on PCBs detected up to 250 µg/kg in area of oil staining; extent based on staining extent and down drainage sample.**
Debris Area south of Hydrogen Compressor Area	**--**	**Coca-19**	**4,524**	**3**	**503**	**CMI area added based on PCB DLs in debris area where lubricant oil range TPH detected; extent based on area of debris**
	23,679				**38,047**	**Estimated Volume**

Table A3-4. Comparison of Base Case and Default SB990 Alternative Estimated Remedial Volumes

FSDF RFI Site						
Concrete Pool Area/Southern FSDF (Extended)	**1,065**	**FSDF-1**	**32,575**	**6**	**7,239**	**CMI area extended based on PCB and dioxin DLs; extent based on former site activities, extent of former excavation, and topography**
Drainage/Drum Debris Area (Extended)	**928**	**FSDF-2**	**13,787**	**2**	**1,021**	**CMI area extended based on detected PCBs in upper drainage; extent based on downstream confluence with Channel A**
FSDF Pistol Range (Extended)	**133**	**FSDF-3**	**9,158**	**2**	**678**	**CMI area extended based on detected dioxins and PCB DLs and lower RBSLs; extent based on downstream confluence with Channel B (also included as CMI for Default SB990) and extent of former excavation.**
NE Rim of Former IM Excavation (upper portion)	**--**	**FSDF-4**	**21,146**	**2**	**1,566**	**CMI area added based on DLs for PCBs, dioxins and PAHs relative to lower RBSLs; extent based on topography and extent of former excavation**
NW Rim of Former IM Excavation (upper portion)	**--**	**FSDF-5**	**1,653**	**2**	**122**	**CMI area added based on DLs for PCBs and dioxins relative to lower RBSLs; extent based on adjacent steep (outcrop) topography and extent of former excavation**
East Rim of Former IM Channel B Excavation	**--**	**FSDF-6**	**1,337**	**2**	**99**	**CMI area extended based on detected dioxins and PCB DLs and lower RBSLs; extent based on adjacent steep (outcrop) topography and extent of former excavation**
FSDF Channel A	**--**	**FSDF-A**	**7,032**	**2**	**521**	**CMI area added based on detected PCBs and dioxins relative to lower RBSLs; extent based on approximate channel width (10 feet) and continues to Channel C**
FSDF Channel B	**--**	**FSDF-B**	**3,042**	**2**	**225**	**CMI area added based on detected PCBs and dioxins relative to lower RBSLs; extent based on approximate channel width (10 feet) and continues to Channel C**
FSDF Channel C	**--**	**FSDF-C**	**8,192**	**2**	**607**	**CMI area added based on detected PCBs relative to lower RBSLs; extent based on approximate channel width (10 feet) and very steep channel downstream (very ittle soil)**
FSDF Channel D	**--**	**FSDF-D**	**18,633**	**2**	**1,380**	**CMI area added based on detected PCBs (up to 56 µg/kg) relative to lower RBSLs; extent based on approximate channel width (10 feet) and sample data (22 µg/kg in last sample)**
	2,126				**13,460**	**Estimated Volume**
ESADA RFI Site						
ESADA Former Storage Yard (Extended)	**1,231**	**ESADA-1**	**68,632**	**3**	**7,626**	**CMI area extended based on detected PCBs and DLs relative to lower RBSLs; extent based on sample data, former operations and topography**
	1,231				**7,626**	**Estimated Volume**
Notes:						
Indicates new CMI added compared to Base Case						
Bold font indicates change in CMI volume						
--	Not applicable					

Figure A3-1

Default Rural Residential Human Health Risk Assessment Conceptual Site Model for Soil and Weathered Bedrock
Santa Susana Field Laboratory (SSFL)



NOTES:

(*) Exposure limited to volatile compounds as defined in the text; residential receptors include both indoor and outdoor air exposure to volatiles.

[shaded box] - potentially complete exposure pathways evaluated in this risk assessment

[open box] - incomplete exposure pathways not evaluated in this risk assessment

FSDF and ESADA RFI Site
Default SB990 Alternative

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Report Group Boundary
- Existing Building
- Removed Building
- Ponds
- Drainage
- Bedrock Outcrop
- Elevation Contour
- Interim Measure (IM) Excavation

Default SB990 CMI Area

Sample Locations

- Detects above Default RBSLs
- Non Detects above Default RBSLs
- All sample locations

Notes:
1) Default SB990 RBSLs based on default rural resident exposure pathways for ILCR = 1 x 10-6 and HI = 1.

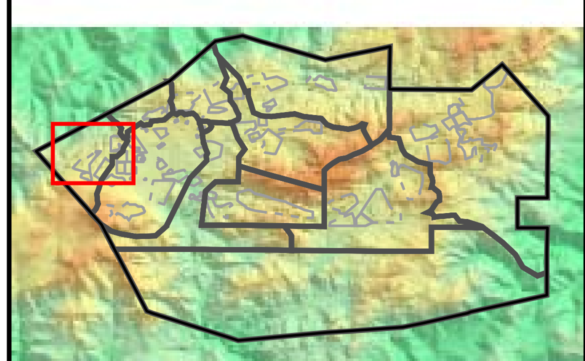
2) Estimated remediation areas rationale provided in Table A3-4.

3) Other samples include detects or non detects below Default SB990 RBSLs and sample results for chemicals not included in this evaluation.

Document: DefaultGroup8.mxd | Date: Sept 12, 2008

1 inch = 200 feet

0 200 400 Feet



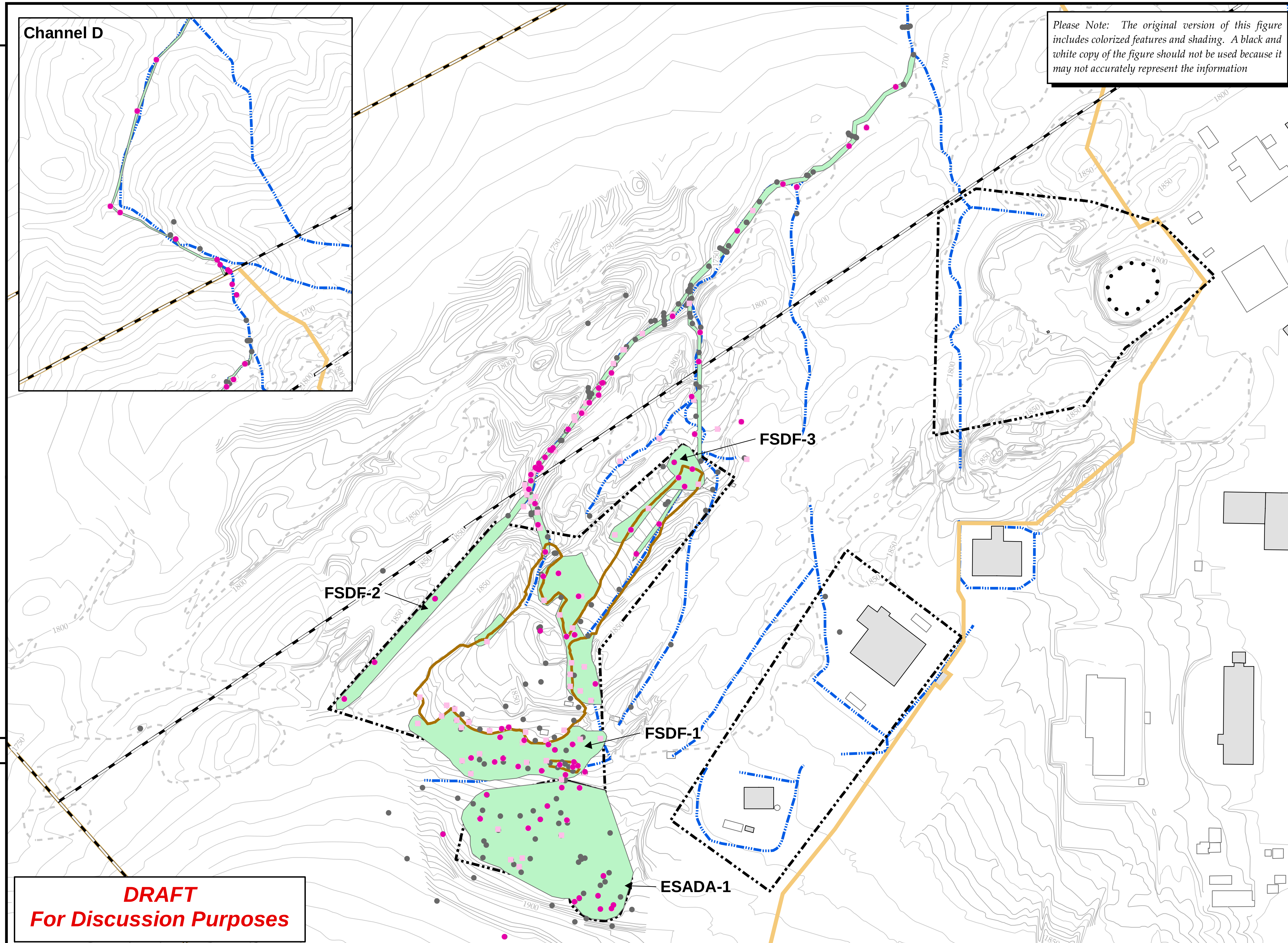


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Figure A3-2

OCY RFI Site Default SB990 Alternative

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Report Group Boundary
- Existing Building
- Removed Building
- Ponds
- Drainage
- Bedrock Outcrop
- Elevation Contour

Default SB990 CMI Area

Sample Locations

- Detects above Default RBSLs
- Non Detects above Default RBSLs
- All other samples

Notes:
1) Default SB990 RBSLs based on default rural resident exposure pathways for ILCR = 1 x 10-6 and HI = 1.

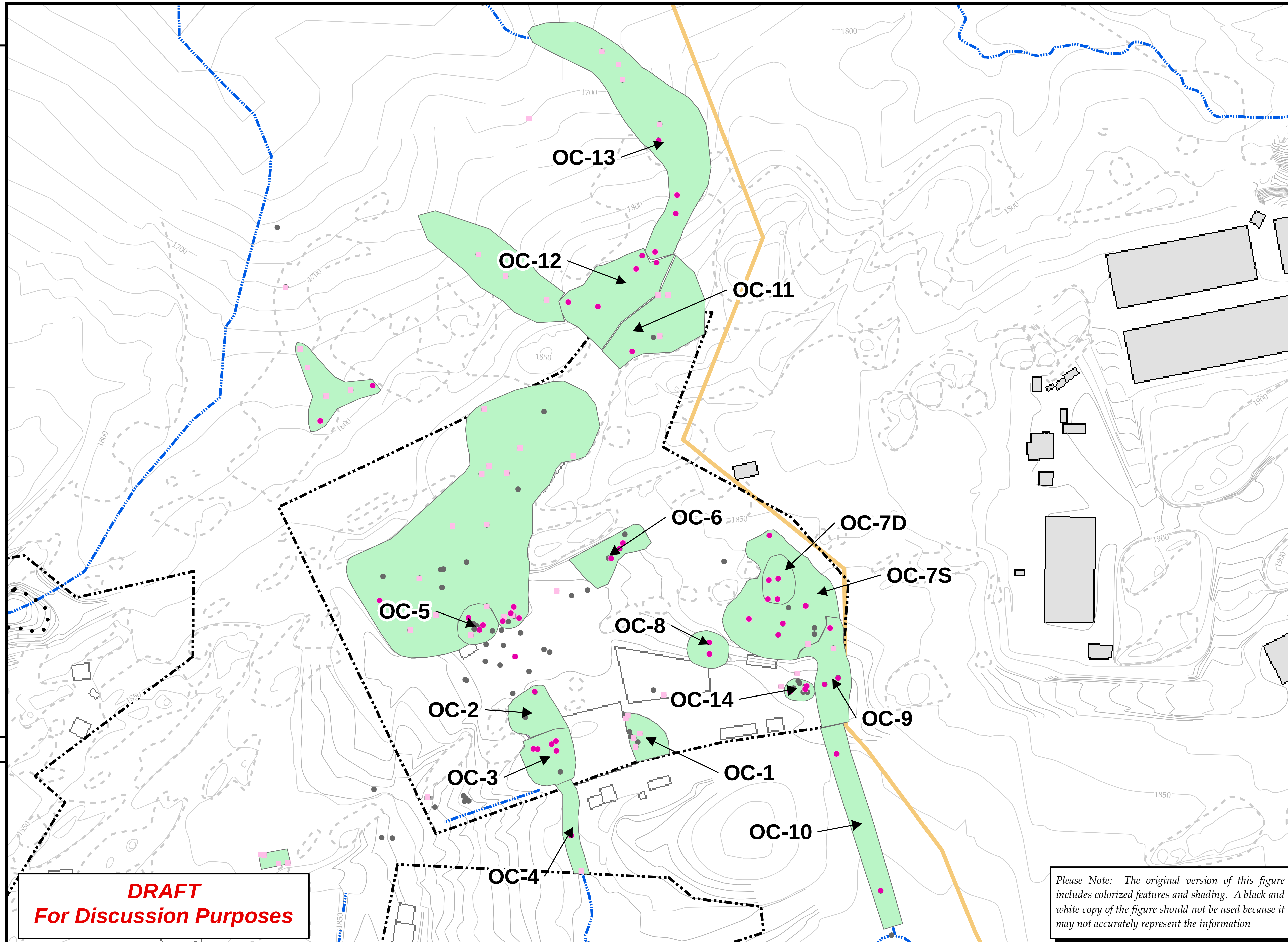
2) Estimated remediation areas rationale provided in Table A3-4.

