Investigative Activities

Assessing Contaminant Migration

Drilling, Coring, and Analysis

Drilling at the site

Rock core samples are collected and logged

Laboratory results are shown here versus depth providing a detailed profile of the contamination.

The results from the multilevel wells. It provides a vertical profile of the water level elevations and the contaminant concentrations.

Seep/Spring Sampling

Seep/Springs have been mapped onsite and around the site. Samples have been collected from the seeps/springs. There was one location onsite with TCE detections. Additional sampling by both DTSC and Boeing has been completed at these locations. The initial detections were not repeated.

Seep/Springs are mapped onsite and around the site. Samples have been collected from the seeps/springs. There was one location onsite with TCE detections. Additional sampling by both DTSC and Boeing has been completed at these locations. The initial detections were not repeated.

Groundwater Monitoring

There are over 450 monitoring wells at the site. Groundwater samples are collected throughout the site on a quarterly basis. DTSC collected split-samples to confirm results.

Geology

Geology

Geology

Underlying the site is a geologic formation referred to as the Chatsworth Formation. The Chatsworth Formation is made up of large sandstone layers with siltstone/shale layers distributed throughout.

Santa Valley, Simi Hills, and the Santa Susana Mountains are a result of the folding of the rock beds into a structure called a syncline. The Simi Hills is the north leg of the fold and therefore the rock beds at the site are tilted to the northeast.

Faults are present at the site. In general, they are oriented either west-east or northeast-southwest.

Sandstone, Siltstones, and Shales

Sandstone, Siltstones, and Shales

Sandstone, Siltstones, and Shales

SANDSTONE – Faster groundwater movement

SILTSTONE/SHALE – Slower groundwater movement

Groundwater System

Groundwater System

Groundwater System

The site can be divided into compartments based on the occurrence of faults and the rock units. However, the water table within these geologic units can be tested and evaluated.

Matrix Diffusion Hypothesis

Source: Parker, Cherry presentation to DTSC

Above are pictures to 2 types of multilevel well systems being utilized at the site.

Well 1 is an open borehole well; groundwater samples would not contain contaminants since contamination is constrained by a fine-grained shale unit below the depth of the wells.

Well 2 is an open borehole well; groundwater samples may contain detectable contaminants of the same concentration as the well fluid. However, groundwater samples are collected and logged from the well providing a representative profile of the contaminants.

Pure TCE released at the site as a dense (heavier than water) non-aqueous phase liquid (DNAPL). It passes down through the sediment. When it reached the bedrock it continues to move downward through the fractures in the bedrock.

As groundwater flows through the source zone, a groundwater contaminant plume forms. The presence of fractures creates a complex plume.

As high concentrations of the contaminants is transported via groundwater flow, the contaminants diffuse into the surrounding matrix due to concentration gradients.

Over time, DNAPL mass is transferred into bedrock matrix through diffusion resulting in a large mass of TCE within the rock.

The overall effect of matrix diffusion is the retardation of groundwater plume.

It is important to note that matrix diffusion is a working hypothesis for SSFL. The potential effects of matrix diffusion must be substantiated through the collection of site-specific data. DTSC is directing Boeing to install additional coreholes offsite to the northeast along with other work to assess matrix diffusion and to better define groundwater movement and contaminant migration.
**Group 4 RFI – Santa Susana Field Laboratory**

The Santa Susana Field Laboratory (SSFL) RFI Facility Investigation Program is divided into 16 RFI groups. The Group 4 RFI area is located within the National Aeronautics & Space Administration (NASA) administrative area, near the center of the SSFL facility.

**Scope of Review of RFI Reports**
- Site History and Chemical Use
- Site Conditions
- Nature and Extent of Chemical Impacts for all media
- Review key decision points for characterization

**Rocket Engine Testing – Coca Test Area**
One of the main operations conducted at the SSFL involved rocket engine testing. The Coca RFI site consists of a number of structures including test stands, spillways, spillway point buildings, and sanitary landfill dike and tanks that were used to conduct and support the rocket engine tests.

During the mid-1950’s, the three original test stands were built to test large rocket engines using primarily petroleum-based fuels (RP-1) with liquid oxygen as an oxidizer. Water was used to cool the flame deflector shields during testing, solvents (TCE) were used to flush out the engine of residual fuel and carbon. The cooling water along with TCE and petroleum-based fuel were discharged to the spillways leading to the Coca pond. TCE use at Coca ceased in the early 1960’s after establishment of a TCE recycling program. Between 1952-1970, the original test stands were removed or partially dismantled and two large test stands were built to support rocket engine testing for the Apollo Space Program. Between 1975-1988, the site was used to test the main engines for the Space Shuttle, which used liquid oxygen (LOX) and liquid hydrogen.

**Rocket Engine Testing – Delta Test Area**
Similar to the Coca RFI site, the Delta RFI site was primarily used to conduct rocket engine testing. Three test stands were constructed in 1956-1957 and were operational until 1976. In addition to petroleum fuels with liquid oxygen, other types of fuels were also used at the Delta test stands, namely fluorine, nitric acid, and unsymmetrical dimethylhydrazine. Water was used as a cooling agent and solvents such as TCE were used to flush the rocket engines after testing. The water and TCE flowed from the test stands, into the spillways, and ultimately into the Delta 5km Pond. In 1951, a TCE recycling system was implemented at the site. Approximately 45,000 gallons of TCE had already been used at Delta prior to the TCE recovery system.

**Propellant Load Facility (PLF)**
The area where PLF is located was constructed around 1956 and was initially used from 1956 to 1970 as the Delta control center for rocket engine testing for the Delta Test Area. In 1981, the Delta control center was modified to accommodate propellant loading & unloading for the Peacekeeper Stage IV rockets, at which time it was renamed as the Propellant Load Facility. The PLF was operational from 1982 to 1