3) Other samples include detects or non detects below Default SB990 RBSLs and sample results for chemicals not included in this evaluation.

Document: SiteSpecificGroup6.mxd   Date: Sept 12, 2008

1 inch = 150 feet

0 50 100 150 200 Feet



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S A N T A   S U S A N A   F I E L D   L A B O R A T O R Y

Figure A3-3

Coca RFI Site Default SB990 Alternative

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Report Group Boundary
- Existing Building
- Removed Building
- Ponds
- Drainage
- Bedrock Outcrop
- Elevation Contour

Default SB990 CMI Area

Sample Locations

- Detects above Default RBSLs
- Non Detects above Default RBSLs
- All other samples

Notes:
1) Default SB990 RBSLs based on default rural resident exposure pathways for ILCR = 1 x 10-6 and HI = 1.

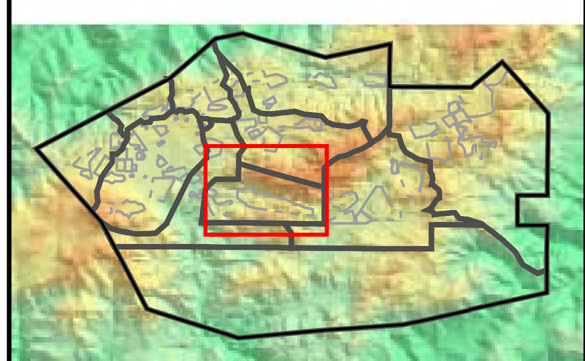
2) Estimated remediation areas rationale provided in Table A3-4.

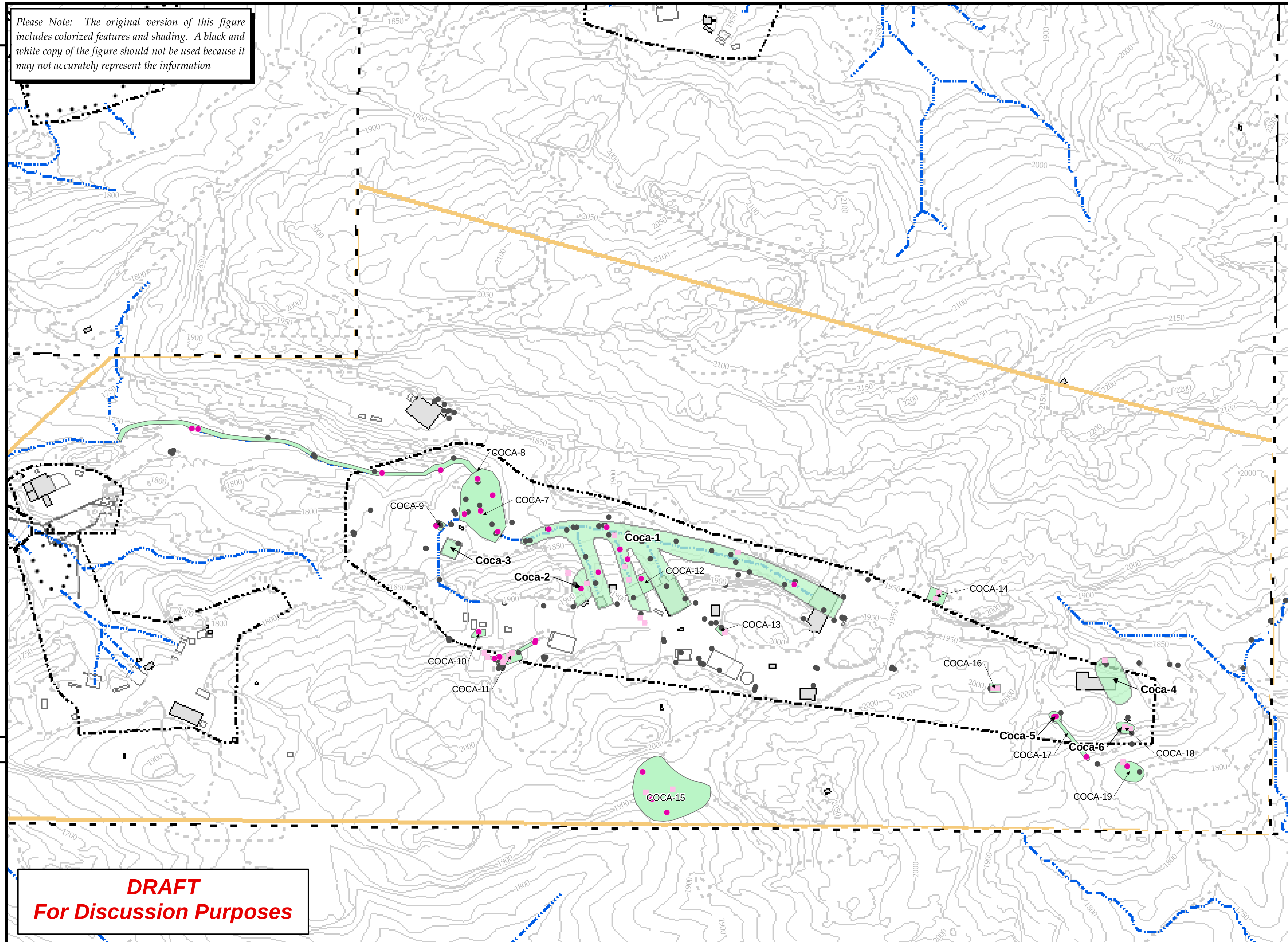
3) Other samples include detects or non detects below Default SB990 RBSLs and sample results for chemicals not included in this evaluation.

Document: DefaultGroup4.mxd | Date: Sep 10, 2008

1 inch = 300 feet

Feet: 0, 200, 400





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SANTA SUSANA FIELD LABORATORY

Figure A3-4

ATTACHMENT 4

SSFL SB990 ALTERNATIVE ASSUMPTION AND CALCULATION DETAILS

ATTACHMENT 4
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LIST OF ELECTRONIC ATTACHMENTS

File No.

File A4-1 RBSL Calculations

File A4-2 Risk Calculations

ATTACHMENT 4

SSFL SB990 ALTERNATIVE ASSUMPTION AND CALCULATION DETAILS

1 INTRODUCTION

This attachment presents the exposure assumptions and equations used to develop SSFL site-specific rural residential risk-based screening levels (RBSLs $_{RRs}$) for soil, assumptions and equations used to estimate human health risks using these RBSLs $_{RRs}$, and details associated with estimated remedial volumes for the SSFL site-specific SB990 alternative (herein called the SSFL SB990 Alternative).

In order to complete this SSFL SB990 Alternative evaluation in a timely manner, a short-list of chemicals was selected for inclusion in the evaluation. The included chemicals were selected because they are the major risk drivers and/or contributors identified in the Base Case for the four example RCRA Facility Investigation (RFI) sites (see Section 2 of the main text of this technical memorandum). These chemicals are also generally considered the primary chemical contaminants and potential risk drivers/contributors across the SSFL. The selected chemicals are listed in Tables A4-2 and A4-3 of this attachment.

2 EXPOSURE ASSUMPTIONS

2.1 CONCEPTUAL MODEL

A conceptual site model (CSM) for the SSFL potential future rural residential/agricultural pathway has been developed for the four example RFI sites based on field observations, SB990 requirements, and data collected to date during environmental programs at the SSFL. Potential soil-based exposure pathways were considered to determine if they might be "potentially complete" (exposure may occur if site conditions change) or "incomplete" (no exposure expected). Exposure pathways for other site media (i.e., groundwater, surface water, and sediment) are not included, as this evaluation focuses on comparing soil remediation alternatives. The CSM is shown on Figure A4-1. Onsite rural residents are considered potential future human receptors for this evaluation. Potentially complete exposure pathways for these receptors for the four example RFI sites include direct contact with soil, weathered bedrock, and air, as well as indirect exposure to chemicals in soil via uptake into fruits and vegetables, beef cattle, chickens, and eggs. Justification for the exposure pathway selections is provided below.

2.2 POTENTIAL EXPOSURE PATHWAYS FOR SOIL

The following pathways were considered for inclusion in the evaluation of potential future rural residential exposure to soil at the SSFL:

- Direct inhalation of vapors and particles
- Incidental ingestion of soil and weathered bedrock
- Ingestion of homegrown produce (i.e., fruits and vegetables)
- Ingestion of home-raised beef
- Ingestion of milk from home-raised cows
- Ingestion of home-raised poultry
- Ingestion of eggs from home-raised poultry
- Ingestion of home-raised swine
- Ingestion of pond-raised fish

Potential future rural residents may be exposed to chemicals in soil and weathered bedrock via direct contact pathways (ingestion and dermal exposures). These pathways are therefore considered potentially complete. Potential exposure to chemicals migrating from soil, soil vapor, or weathered bedrock to outdoor and/or indoor air is also considered a potentially complete pathway, but only for chemicals that meet the Department of Toxic Substance Control (DTSC) definition of a volatile chemical. Potential future rural residential exposure via inhalation of nonvolatile chemicals in fugitive dust is also considered a potentially complete pathway.

If rural residences are constructed at the SSFL in the future, it is possible that fruits and vegetables may be grown in impacted soil. Chemicals in soil may then be incorporated into edible plant tissues via root uptake, and rural residents could be exposed to these chemicals via consumption of produce. This is considered to be a potentially complete exposure pathway, although it is unlikely that weathered bedrock could support the types of vegetation typically grown and consumed by rural residents.

Potential future rural residents at the SSFL could also raise and consume beef cattle and free-range chickens (including eggs). Indirect exposure to soil through consumption of beef, chicken, and eggs is considered possible at the SSFL, and these pathways are considered to be potentially complete. Beef cattle could ingest soil while foraging on a grazing field, and could be exposed to soil contaminates incorporated into site pasture via root uptake. Free-range chickens could ingest soil while feeding, and could be exposed to site contaminants incorporated into site pasture via root uptake.

The typical residential soil pathways (dermal contact, ingestion and inhalation of soil vapors and particles, as well as indoor inhalation of vapors) plus the agricultural pathways of homegrown produce consumption, home-raised beef consumption, home-raised poultry consumption, and consumption of eggs from home-raised poultry mentioned above were included as SSFL site-specific rural residential pathways.

The home-produced milk, home-raised swine, and fish consumption pathways were not included in the SSFL site-specific rural residential pathways. The fish pathway was not included because this evaluation used soil media only for comparison purposes between sites. If required, the fish consumption pathway could be evaluated at the limited RFI sites which have perennial ponds large enough to sustain a fish population. USEPA (2005a) indicated that the ingestion of fish exposure pathway for the farmer exposure scenario is usually not recommended unless site-specific exposure setting characteristics such as the presence of ponds are identified. Consumption of home-raised milk and swine was not included in the SSFL SB990 Alternative because these pathways were not considered practical in conjunction with land use for beef cattle and poultry given site-specific topographic, bedrock, and forage constraints as described below.

Dairy cattle would either get their fodder from a large range or be contained within a yard or small field and fed supplemental feed, such as grain. If they are free-ranging over an area large enough to provide adequate fodder, then each morning the farmer would have to go out, find the cow, and bring it back to the barn for milking, which would not be practical. Milking of the cow would need to be done at least once daily to keep the cow lactating. If the cattle are corralled, then they would most likely be fed from purchased supplemental feed, and would have only very limited exposure to contaminants present in soil.

Growing supplemental feed (e.g., grain) at the SSFL would not be likely. Native vegetation communities at the SSFL are primarily comprised of scrub and other arid vegetation. In addition, large areas of many SSFL sites contain extensive bedrock outcrops, which would make growing grain impractical, if not impossible. In areas without extensive bedrock outcrops, land clearing and irrigation would be required to convert native scrub vegetation to agricultural land capable of producing grains.

Another consideration for not including the milk pathway is that the vegetation present at the SSFL sites would not support both dairy and beef cattle, and beef cattle were determined to be more likely at the SSFL. This is supported by nearby land use, which includes ranging cattle that are most likely being raised for beef consumption.

For swine to be fully exposed to contaminants in soil, they would need to be managed free-range. Given the natural wildlife present at SSFL and surrounding areas and the extensive bedrock outcrops present at many of the SSFL sites, the practice of raising free-ranging swine would not be successful. Consequently, swine would most likely be contained within a yard or small field and fed supplemental feed, such as grain. As discussed above, growing supplemental feed (e.g., grain) at the SSFL would not be likely. Because swine would have only very limited exposure to contaminants present in soil, this pathway was not included in the SSFL site-specific rural residential pathways during evaluation of the SSFL SB990 Alternative.

3 RBSL QUANTIFICATION

The SSFL Standardized Risk Assessment Methodology (SRAM) Residential RBSLs for ingestion of soil, dermal contact with soil, inhalation of dust, and inhalation of vapors from soil are provided in Table 2 of the main text of this Technical Memorandum. SSFL site-specific rural residential RBSLs for homegrown fruits and vegetables, beef, poultry, and eggs were calculated using risk assessment procedures and equations provided on the online RAIS PRG calculation tool (http://rais.ornl.gov/homepage/tm/for_ag.shtml). These equations are based on guidance in *Risk Assessment Guidance for Superfund: Volume 1, Human Health Evaluation Manual (Part A - Baseline Risk Assessment)* (RAGS, Part A; USEPA, 1989) and *Risk Assessment Guidance for Superfund: Volume 1, Human Health Evaluation Manual (Part B - Development of Risk-based Preliminary Remediation Goals)* (RAGS, Part B; USEPA, 1991). SSFL site-specific rural residential RBSLs were estimated separately for adults and children for both carcinogenic and non-carcinogenic effects using the equations presented in the following sections.

3.1 INGESTION OF FRUITS AND VEGETABLES

The site-specific rural residential soil RBSLs for the fruits and vegetables pathway were estimated using the following equations:

$$RBSL_{fv} = \frac{C_{fv}}{Bv_{wet} + MLF}$$; where

$$C_{fv} = \frac{T \times BW \times AT}{TV \times (IR_f + IR_v) \times CPF \times EF \times ED}$$

And where:

$RBSL_{fv}$ = site-specific rural residential Soil RBSL for fruits and vegetables pathway (mg/kg)

C_{fv} = target chemical concentration in fruits and vegetables (mg/kg)

Bv_{wet} = soil to plant uptake wet weight (kg/kg)

MLF = plant mass loading factor (unitless)

AT = averaging time (yr x day/yr)

BW = body weight (kg)

ED = exposure duration (yr)

EF = exposure frequency (day/yr)

CPF = contaminated plant fraction (unitless)

IRf = fruit ingestion rate (kg/day)

IRv = vegetable ingestion rate (kg/day)

T = target cancer risk of 1 x 10^{-6} or target hazard index of 1 (unitless)

TV = oral toxicity value (SFo or 1/RFDo)

where:

SFo = oral cancer slope factor $(mg/kg\text{-}day)^{-1}$

RfDo = oral chronic reference dose (mg/kg-day)

3.2 Ingestion of Beef

The site-specific rural residential soil RBSLs for the beef pathway were estimated using the following equations:

$$RBSL_b = \frac{C_b}{F_b \times [(Qp_b \times fp_b \times fs_b \times (Bv_{dry} + MLF_b)) + (Qs_b \times fp_b)]}\text{; where}$$

$$C_b = \frac{T \times BW \times AT}{TV \times IR_b \times FI_b \times EF \times ED}$$

And where:

$RBSL_b$ = site-specific rural residential Soil RBSL for beef pathway (mg/kg)

C_b = target chemical concentration in beef (mg/kg)

Bv_{dry} = soil to plant uptake dry weight (kg/kg)

fp_b = fraction of year animal is on site – beef cattle (unitless)

fs_b = fraction of animal's food is from site – beef cattle (unitless)

F_b = beef transfer coefficient (day/kg)

MLF_b = plant mass loading factor –beef pasture (unitless)

Qp_b = quantity of pasture ingested – beef cattle (kg/day)

Qs_b = quantity of soil ingested – beef cattle (kg/day)

AT = averaging time (yr x day/yr)

BW = body weight (kg)

ED = exposure duration (yr)

EF = exposure frequency (day/yr)

FI_b = fraction ingested (unitless)

IR_b = beef ingestion rate (kg/day)

T = target cancer risk of 1 x 10^{-6} or target hazard index of 1 (unitless)

TV = oral toxicity value (SFo or 1/RFDo)

where:

SFo = oral cancer slope factor $(mg/kg\text{-}day)^{-1}$

RfDo = oral chronic reference dose (mg/kg-day)

3.3 Ingestion of Poultry

The site-specific rural residential soil RBSLs for the poultry pathway were estimated using the following equations:

$$RBSL_p = \frac{C_p}{F_p \times \left[\left(Qp_p \times fp_p \times fs_p \times \left(Bv_{dry} + MLF_p\right)\right) + \left(Qs_p \times fp_p\right)\right]}$$; where

$$C_p = \frac{T \times BW \times AT}{TV \times IR_p \times FI_p \times EF \times ED}$$

And where:

$RBSL_p$	= site-specific rural residential Soil RBSL for poultry pathway (mg/kg)
C_p	= target chemical concentration in poultry (mg/kg)
Bv_{dry}	= soil to plant uptake dry weight (kg/kg)
fp_p	= fraction of year animal is on site – poultry (unitless)
fs_p	= fraction of animal's food is from site – poultry (unitless)
F_p	= poultry transfer coefficient (day/kg)
MLF_p	= plant mass loading factor – poultry pasture (unitless)
Qp_p	= quantity of fodder ingested – poultry (kg/day)
Qs_p	= quantity of soil ingested – poultry (kg/day)
AT	= averaging time (yr x day/yr)
BW	= body weight (kg)
ED	= exposure duration (yr)
EF	= exposure frequency (day/yr)
FI_p	= fraction ingested (unitless)
IR_p	= poultry ingestion rate (kg/day)
T	= target cancer risk of 1 x 10^{-6} or target hazard index of 1 (unitless)

TV = oral toxicity value (SFo or 1/RFDo)

where:

SFo = oral cancer slope factor $(mg/kg\text{-}day)^{-1}$

RfDo = oral chronic reference dose (mg/kg-day)

3.4 INGESTION OF EGGS

The site-specific rural residential soil RBSLs for the egg pathway were estimated using the following equations:

$$RBSL_e = \frac{C_e}{F_e \times \left[\left(Qp_p \times fp_p \times fs_p \times \left(Bv_{dry} + MLF_p\right)\right) + \left(Qs_p \times fp_p\right)\right]}\text{; where}$$

$$C_e = \frac{T \times BW \times AT}{TV \times IR_e \times FI_e \times EF \times ED}$$

And where:

$RBSL_e$ = site-specific rural residential Soil RBSL for egg pathway (mg/kg)

C_e = target chemical concentration in eggs (mg/kg)

Bv_{dry} = soil to plant uptake dry weight (kg/kg)

fp_p = fraction of year animal is on site – poultry (unitless)

fs_p = fraction of animal's food is from site – poultry (unitless)

F_e = egg transfer coefficient (day/kg)

MLF_p = plant mass loading factor – poultry pasture (unitless)

Qp_p = quantity of pasture ingested – poultry (kg/day)

Qs_p = quantity of soil ingested – poultry (kg/day)

AT = averaging time (yr x day/yr)

BW = body weight (kg)

ED = exposure duration (yr)

EF = exposure frequency (day/yr)

FI_e = fraction ingested (unitless)

IR_e = egg ingestion rate (kg/day)

T = target cancer risk of 1 x 10^{-6} or target hazard index of 1 (unitless)

TV = oral toxicity value (SFo or 1/RFDo)

where:

SFo = oral cancer slope factor $(mg/kg\text{-}day)^{-1}$

RfDo = oral chronic reference dose (mg/kg-day)

3.5 CUMULATIVE RBSL

The cumulative rural residential RBSLs for soil were estimated using the following equations:

$$SUM = \left(\frac{USC}{RBSL_{res}}\right) + \left(\frac{USC}{RBSL_{fv}}\right) + \left(\frac{USC}{RBSL_{b}}\right) + \left(\frac{USC}{RBSL_{p}}\right) + \left(\frac{USC}{RBSL_{e}}\right); \text{ and}$$

$$RBSL_{RRs} = \frac{USC}{SUM}$$

where:

$RBSL_{res}$ = SRAM residential soil RBSL (mg/kg)

$RBSL_{fv}$ = site-specific rural residential Soil RBSL for fruits and vegetables pathway (mg/kg)

$RBSL_b$ = site-specific rural residential Soil RBSL for beef pathway (mg/kg)

$RBSL_p$ = site-specific rural residential Soil RBSL for poultry pathway (mg/kg)

$RBSL_e$ = site-specific rural residential Soil RBSL for egg pathway (mg/kg)

SUM = sum of USC/pathway-specific RBSLs

USC = unit soil concentration (mg/kg)

$RBSL_{RRs}$ = SSFL site-specific cumulative rural residential RBSL (mg/kg)

The exposure parameters and rationale for the SSFL site-specific rural residential pathway are presented in Table A4-1. Chemical-specific parameters are presented in Table A4-2.

Toxicity values for the RBSL calculations were obtained from the following hierarchy of sources, as specified in the SRAM (MWH, 2005):

1. OEHHA (http://www.oehha.ca.gov/risk/chemicalDB/index.asp)
2. Integrated Risk Information System (IRIS; USEPA 2005a)
3. Health Effects Assessment Summary Table (HEAST; USEPA 1997c)
4. USEPA criteria documents
5. Agency for Toxic Substances and Disease Registry (ATSDR) toxicological profiles
6. Environmental Criteria and Assessment Office (ECAO)
7. Other sources

The toxicity values used in the RBSL calculations are presented in Table A4-3.

4 RISK QUANTIFICATION

Risks were calculated using a sum-of-fractions methodology. This sum-of-fractions approach provides good estimates of total RFI site risks. A comparison of total risks using this approach to the risks published in the RFI reports was completed and were found to be in good agreement between the two. Based on this comparison, it was concluded that this expedited approach was appropriate to use in the evaluation of the SSFL SB990 Alternative.

The following equations were used to estimate risks for each chemical using the sum-of-fractions approach:

$$ILCR = \frac{EPC}{RBSL_{RRs}} \times 10^{-6}; \text{ and}$$

$$HQ = \frac{EPC}{RBSL_{RRs}}$$

where:

ILCR = Incremental lifetime cancer risk

HI = Hazard quotient

EPC = Arithmetic mean exposure point concentration (mg/kg)

$RBSL_{RRs}$ = SSFL site-specific cumulative rural residential RBSL (mg/kg)

The EPCs used in these equations were based on arithmetic mean concentrations of chemicals in soil. The arithmetic mean concentrations were calculated in the RFI Report Risk Appendix for each of the four example sites and are provided in the risk calculation files (File A4-2). Arithmetic mean concentrations are considered appropriate for use in this evaluation because, in general, the EPCs estimated for the site are biased high due to judgmental sampling methods used in RFI data collection.

5 ESTIMATED REMEDIATION EVALUATION

The process for estimating remediation areas and volumes associated with the SSFL SB990 Alternative is described in Section 4.0 of this Technical Memorandum. This attachment provides details regarding site-specific application of the process described in the main body of this document.

Table A4-4 summarizes the remedial estimate changes from Base Case when estimated SSFL SB990 Alternative risks were evaluated spatially for the four example RFI sites. Rationale for changes in or additions to the Base Case remedial areas / volumes are described in these tables. Figures A4-2 through A4-4 depict the extent of estimated remediation areas (called CMI Areas) for the SSFL site-specific SB990 Alternative; Base Case estimated remediation areas are shown in figures included in Attachment 2 for reference. Included on these figures are the sampling data screened against the SB990 Alternative $RBSLs_{RRs}$, with results exceeding $RBSLs_{RRs}$ shown in red. The data sets used for this analysis for each site are provided in Attachment 5.

6 REFERENCES

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Table A4-1

Exposure Parameters and Rationale for SSFL Site-Specific Rural Residential Risk-Based Screening Level Calculations

Parameter	Units	Rural Residential Receptor		Rationale
		Adult	Child	
General				
CS = soil/sediment/dust concentration	mg/kg	site-specific	site-specific	site-specific
BW = body weight	kg	70	15	(a)
ED = exposure duration	years	24	6	(a)
EF = exposure frequency	days/year	350	350	(a)
ATc = averaging time for carcinogens	year x days/year	25550	25550	= 70 * 365
ATn = averaging time for non-carcinogens	year x days/year	8760	2190	= ED * 365
Ingestion of Fruits and Vegetables				
CPF = contaminated plant fraction	unitless	0.25	0.25	(a)
IR_f = fruit ingestion rate	kg/day	0.0562	0.0148	(a)
IR_v = vegetable ingestion rate	kg/day	0.0285	0.0104	(a)
MLF = plant mass-loading factor	unitless	0.26	0.26	(a)
Ingestion of Beef				
fp_b = fraction of year animal is on site - beef cattle	unitless	1	1	(a)
fs_b = fraction of animal's food is on site - beef cattle	unitless	GUF*Site acreage	GUF*Site acreage	limited forage on-site (b)
FI_b = ingestion fraction - beef	unitless	1	1	(a)
IR_b = beef ingestion rate	kg/day	0.077	0.0072	default value adjusted for cooking and preparation losses (c)
MLF_b = plant mass-loading factor - beef pasture	unitless	0.25	0.25	(a)
Qp_b = quantity of pasture ingested - beef cattle	kg/day	11.77	11.77	(a)
Qs_b = quantity of soil ingested - beef cattle	kg/day	0.39	0.39	(a)
Ingestion of Poultry				
fp_p = fraction of year animal is on site - poultry	unitless	1	1	(a)
fs_p = fraction of animal's food is on site - poultry	unitless	0.05	0.05	limited calories obtained from on-site pasture (e)
FI_p = ingestion fraction - poultry	unitless	1	1	(a)
IR_p = poultry ingestion rate	kg/day	0.046	0.0064	default value adjusted for cooking and preparation losses (c)
MLF_p = plant mass-loading factor - poultry pasture	unitless	0.25	0.25	(a)
Qp_p = quantity of pasture ingested - poultry	kg/day	0.2	0.2	(d)
Qs_p = quantity of soil ingested - poultry	kg/day	0.022	0.022	(d)

Table A4-1

Exposure Parameters and Rationale for SSFL Site-Specific Rural Residential Risk-Based Screening Level Calculations

Parameter	Units	Rural Residential Receptor		Rationale
		Adult	**Child**	
Ingestion of Eggs				
FI_e = ingestion fraction - eggs	unitless	1	1	(a)
IR_e = egg ingestion rate	kg/day	0.041	0.0063	(d)

Notes:

kg - kilogram(s)

mg - milligram(s)

NA - not applicable

(a) Online RAIS (http://rais.ornl.gov/cgi-bin/prg/PRG_search) default parameter.

(b) For annual grassland or oak woodland, a grazing permit would require approximately 3 – 6 acres of land per cow per month, or 36 – 72 acres of land per cow per year (Source: Karen Doran, Bureau of Land Management, 2008). In land dominated by scrub or rough terrain, which is typical at the SSFL, the amount of land required for grazing may increase to 120 – 240 acres per cow per year. The fraction of animal's food on site assumes a minimum land requirement of 120 acres of land per cow per year as a protective estimate of a cow's forage requirement. On a per acre basis, this results in a grazing utilization factor (GUF) of 1 divided by 120 (or 0.0083). The GUF can be multiplied by the total acreage comprising an RFI site to derive the fraction of forage a cow obtains from the site.

(c) The default ingestion rates were adjusted for cooking and post-cooking losses of 27% and 24%, respectively, for beef and 32% and 31%, respectively, for chicken (see Table 13-5 of USEPA, 1997).

(d) EPA Online PRG calculator for radionuclides (http://epa-prgs.ornl.gov/cgi-bin/radionuclides/rprg_search) default parameter.

(e) Free-range chickens can obtain up to 5 – 20% of their calories from ideal pasture, which has abundant clover, weed seeds, and insects (Source: Jean Nick, American Pastured Poultry Producers Association, 2008). Therefore, supplemental feed would be required. Native vegetation communities at the SSFL are primarily comprised of scrub and other arid vegetation which provides limited caloric value. In addition, large areas of many SSFL sites contain extensive bedrock outcrops. Therefore, in order for chickens to obtain even the lower percentage of their calories from pasture (i.e., 5%) , the land would have to be cleared, irrigated, and converted from native vegetation to non-native, annual grassland. However, for a conservative evaluation, chickens were assumed to obtain 5% of their calories from pasture at the site. It would be unlikely for supplemental feed to be grown on site because the specialized equipment and amount of land required would make it cost-prohibitive. Most, if not all, poultry

Table A4-2

Chemical-Specific Parameters Used in SSFL Site-Specific Rural Residential Risk-Based Screening Level Calculations

Analyte	Log of [a] Octanol-Water Partition Coefficient log(Kow)	Soil to Plant [b] Uptake Wet Weight Bv_{wet} (kg/kg)	Soil to Plant [b] Uptake Dry Weight Bv_{dry} (kg/kg)	Beef [b] Transfer Coefficient F_b (day/kg)	Poultry [a] Transfer Coefficient F_p (day/kg)	Egg [a] Transfer Coefficient F_e (day/kg)
Inorganic Compounds						
Aluminum	NA	1.0E-03	4.0E-03	1.5E-03	na	na
Antimony	NA	1.0E-02	5.0E-02	4.0E-05	na	na
Arsenic	NA	1.0E-02	4.0E-02	2.0E-03	na	na
Cadmium	NA	1.4E-01	5.5E-01	4.0E-04	1.1E-01	2.5E-03
Lead	NA	7.6E-04	9.0E-02	4.0E-04	na	na
Mercury	NA	3.0E-01	1.0E+00	1.0E-02	na	na
Perchlorate	NA	na	na	na	na	na
Selenium	NA	1.0E-01	5.0E-01	1.0E-01	1.1E+00	1.1E+00
Thallium	NA	1.0E-03	4.0E-03	4.0E-02	na	na
Zinc	NA	2.6E-01	9.9E-01	1.0E-01	8.8E-03	8.8E-03
Volatile Organic Compounds						
1,1-Dichloroethene	NA	7.0E-01	3.4E+00	1.6E-06	2.5E-03	1.4E-03
Benzene	NA	4.7E-01	2.3E+00	3.1E-06	2.5E-03	1.4E-03
cis-1,2-Dichloroethene	NA	6.1E-01	3.0E+00	2.0E-06	1.8E-03	1.0E-03
Methylene chloride	NA	1.4E+00	6.7E+00	5.0E-07	6.5E-04	3.7E-04
Tetrachloroethene	NA	2.4E-01	1.2E+00	1.0E-05	1.2E-02	6.9E-03
Trichloroethene	NA	3.1E-01	1.5E+00	6.3E-06	3.8E-03	2.2E-03
Vinyl Chloride	NA	1.2E+00	5.9E+00	6.3E-07	7.8E-04	4.4E-04
Semi-Volatile Organic Compounds						
Benzo(a)anthracene	NA	3.8E-03	1.9E-02	1.3E-02	2.9E-02	1.7E-02
Benzo(a)pyrene	NA	2.2E-03	1.1E-02	3.1E-02	2.8E-02	1.6E-02
Benzo(b)fluoranthene	NA	2.2E-03	1.1E-02	3.1E-02	2.7E-02	1.5E-02
Benzo(k)fluoranthene	NA	8.8E-04	4.3E-03	1.6E-01	2.7E-02	1.5E-02
Dibenz(a,h)anthracene	NA	8.8E-04	4.3E-03	1.6E-01	2.3E-02	1.3E-02
Phenanthrene	NA	1.7E-02	8.2E-02	1.0E-03	2.5E-02	1.4E-02
PCDD/PCDFs						
2,3,7,8-TCDD	NA	8.8E-04	4.3E-03	1.6E-01	1.9E-02	1.1E-02
1,2,3,7,8-PeCDD	NA	1.3E-03	6.5E-03	7.9E-02	2.1E-02	1.2E-02
1,2,3,4,7,8-HxCDD	7.8E+00	2.3E-04 [c]	1.1E-03 [d]	1.6E+00 [e]	8.1E-03	4.6E-03
1,2,3,6,7,8-HxCDD	7.3E+00	4.5E-04 [c]	2.2E-03 [d]	5.0E-01 [e]	1.3E-02	7.6E-03
1,2,3,7,8,9-HxCDD	7.3E+00	4.5E-04 [c]	2.2E-03 [d]	5.0E-01 [e]	1.3E-02	7.6E-03
1,2,3,4,6,7,8-HpCDD	8.0E+00	1.8E-04 [c]	8.7E-04 [d]	2.5E+00 [e]	6.5E-03	3.7E-03
OCDD	NA	6.2E-05	3.1E-04	1.5E+01	5.1E-03	2.9E-03
2,3,7,8-TCDF	NA	3.2E-03	1.6E-02	1.7E-02	2.7E-02	1.5E-02
1,2,3,7,8-PeCDF	NA	8.9E-04	4.4E-03	1.5E-01	1.9E-02	1.1E-02
2,3,4,7,8-PeCDF	NA	7.5E-04	3.7E-03	2.1E-01	2.3E-02	1.3E-02
1,2,3,4,7,8-HxCDF	7.0E+00	6.7E-04 [c]	3.3E-03 [d]	2.5E-01 [e]	1.7E-02	9.6E-03
1,2,3,6,7,8-HxCDF	7.0E+00	6.7E-04 [c]	3.3E-03 [d]	2.5E-01 [e]	1.7E-02	9.6E-03
2,3,4,6,7,8-HxCDF	7.0E+00	6.7E-04 [c]	3.3E-03 [d]	2.5E-01 [e]	1.7E-02	9.6E-03
1,2,3,7,8,9-HxCDF	7.0E+00	6.7E-04 [c]	3.3E-03 [d]	2.5E-01 [e]	1.7E-02	9.6E-03
1,2,3,4,6,7,8-HpCDF	7.4E+00	3.9E-04 [c]	1.9E-03 [d]	6.3E-01 [e]	1.2E-02	6.9E-03
1,2,3,4,7,8,9-HpCDF	7.4E+00	3.9E-04 [c]	1.9E-03 [d]	6.3E-01 [e]	1.2E-02	6.9E-03
OCDF	NA	7.9E-05	3.9E-04	1.0E+01	6.5E-03	3.7E-03

Table A4-2

Chemical-Specific Parameters Used in SSFL Site-Specific Rural Residential Risk-Based Screening Level Calculations

Analyte	Log of [a] Octanol-Water Partition Coefficient log(Kow)	Soil to Plant [b] Uptake Wet Weight Bv_{wet} (kg/kg)	Soil to Plant [b] Uptake Dry Weight Bv_{dry} (kg/kg)	Beef [b] Transfer Coefficient F_b (day/kg)	Poultry [a] Transfer Coefficient F_p (day/kg)	Egg [a] Transfer Coefficient F_e (day/kg)
Polychlorinated Biphenyls (PCBs)						
Aroclor-1248	NA	3.3E-03	1.6E-02	1.6E-02	2.5E-02	1.4E-02
Aroclor-1254	NA	2.5E-03	1.3E-02	2.5E-02	2.3E-02	1.3E-02
Aroclor-1260	NA	5.9E-04	2.9E-03	3.1E-01	5.1E-03	2.9E-03

Notes:
NA - not applicable in the calculations of rural residential human health risks
na - not available

[a] Unless otherwise noted, values are obtained from Human Health Risk Assessment Protocol Companion Database, 2005.
[b] Unless otherwise noted, values are obtained from online RAIS (http://rais.ornl.gov/cgi-bin/tox/TOX_select?select=csf) chemical-
[c] Calculated using equation ($7.7*Kow^{-0.58}$): McKone, T. E. 1994. Uncertainty and variability in human exposures to soil contaminants through home-grown food: a Monte Carlo assessment. Risk Anal. 14(4):449-463.
[d] Calculated using equation ($38*Kow^{-0.58}$): McKone, T. E. 1994. Uncertainty and variability in human exposures to soil contaminants through home-grown food: a Monte Carlo assessment. Risk Anal. 14(4):449-463.
[e] Calculated using equation ($2.5*10^{-8}*Kow$): McKone, T. E. 1994. Uncertainty and variability in human exposures to soil contaminants through home-grown food: a Monte Carlo assessment. Risk Anal. 14(4):449-463.

Table A4-3

Toxicity Values Used in Rural Residential Risk-Based Screening Level Calculations

	Cancer Slope Factor - CSF (mg/kg-d)$^{-1}$						Reference Dose - RfD (mg/kg-d)					
Analyte	**Oral**		**Dermal**		**Inhalation**		**Oral**		**Dermal**		**Inhalation**	
Inorganic Compounds												
Aluminum	NTV		NTV		NTV		1.0E+00	P	1.0E+00	R	1.4E-03	P
Antimony	NTV		NTV		NTV		4.0E-04	I	4.0E-04	R	NTV	
Arsenic	9.5E+00	C	9.5E+00	R	1.2E+01	C	3.0E-04	I	3.0E-04	R	8.6E-06	C
Cadmium	NTV		NTV		NTV		1.0E-03	I	1.0E-03	R	5.7E-06	C
Lead	NTV		NTV		NTV		NTV		NTV		NTV	
Mercury [a]	NTV		NTV		NTV		3.0E-04	I	3.0E-04	R	2.6E-05	C
Perchlorate	NTV		NTV		NTV		1.2E-04	C	1.2E-04	R	1.2E-04	C
Selenium	NTV		NTV		NTV		5.0E-03	I	5.0E-03	R	5.7E-03	C
Thallium	NTV		NTV		NTV		8.0E-05	I	8.0E-05	R	NTV	
VOCs												
1,1-Dichloroethene	NTV		NTV		NTV		5.0E-02	I	5.0E-02	R	2.0E-02	C
Benzene	1.0E-01	C	1.0E-01	R	1.0E-01	C	4.0E-03	I	4.0E-03	R	8.6E-03	I
Methylene chloride	1.4E-02	C	1.4E-02	R	3.5E-03	C	6.0E-02	I	6.0E-02	R	1.1E-01	C
Tetrachloroethene	5.4E-01	C	5.4E-01	R	2.1E-02	C	1.0E-02	I	1.0E-02	R	1.0E-02	C
Trichloroethene	1.3E-02	C	1.3E-02	R	7.0E-03	C	3.0E-04	I	3.0E-04	R	1.7E-01	C
SVOCs												
Benzo(a)anthracene	1.2E+00	C	1.2E+00	R	3.9E-01	C	NTV		NTV		NTV	
Benzo(a)pyrene	1.2E+01	C	1.2E+01	R	3.9E+00	C	NTV		NTV		NTV	
Benzo(b)fluoranthene	1.2E+00	C	1.2E+00	R	3.9E-01	C	NTV		NTV		NTV	
Benzo(k)fluoranthene	1.2E+00	C	1.2E+00	R	3.9E-01	C	NTV		NTV		NTV	
Dibenz(a,h)anthracene	4.1E+00	C	4.1E+00	R	4.1E+00	C	NTV		NTV		NTV	
PCDD/PCDFs [b]												
2,3,7,8-TCDD	1.3E+05	C	1.3E+05	R	1.3E+05	C	NTV		NTV		NTV	
1,2,3,7,8-PeCDD	1.3E+05	C	1.3E+05	R	1.3E+05	C	NTV		NTV		NTV	
1,2,3,4,7,8-HxCDD	1.3E+04	C	1.3E+04	R	1.3E+04	C	NTV		NTV		NTV	
1,2,3,6,7,8-HxCDD	1.3E+04	C	1.3E+04	R	1.3E+04	C	NTV		NTV		NTV	
1,2,3,7,8,9-HxCDD	1.3E+04	C	1.3E+04	R	1.3E+04	C	NTV		NTV		NTV	
1,2,3,4,6,7,8-HpCDD	1.3E+03	C	1.3E+03	R	1.3E+03	C	NTV		NTV		NTV	
OCDD	3.9E+01	C	3.9E+01	R	3.9E+01	C	NTV		NTV		NTV	
2,3,7,8-TCDF	1.3E+04	C	1.3E+04	R	1.3E+04	C	NTV		NTV		NTV	
1,2,3,7,8-PeCDF	3.9E+03	C	3.9E+03	R	3.9E+03	C	NTV		NTV		NTV	
2,3,4,7,8-PeCDF	3.9E+04	C	3.9E+04	R	3.9E+04	C	NTV		NTV		NTV	
1,2,3,4,7,8-HxCDF	1.3E+04	C	1.3E+04	R	1.3E+04	C	NTV		NTV		NTV	
1,2,3,6,7,8-HxCDF	1.3E+04	C	1.3E+04	R	1.3E+04	C	NTV		NTV		NTV	
2,3,4,6,7,8-HxCDF	1.3E+04	C	1.3E+04	R	1.3E+04	C	NTV		NTV		NTV	
1,2,3,7,8,9-HxCDF	1.3E+04	C	1.3E+04	R	1.3E+04	C	NTV		NTV		NTV	
1,2,3,4,6,7,8-HpCDF	1.3E+03	C	1.3E+03	R	1.3E+03	C	NTV		NTV		NTV	
1,2,3,4,7,8,9-HpCDF	1.3E+03	C	1.3E+03	R	1.3E+03	C	NTV		NTV		NTV	
OCDF	3.9E+01	C	3.9E+01	R	3.9E+01	C	NTV		NTV		NTV	
PCBs												
Aroclor-1248	2.0E+00	I	2.0E+00	R	2.0E+00	I	NTV		NTV		NTV	
Aroclor-1254	2.0E+00	I	2.0E+00	R	2.0E+00	I	2.0E-05	I	2.0E-05	R	2.0E-05	R
Aroclor-1260	2.0E+00	I	2.0E+00	R	2.0E+00	I	NTV		NTV		NTV	

Note:
CSF - Cancer slope factor
mg/kg-d - Milligram per kilogram per day
RfD - Reference dose
NTV - no toxicity value
WHO TEF = World Health Organization Toxicity Equivalency Factor

[a] Mercuric chloride used as a surrogate.

[b] Toxicity values are based on Cal-EPA's 2,3,7,8-TCDD toxicity values and 2005 WHO TEFs.

Source Data:
C California EPA (Cal-EPA)
I Integrated Risk Information System (IRIS) Database (USEPA)
P Provisional Peer Reviewed Toxicity Values (PPRTV)
R Route extrapolation

Table A4-4. Comparison of Base Case and SSFL SB990 Alternative Remedial Estimates

Description	Base Case Estimates	SSFL SB990 Alternative Estimates				Basis for Potential Additional Cleanup
	CMI Volume (cubic yds)	CMI NAME	AREA (Sq. Ft)	Depth (ft)	Volume (cubic Yds)	
Old Conservation Yard RFI Site						
Rocketdyne Cons Yard	401	OC-1	3,605	3	401	--
SRE Pond Discharge Pipeline	565	OC-2	3,815	4	565	Limited exceedence of RBSLs by two dioxin congeners; expansion not warrented
OCY Low Spot	**491**	**OC-3**	**4,793**	**4**	**710**	**CMI area widened for detected dioxins and PAHs; extent based on topography and concentrations relative to RBSLs (less than for default case)**
Asphalt Drainage South of Low Spot	**232**	**OC-4**	**2,722**	**3**	**302**	**CMI area widened approximately 5 feet for detected chemicals upstream at OCY Low Spot (limited sampling in drainage (assumed slightly wider impacts in drainage)**
Transformer (central)	**594**	**OC-5**	**3,128**	**6**	**695**	**CMI area expanded for detected PCBs near source based on lower RBSLs; area extended 5 to 8 feet on east side (highest concentrations).**
AI Conservation Yard	604	OC-6	5,436	3	604	--
OCY N/S Debris Areas (deep)	703	OC-7D	3,163	6	703	--
OCY N/S Debris Areas (sfc.)	**1,006**	**OC-7S**	**16,579**	**2**	**1,228**	**CMI area expanded to west, south & east for detected thallium and dioxins; extent based on topography, concentrations, bedrock and debris extent (less than for default case based on concentration/RBSL ratio**
Telephone Pole Storage Area	**193**	**OC-8**	**2,329**	**3**	**259**	**CMI area expanded for detected Dioxins based on lower RBSLs (assumed cleanup to RBSL; less than Default case**
Soil Downslope of N/S Debris Area	**433**	**OC-9**	**6,605**	**2**	**489**	**CMI area expanded for detected Dioxins and thallium DLs based on lower RBSLs (assumed cleanup to RBSL; less than Default case)**
Southeast Drainage	**872**	**OC-10**	**9,191**	**3**	**1,021**	**CMI area widened approximately 5 feet for detected Dioxins based on lower RBSLs (assumed cleanup to RBSL, less than Default case)**
North Storage Area	**431**	**OC-11**	**4,626**	**3**	**514**	**CMI area extended for PAH DLs and lower RBSLs; samall extent based on DL relative to RBSL, historical storage and bedrock**
North Storage - Downslope	1,517	OC-12	13,654	3	1,517	--
North Storage - Downslope drainage	--	OC-12B	--	--	--	No RBSLs exceeded down drainage
North Slope Debris Area "A"	1,779	OC-13	24,011	2	1,779	--
Transformer (southeast)	**93**	**OC-14**	**921**	**3**	**102**	**CMI area expanded slightly to east for detected PCBs near source based on lower RBSLs;**
North Slope Debris Area "B"	--	OC-15	--	--	--	Ratio of PCB DLs to RBSLs do not warrant removal (lower than Default) since no identified source
Transformer (west)	--	OC-16	--	--	--	No RBSLs exceeded for SSFL SB990
Tank Area Soils	--	OC-17	--	--	--	Most PAH DLs < RBSLs
	9,912				**10,889**	**Estimated Volume**
Coca Area RFI Site						
Spilways and test stands	21,860	Coca-1	98,368	6	21,860	-----------
Lubricant Oil Area	181	Coca-2	4,894	1	181	-----------
Bulk Test Facility	287	Coca-3	2,579	3	287	-----------
Hydrogen Compressor Area Buildings	1,213	Coca-4	10,914	3	1,213	-----------
Hydrogen Compressor Bleed-off Valve Area	70	Coca-5	944	2	70	-----------
Hydrogen Compressor Building 933 Discharge Area	69	Coca-6	928	2	69	PCB DLs < RBSLs
Coca Skim Pond	**--**	**Coca-7**	**23,744**	**6**	**5,276**	**Area added based on detected dioxins and lower RBSLs; extent based on pond size**
Drainage below Coca Skim Pond	--	Coca-8	--	--	--	Dioxins < RBSLs
Transformer area west of Coca Skim Pond	--	Coca-9	--	--	--	Area not included in CMI; PCBs < SSFL SB990 RBSLs
Pump Shed Area	**--**	**Coca-10**	**77**	**2**	**6**	**Area added for PCBs up to 240 µg/kg, slightly above RBSL; limited extent based on slight exceedance.**
B222 Leach Field & Transformer	--	Coca-11	--	--	--	Area not included in CMI; PCBs and PAHs below RBSLs; DLs > RBSLs (shown on map) not driver evaluated.
Soil between Coca 2 and Coca 3 Test Stands	--	Coca-12	--	--	--	PCB DLs < RBSLs
Transformer area south of B240	--	Coca-13	--	--	--	PCB DLs < RBSLs
Transformer area east of B919	--	Coca-14	--	--	--	PCB DLs < RBSLs
Debris Area (south of Building 234)	--	Coca-15	--	--	--	All chemicals < RBSLs
V99 Bleed-off Valves Vent Stack (oil spray)	--	Coca-16	--	--	--	PCB DLs < RBSLs
V99 Bleed-off Valves pipeline oil stained soil locations	--	Coca-17	--	--	--	PCBs < RBSLs
Debris Area south of Hydrogen Compressor Area	--	Coca-19	--	--	--	PCB DLs < RBSLs
	23,679				**28,961**	**Estimated Volume**
FSDF RFI Site						
Concrete Pool Area/Southern FSDF	1,065	FSDF-1	4,794	6	1065	
Drainage/Drum Debris Area	928	FSDF-2	12,521	2	928	
FSDF Pistol Range	133	FSDF-3	1,793	2	133	
NE Rim of Former IM Excavation (upper portion)	--	FSDF-4	--	--	--	
NW Rim of Former IM Excavation (upper portion)	--	FSDF-5	--	--	--	Overall non cancer hazard acceptable; area not added for exceedences of RBSLs
East Rim of Former IM Channel B Excavation	--	FSDF-6	--	--	--	
FSDF Channel A	--	FSDF-A	--	--	--	
FSDF Channel B	--	FSDF-B	--	--	--	
FSDF Channel C	--	FSDF-C	--	--	--	
	2,126				**2,126**	**Estimated Volume**
ESADA RFI Site						
ESADA Former Storage Yard	1,231	ESADA-1	11,076	3	1,231	Overall cancer risk acceptable; area not added for few exceedences of RBSLs
	1,231				**1,231**	**Estimated Volume**

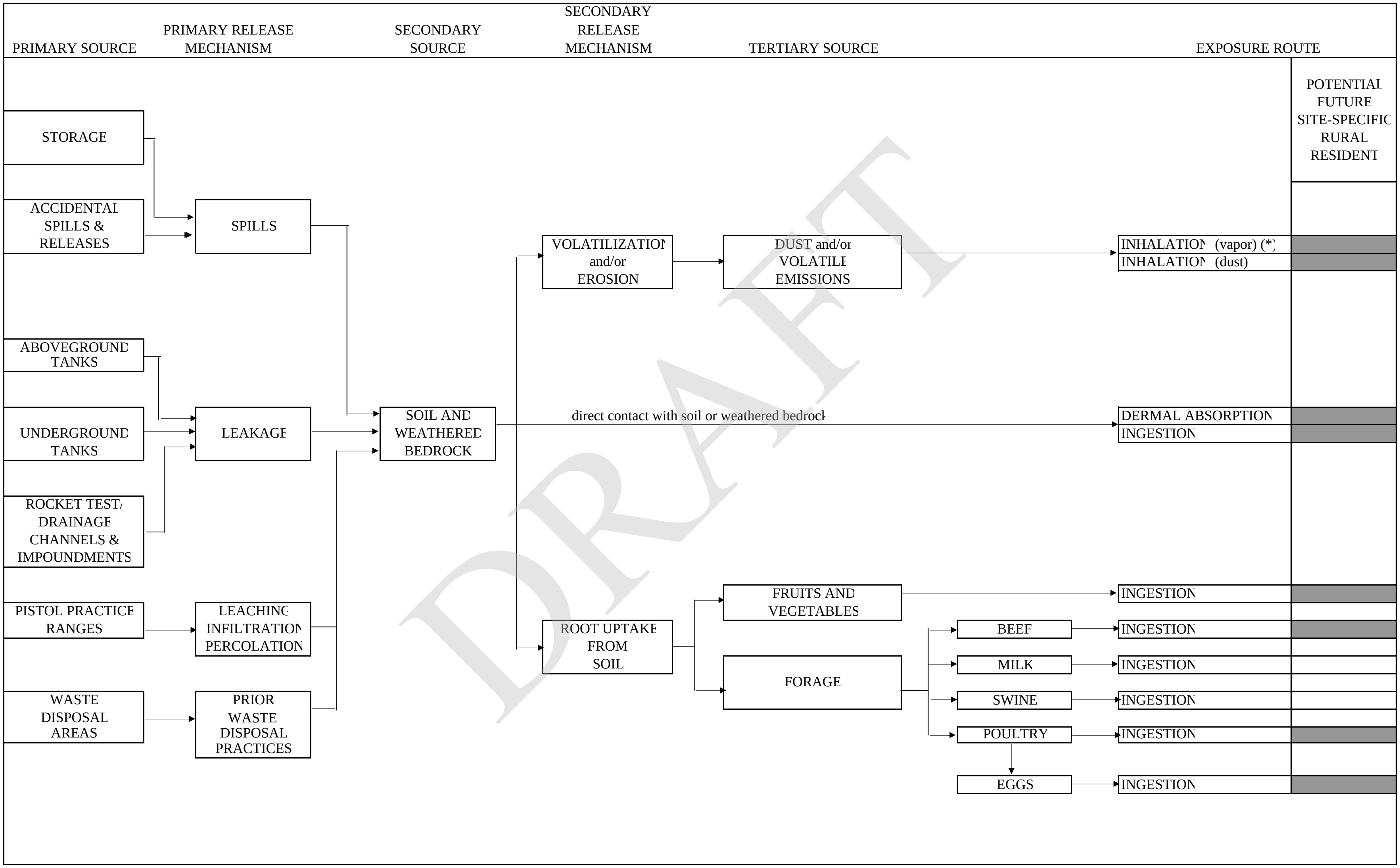
Notes:

Indicates new CMI Added

Bold font indicates change in CMI volume

Figure A4-1

SSFL-Specifc Rural Residential Human Health Risk Assessment Conceptual Site Model for Soil and Weathered Bedrock
Santa Susana Field Laboratory (SSFL)



NOTES:

(*) Exposure limited to volatile compounds as defined in the text; residential receptors include both indoor and outdoor air exposure to volatiles.

[shaded box] - potentially complete exposure pathways evaluated in this risk assessment

[white box] - incomplete exposure pathways not evaluated in this risk assessment

SSFL SB990 Alternative, FSDF and ESADA RFI Sites

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Report Group Boundary
- Existing Building
- Removed Building
- Ponds
- Drainage
- Bedrock Outcrop
- Elevation Contour
- Interim Measure (IM) Excavation

SSFL SB990 CMI Area

Sample Locations

- Detects above SSFL SB990 RBSLs
- Non Detects above SSFL SB990 RBSLs
- All other samples

Notes:

1) SSFL SB990 RBSLs based on site-specific rural resident exposure pathways for ILCR = 1 x 10-4 and HI = 1.

2) Estimated remediation areas rationale provided in Table A4-4.

3) Other samples include detects or non detects below SSFL B990 RBSLs and sample results for chemicals not included in this evaluation.

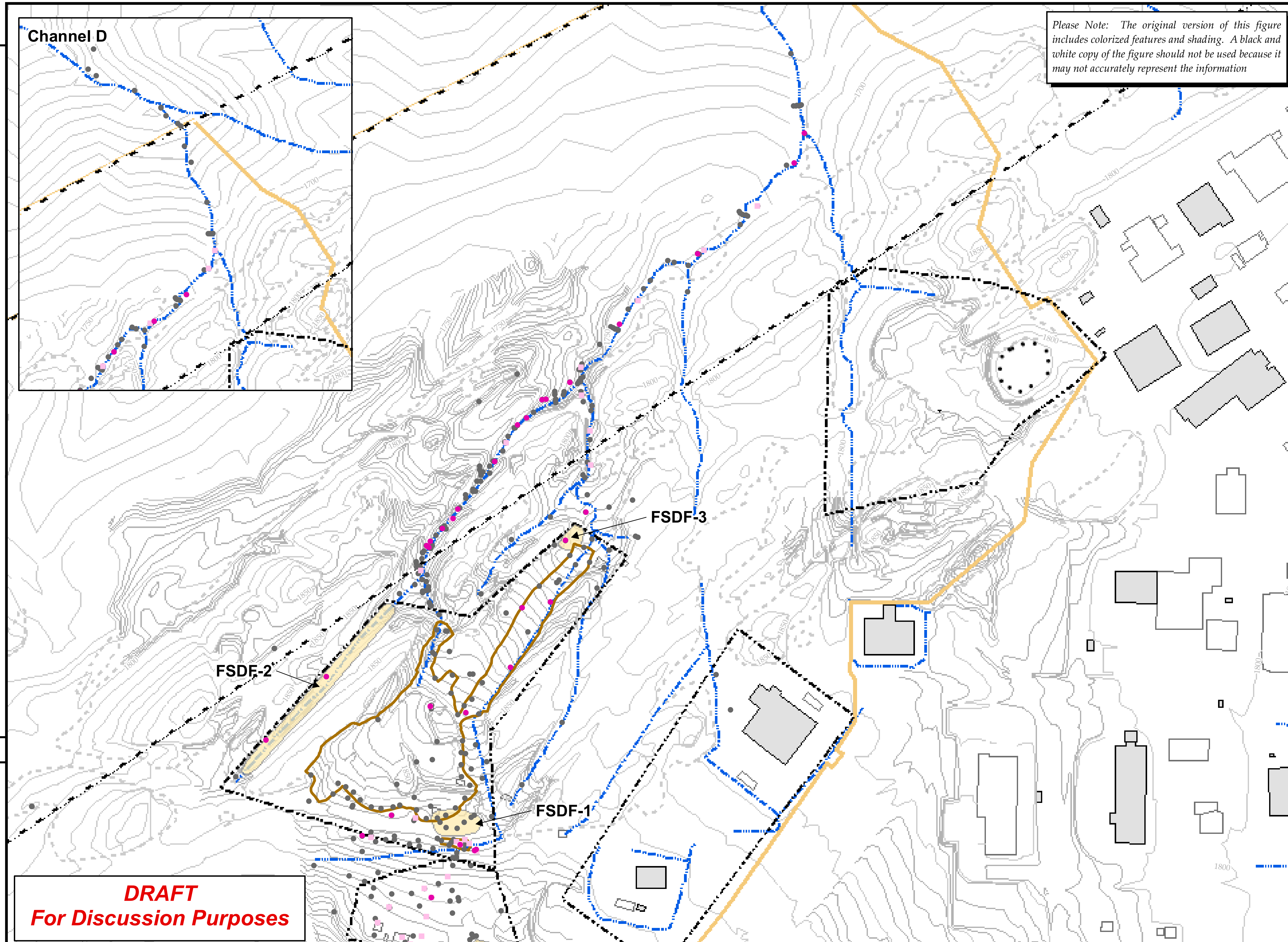
Document: SiteSpecificGroup8.mxd

Date: Sept 12, 2008

1 inch = 200 feet

0 200 400 Feet

N



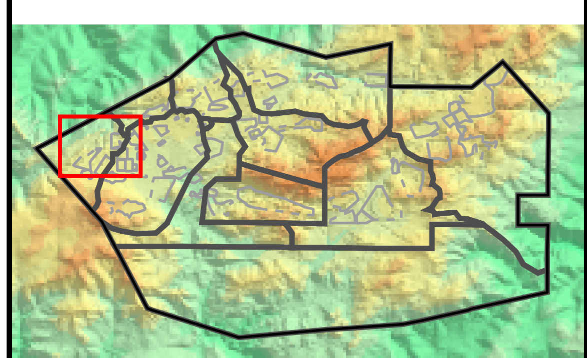


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Figure A4-2

SSFL SB990 Alternative, OCY RFI Site

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Report Group Boundary
- Existing Building
- Removed Building
- Ponds
- Drainage
- Bedrock Outcrop
- Elevation Contour

SSFL SB990 CMI Area

Sample Locations

- Detects above SSFL SB990 RBSLs
- Non Detects above SSFL SB990 RBSLs
- All other samples

Notes:

1) SSFL SB990 RBSLs based on site-specific rural resident exposure pathways for ILCR = 1 x 10-4 and HI = 1.

2) Estimated remediation areas rationale provided in Table A4-4.

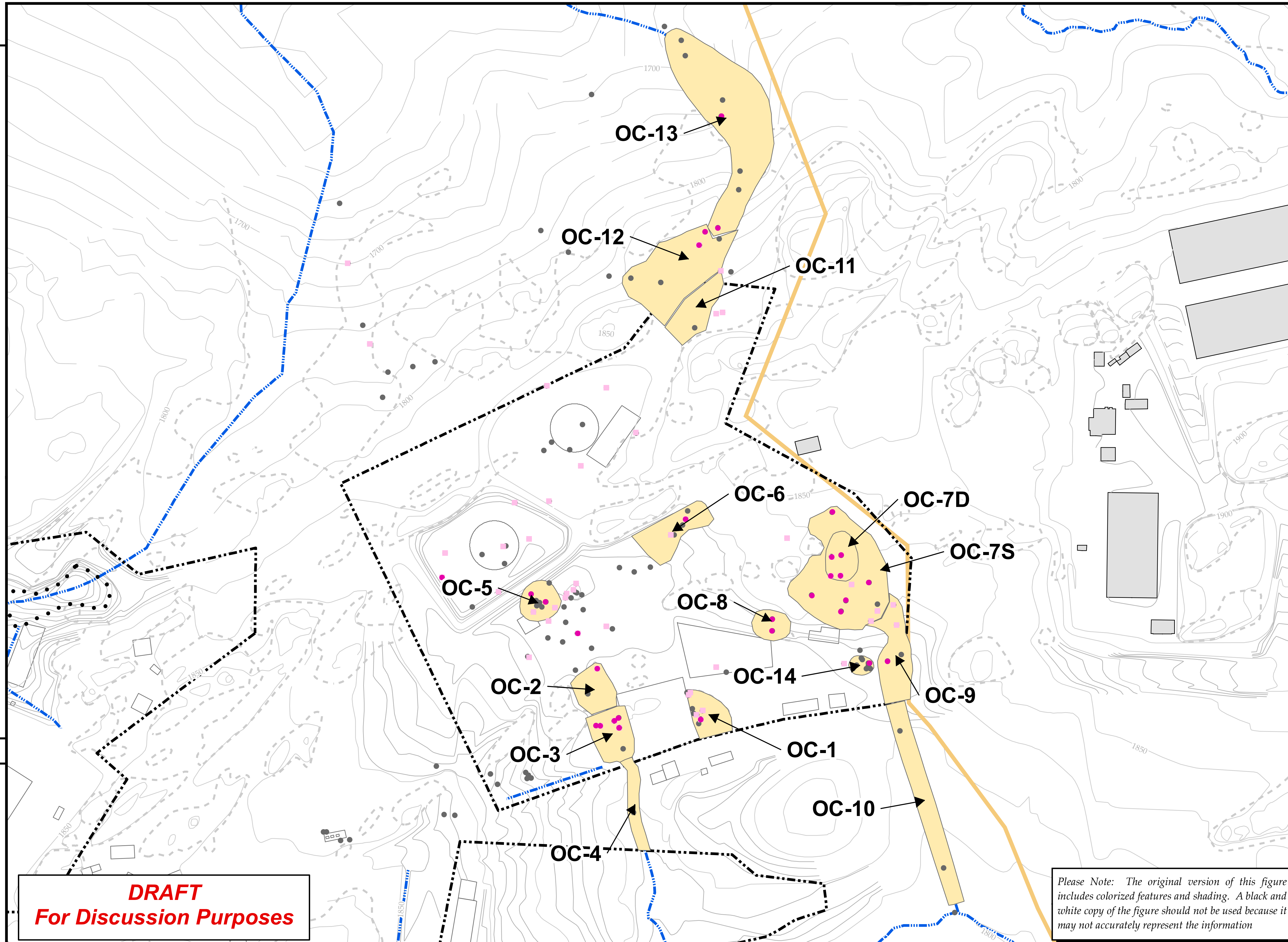
3) Other samples include detects or non detects below SSFL SB990 RBSLs and sample results for chemicals not included in this evaluation.

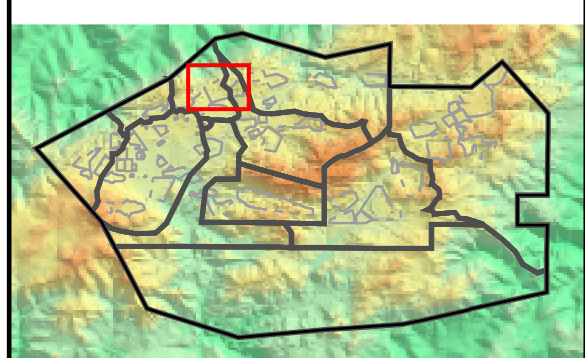
Document: SiteSpecificGroup6.mxd

Date: Sept 12, 2008

1 inch = 150 feet

0 50 100 150 Feet





DRAFT
For Discussion Purposes

Please Note: The original version of this figure includes colorized features and shading. A black and white copy of the figure should not be used because it may not accurately represent the information

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S A N T A S U S A N A F I E L D L A B O R A T O R Y

Figure A4-3

SSFL SB990 Alternative, Coca RFI Site

Base Map Legend

- Administrative Area Boundary
- RFI Site Boundary
- Report Group Boundary
- Existing Building
- Removed Building
- Ponds
- Drainage
- Bedrock Outcrop
- Elevation Contour

SSFL SB990 CMI Area

Sample Locations

- Detects above SSFL SB990 RBSLs
- Non Detects above SSFL SB990 RBSLs
- All other samples

Notes:

1) SSFL SB990 RBSLs based on site-specific rural resident exposure pathways for ILCR = 1 x 10-4 and HI = 1.

2) Estimated remediation areas rationale provided in Table A4-4.

3) Other samples include detects or non detects below SSFL B990 RBSLs and sample results for chemicals not included in this evaluation.

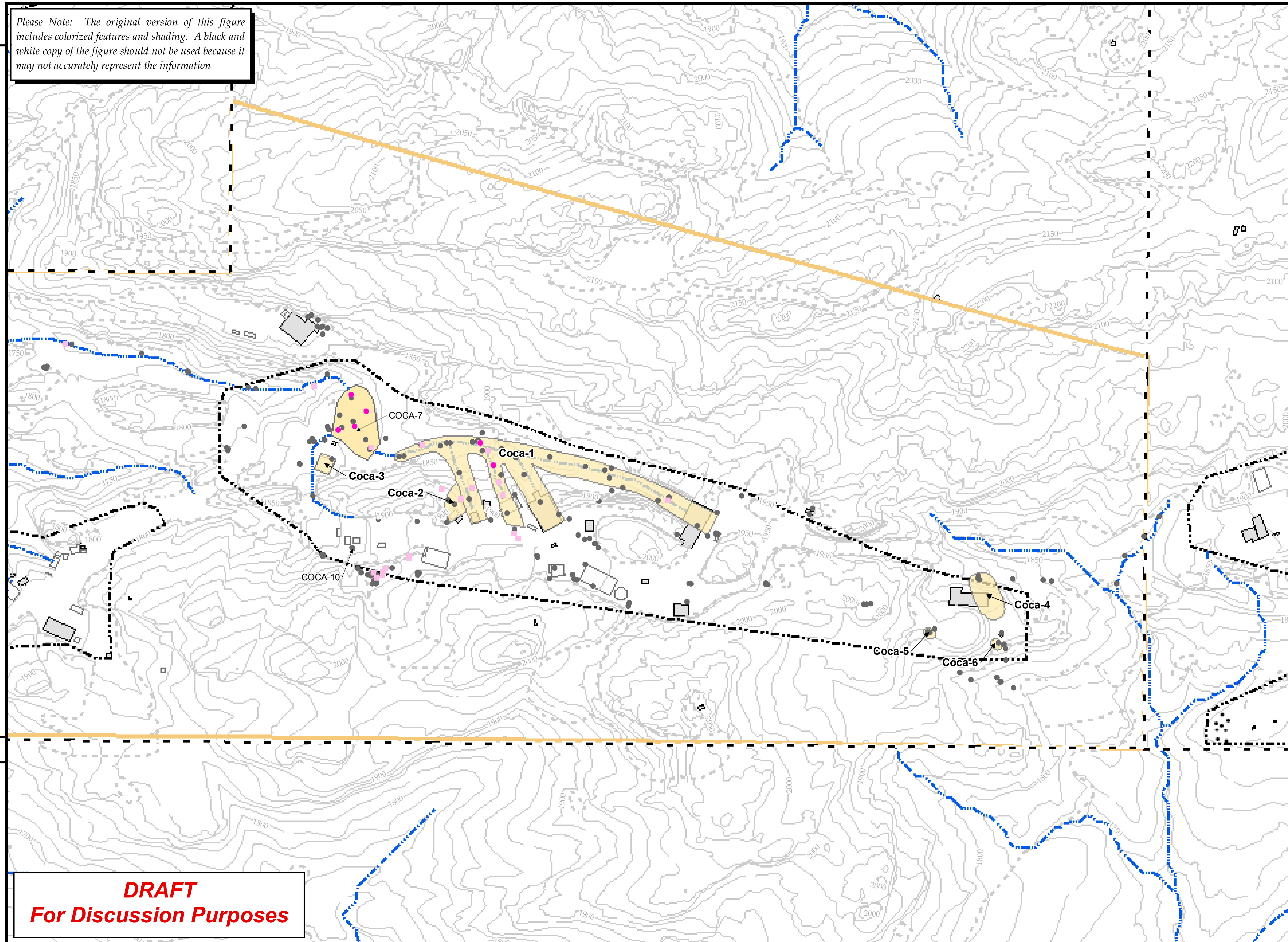
Document: SiteSpecificGroup4.mxd

Date: Sep 10, 2008

1 inch = 300 feet

Feet 0 200 400

Please Note: The original version of this figure includes colorized features and shading. A black and white copy of the figure should not be used because it may not accurately represent the information



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For Discussion Purposes

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Figure A4-4

ATTACHMENT 5

RISK DRIVER / CONTRIBUTOR DATA FOR EXAMPLE RFI SITES

ATTACHMENT 6

ENVIRONMENTAL IMPACT ANALYSIS FOR REMEDIATION CLEANUP ALTERNATIVES

Memorandum

Date: September 9, 2008

To: The Boeing Company

From: Geosyntec Consultants

Subject: Environmental Impact Analysis for Remediation Cleanup Alternatives
Santa Susana Field Laboratory

INTRODUCTION

This document presents the results of the environmental impact analysis for three excavation and offsite disposal alternatives addressed in the Technical Memo prepared for The Boeing Company in support of remediation cleanup at Santa Susana Field Laboratory (SSFL) in Ventura County, CA. The environmental impact analysis was performed by Geosyntec Consultants (Geosyntec), on behalf of The Boeing Company (Boeing).

The environmental impact analysis was performed in four categories, as follows:

- **Emissions Footprint:** Quantitative analysis of emissions from heavy equipment operation, transportation and offsite disposal.

- **Natural Capacity Conservation and Restoration:** Qualitative analysis for habitat preservation and restoration, biomass balance, biodiversity, local and regional watershed impacts, contaminant reduction and overall ecosystem impacts from excavation.

- **Resource Conservation and Usage:** Assessment of major resource requirements and potential natural resource impacts from heavy equipment operation, transportation and offsite disposal.

- **Community Impacts:** Assessment of community impacts such as community acceptance, aesthetics, noise and construction disturbance, future land use considerations, and downstream public watershed impacts from excavation, transportation and waste disposal.

ALTERNATIVES

The three remediation excavation alternatives evaluated in the Technical Memo and assessed herein are:

- **Alternative I –** The Base Case, which would require 180,000 cubic yards (cy) of soil to be excavated and disposed of offsite.

- **Alternative II –** The Default Senate Bill 990 (SB990) Alternative, which estimated that 720,000 cy of soil be excavated and disposed of offsite.

- **Alternative III –** The SSFL SB990 Alternative, which estimated that 207,000 cy of soil be excavated and disposed of offsite.

For assessment of the excavation alternatives, the following assumptions were used:

1. Soil to be excavated is 80% hazardous waste. Hazardous waste will be sent to Waste Management's (WM) Kettleman Hills Facility in Kettleman Hills, CA (180 miles (mi) one-way). Soil to be excavated is 20% non-hazardous waste. Non-hazardous waste will be sent to WM's Lancaster Facility (68 mi one-way).

2. The project site is restricted to 20 downhill export truck trips per day.

3. Excavation crew will consist of ten persons, each of whom will travel an estimated 40 mi one-way. Excavation equipment will be consistent with a small-output generating excavation crew consisting of one mid-sized excavator and two mid-sized front end-loaders.

4. Standard best management practices (BMPs) will be executed including dust suppression, spill control and construction stormwater pollution prevention.

EMISSIONS FOOTPRINT

Three main sources of air emissions have been identified: (1) waste transportation; (2) heavy machinery operation; and (3) crew transportation. The emissions compounds identified for analysis include greenhouse gas, smog and haze producing compounds including carbon dioxide (CO_2), carbon monoxide (CO), volatile organic compounds (VOCs), nitrogen oxides (NO_x), sulfur oxides (SO_x) and dust (PM-10).

Emissions from waste transportation were estimated based on the calculation of total mileage required and average end-dump fuel economy. These emissions were then compared to the emissions per gallon of diesel consumed for heavy vehicles as stated in *South Coast Air Quality Management District's 2006-2008 Emissions Report*. Additionally, road dust was calculated using the California Air Resources Board's 2006 model based upon vehicle miles travelled.

Emissions for heavy machinery operation were calculated by using an experience factor for the amount of diesel consumed by a similar crew of the size proposed and again comparing to the emissions per gallon of diesel consumed for heavy vehicles as stated in *South Coast Air Quality Management District's 2006-2008 Emissions Report*.

Emissions from crew transportation were estimated based on the calculation of total mileage required for each crew member and the average passenger vehicle fuel economy. These factors were then compared to the emissions per gallon of gasoline consumed for passenger vehicles as stated in *South Coast Air Quality Management District's 2006-2008 Emissions Report*.

The results of the emissions analysis are summarized as follows:

	Alternative I: Base Case	**Alternative II: Default SB990**	**Alternative III: SSFL SB990**	**Units**
Soil Excavated	**180,000 cy**	**720,000 cy**	**207,000 cy**	**cy**
CO_2	24,000,000	97,000,000	28,000,000	*lb*
CO	240,000	961,000	276,000	*lb*
VOC	47,000	188,000	54,000	*lb*
NO_x	504,000	2,017,000	580,000	*lb*
SO_x	8,000	31,000	9,000	*lb*
PM-10 Dust	106,000	426,000	122,000	*lb*
GHG Units[1]	24,000,000	97,000,000	28,000,000	*lb of CO2 Equivalents*

NATURAL CAPACITY CONSERVATION AND RESTORATION

Natural capacity refers the ability of a given area to support ecological life including both flora and fauna. While the ecological health of a given area may be difficult to quantify, parameters important to an area's natural health can be assessed qualitatively. These parameters would include, but are not limited to, the suitability of habitat, breeding, feeding, natural filtration and biodiversity. Impacts may be both local to the area directly affected by the excavation, or may be regional, including downstream impacts.

The existing natural capacity of an area can be described as a mix of developed areas and green space. Preliminary ecological surveys have been conducted at SSFL, and are ongoing for RCRA Facility Investigation (RFI) reporting and planned remediation. The areas surrounding the SSFL have been known to be frequented by a variety of animals and contain a mix of native and non-native vegetative species. The area currently consists of long grasses, trees and shrubs which provide sensitive habitat for variety of nesting birds, small mammals and other local wildlife.

[1] Note that one pound of greenhouse gas (GHG) unit is equivalent to one lb of CO_2 or 1/8 lb of methane spanning the lifetime of the gas. This is also referred to as greenhouse gas potential.

Each of the proposed excavation alternatives would disturb a local area directly where the soil is being removed, as well as any areas being used for stockpiles or for temporary access or haul-routes.

RESOURCE CONSERVATION AND USAGE

For this analysis, a resource is defined as a physical entity of limited quantity which provides a beneficial use to humans. The proposed excavation area does not currently provide significant resources, nor has the area been identified for future resource development. However, in the excavation and transportation of waste soil, significant quantities of fuel (gasoline and diesel) will be consumed.

Through previous project experiences using small-scale excavation crews, approximately 0.1 gallons of fuel per cubic yards of soil are used by heavy machinery in similar excavations. Using an estimated 4.5 miles per gallon (mpg) diesel average fuel economy for end-dumps and 12 mpg gasoline for passenger crew vehicles, the estimated transportation fuel usage was calculated for the three alternatives, as follows:

Alternative	Diesel Fuel Usage	Gasoline Fuel Usage
Alternative I: Base Case	1,070,000 gallons	33,000 gallons
Alternative II: Default SB990	4,270,000 gallons	133,000 gallons
Alternative III: SSFL SB990	1,230,000 gallons	38,000 gallons

While not quantitatively defined, significant quantities of water may be required for dust suppression, which is directly correlated to area disturbed. The quantity of water required is contingent on excavation air permitting requirements, if any.

COMMUNITY IMPACTS

Community impacts are defined as impacts by the project or project related activities which pose a change in the quality of life of the community. Impacts include, but are not limited to traffic, odor, noise, access to public space, changes to the local economy and aesthetics.

The areas to be excavated are remote from the nearest residents, thus the impact of the excavations themselves on the community would be minimal. The main impact on the local community will be an increase in truck haul traffic during remediation, which may have secondary associated impacts including odor, noise and dust. Downhill export truck trips are limited to 20 trucks per day, thus the difference in impacts to the community between the various alternatives for transportation is not a matter of severity, but rather duration. Assuming that hauling can only be done 5 days a week, the estimated duration of the various alternatives as it relates to transportation and offsite disposal (T&D) are as follows:

Alternative	Estimated T&D Project Duration	Estimated Truckloads Hauled
Alternative I: Base Case	750 workdays / 3 years	12,000 loads
Alternative II: Default SB990	3,000 workdays / 10 years	48,000 loads
Alternative III: SSFL SB990	860 workdays / 3½ years	13,800 loads

EVALUATION

To compare the various alternatives, a scoring system has been implemented to assign a score for each alternative, with a score of 20 being the most attractive from an environmental standpoint, and zero being the least attractive. Within each of the four categories, a score between zero and five is assigned. The criteria for assigning a score to each category, as well as the individual scores for each alternative, are presented in Table 1.

A weighting has been assigned to each category to reflect the category's overall importance. Again, a higher rating reflects a more attractive alternative from a perspective of that particular sustainability category. Using the various weightings and scores presented in Table 1, an overall sustainability score has been determined, as follows:

Sustainability Category	**Relative Weighting**	**Alternative I Base Case**	**Alternative II Default SB990**	**Alternative III SSFL SB990**
Emissions Footprint	0.25	5	1.2	4.3
Natural Capacity Conservation and Restoration	0.25	3	2	3
Resource Conservation and Usage	0.25	3	2	3
Community Impacts	0.25	3	1	3
Total	**1.0**	**17**	**6.2**	**16.3**

CONCLUSION

The analysis presents Alternative I (Base Case) as the most attractive alternative from an environmental standpoint based upon the emissions footprint, natural capacity conservation and restoration, resource conservation and usage and community impacts. Alternative I is followed closely by Alternative III (SSFL SB990 Alternative). Alternative II (Default SB 990 Alternative) scores considerably lower, representing its significant environmental impacts based on the four categories considered.

REFERENCES

California Environmental Protection Agency, 2008. Air Resources Board Emissions Inventory. http://www.arb.ca.gov/ei/ei.htm. Accessed September 2nd, 2008.

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Impact Sciences, 2008. ENTS Air Quality Analysis. Boeing Santa Susanna Field Laboratory. August.

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United States Environmental Protection Agency, 2005. Emission Facts: Average Carbon Dioxide Emissions Resulting from Gasoline and Diesel Fuel. EPA Docket 420-F-05-001. February.

ATTACHMENTS

Table 1 – Summary of Environmental Impact Criteria and Results

Table 2 – Environmental Impact Summary

* * * * *

TABLE 1

SUMMARY OF ENVIRONMENTAL IMPACT CRITERIA AND RESULTS
SANTA SUSANA FIELD LABORATORY REMEDIATION EXCAVATION ALTERNATIVES

GREENHOUSE GAS AND EMISSIONS FOOTPRINT

Score defined quantitatively by comparing the relative greenhouse gas (GHG) generation quantities between all excavation alternatives. A score of 5 is presented to the alternative with the lowest generation of greenhouse gas emissions. Subsequent alternatives are assigned a score based upon their elative fraction of greenhouse gases per the following formula:

Score = [GHG generated in least-case alternative]/[GHG in alternative being scored] x 5

While greenhouse gases have been identified as the major emission constituent of concern due to their potential impacts on global warming, other emissions have been identified which may cause other air pollution impacts including, but not necessarily limited to: smog, haze, respiratory problems and acid rain. These other emissions include volatile organic compounds (VOC), carbon monoxide (CO), methane, nitrogen oxides (NOx), sulfur oxides (SOx), and dust. To account for the emissions of compounds other than GHGs in the sustainability analysis, a maximum of one point may be either added or subtracted to the score based upon the relative quantities generated in the various alternatives.

Alternative	Features	Score
Alternative I Base Case	• Estimated 24,000,000 lbs (12,000 tons) of CO_2 to be generated • Alternative with lowest GHG, CO, VOC, NOx, SOx, and dust generation.	5
Alternative II Default SB990	• Estimated 97,000,000 lbs (48,000 tons) of CO_2 to be generated • Alternative with highest GHG, CO, VOC, NOx, SOx, and dust generation.	1.2
Alternative III SSFL SB990	• Estimated 28,000,000 lbs (14,000 tons) of CO_2 to be generated • Alternative with 2nd lowest GHG, CO, VOC, NOx, SOx, and dust generation.	4.3

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TABLE 1

SUMMARY OF ENVIRONMENTAL IMPACT CRITERIA AND RESULTS
SANTA SUSANA FIELD LABORATORY REMEDIATION EXCAVATION ALTERNATIVES

NATURAL CAPACITY CONSERVATION AND RESTORATION

Score defined qualitatively by the overall impact of the proposed alternative on the natural capacity of the affected area. A score from zero to five is given based upon the following criteria:

- A score of 5 is given to a alternative which has a net positive impact on the affected area (i.e., remedial measure improves or restores area habitat and encourages ecological growth);
- A score of 4 is given to a alternative which has negligible impacts on the affected area (i.e., area habitat and local ecology unaffected by excavation alternative);
- A score of 3 is given to a alternative which has a minor impact on the affected area (i.e. some area habitat is disturbed, but the overall local ecosystem is unaffected);
- A score of 2 is given to a alternative which has a significant impact on the affected area (i.e., both area habitat and the local ecosystem are impacted);
- A score of 1 is given to a alternative which has major impacts on the affected area (i.e., both the habitat and local ecosystem are irreversibly impacted); and
- A score of 0 is given to a alternative which has major impacts on the affected area and also significantly impacts areas outside the affected area (i.e., the habitat and local ecosystem are irreversibly impacted and offsite or downstream ecosystems are impacted)

The characteristics of "minimal", "significant" and "major" are relative terms and are subjectively assigned based upon the alternatives presented in the analysis.

Alternative	Features	Score
Alternative I Base Case	• A moderate-sized area consisting of grasses, trees and shrubs which provide habitat for variety of nesting birds, small mammals and other local wildlife will be disturbed during excavation, stockpiling and transportation. • This alternative may temporarily remove habitat and other vegetation, however site will be re-developed back to its original landscaping.	3
Alternative II Default SB990	• A large area consisting of grasses, trees and shrubs which provide habitat for variety of nesting birds, small mammals and other local wildlife will be disturbed during excavation, stockpiling and transportation. • This alternative may temporarily remove habitat and other vegetation, however site will be re-developed back to its original landscaping.	2
Alternative III SSFL SB990	• A moderate-sized area consisting of grasses, trees and shrubs which provide habitat for variety of nesting birds, small mammals and other local wildlife will be disturbed during excavation, stockpiling and transportation. • This alternative may temporarily remove habitat and other vegetation, however site will be re-developed back to its original landscaping.	3

TABLE 1

SUMMARY OF ENVIRONMENTAL IMPACT CRITERIA AND RESULTS
SANTA SUSANA FIELD LABORATORY REMEDIATION EXCAVATION ALTERNATIVES

<table>
<tr><th colspan="3">Resource Conservation and Usage</th></tr>
<tr><td colspan="3">Score defined qualitatively by the overall impact of the proposed alternative on local resources and on overall resource usage. A resource, for the purposes of this analysis, is defined as a physical entity of limited quantity which provides a beneficial use to humans. A score from zero to five is given based upon the following criteria:

• A score of 5 is given to a alternative which uses negligible resources in its implementation;
• A score of 4 is given to a alternative which uses minimal resources or strives to use renewable resources in its implementation;
• A score of 3 is given to a alternative which uses significant resources in its implementation;
• A score of 2 is given to a alternative which uses major resources in its implementation;
• A score of 1 is given to a alternative which reduces the overall resource carrying capacity of an affected area (i.e. an area which once provided a resource such as food, water, fuel and/or electricity is impacted);
• A score of 0 is given to a alternative which permanently reduces the overall resource carrying capacity of an affected area (i.e. an area which once provided a resource such as water, fuel or electricity is impacted);

The characteristics of “minimal”, “significant” and “major” are relative terms and are subjectively assigned based upon the alternatives presented in the analysis.</td></tr>
<tr><th>Alternative</th><th>Features</th><th>Score</th></tr>
<tr><td>Alternative I
Base Case</td><td>• An estimated 1.2 million gallons of diesel will be used to operate heavy equipment and fuel the end-dumps.
• An estimated 33,000 gallons of gasoline will be used to fuel crew vehicles.
• Significant quantities of water may be required for dust suppression in order to comply with regional air quality regulation.
• Area impacted does not currently provide resources defined above, nor has the area been identified for future resource development.</td><td>3</td></tr>
<tr><td>Alternative II
Default
SB990</td><td>• An estimated 4.7 million gallons of diesel will be used to operate heavy equipment and fuel the end-dumps.
• An estimated 130,000 gallons of gasoline will be used to fuel crew vehicles.
• Significant quantities of water may be required for dust suppression in order to comply with regional air quality regulation.
• Area impacted does not currently provide resources defined above, nor has the area been identified for future resource development</td><td>2</td></tr>
<tr><td>Alternative
III
SSFL SB990</td><td>• An estimated 1.4 million gallons of diesel will be used to operate heavy equipment and fuel the end-dumps.
• An estimated 38,000 gallons of gasoline will be used to fuel crew vehicles.
• Significant quantities of water may be required for dust suppression in order to comply with regional air quality regulation.
• Area impacted does not currently provide resources defined above, nor has the area been identified for future resource development.</td><td>3</td></tr>
</table>

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TABLE 1

SUMMARY OF ENVIRONMENTAL IMPACT CRITERIA AND RESULTS
SANTA SUSANA FIELD LABORATORY REMEDIATION EXCAVATION ALTERNATIVES

Community Impacts

Score defined qualitatively by overall impact of the proposed alternative on the short-term and long-term community quality of life. Analysis includes, but is not limited to, impacts relating to traffic, odor, noise, access to public space, the economy and aesthetics. A score from zero to five is given based upon the following criteria:

- A score of 5 is given to a alternative which has negligible short-term and long-term impacts to the community;
- A score of 4 is given to a alternative which has minor short-term and negligible long-term impacts to the community (i.e., lane closures, daytime construction noise, increase vehicular traffic);
- A score of 3 is given to a alternative which has a significant short-term and negligible long-term impacts to the community; (i.e., short-term daytime odors, significant traffic re-routing, short-term restriction of public space)
- A score of 2 is given to a alternative which has a major short-term and negligible long-term impacts to the community (i.e., road closures, severe traffic impacts; continuous short-term odors and noise);
- A score of 1 is given to a alternative which has significant long-term impacts to the community (i.e., permanent road closures, closure of public spaces, permanent negative aesthetic changes);
- A score of 0 is given to a alternative which has major long-term impacts to the community; (i.e., business closures, permanent closure of essential public facilities)

The characteristics of “minimal”, “significant” and “major” are relative terms and are subjectively assigned based upon the alternatives presented in the analysis.

Alternative	Features	Score
Alternative I Base Case	• An estimated 750 work days would be required to complete this alternative. Assuming a 5-day week and 8-hour work day, this will result in an estimated 3-year project duration. • Estimated site conversion to public use in 3 to 5 years after start of excavation. • Traffic limited to 20 trucks a day, 12,000 total truckloads hauled.	3
Alternative II Default SB990	• An estimated 3,000 work days would be required to complete this alternative. Assuming a 5-day week and 8-hour work day, this will result in an estimated 12-year project duration. • Estimated site conversion to public use in 12 to 15 years after start of excavation. • Traffic limited to 20 trucks a day, 48,000 total truckloads hauled.	1
Alternative III SSFL SB990	• An estimated 860 work days would be required to complete this alternative. Assuming a 5-day week and 8-hour work day, this will result in an estimated 3½-year project duration. • Estimated site conversion to public use in 3 to 5 years after start of excavation. • Traffic limited to 20 trucks a day, 13,800 total truckloads hauled.	3

TABLE 2

ENVIRONMENTAL IMPACT SUMMARY
SANTA SUSANA FIELD LABORATORY REMEDIATION EXCAVATION ALTERNATIVES

	Alternative I: Base Case	Alternative II: Default SB990	Alternative III: SSFL SB990	Units
Project Metrics				
Soil Excavated	180,000	720,000	207,000	cy
Truckloads Hauled	12,000	48,000	13,800	loads
Estimated Project Duration	750 / 3	3,000 / 10	860 / 3½	workdays / years
Emissions Footprint				
CO_2	24,000,000	97,000,000	28,000,000	*lb*
CO	240,000	961,000	276,000	*lb*
VOC	47,000	188,000	54,000	*lb*
NO_x	504,000	2,017,000	580,000	*lb*
SO_x	8,000	31,000	9,000	*lb*
PM-10 Dust	106,000	426,000	122,000	*lb*
GHG Units[1]	24,000,000	97,000,000	28,000,000	*lb of CO2 Equivalents*
Fuel Consumption				
Diesel	1,070,000	4,270,000	1,230,000	*gallons*
Gasoline	33,000	133,000	38,000	*gallons*
Sustainability Score	**17**	**6.2**	**16.3**	***Out of 20***

[1] Note that one pound of greenhouse gas (GHG) unit is equivalent to one lb of CO_2 or 1/8 lb of methane spanning the lifetime of the gas. Also referred to as greenhouse gas potential.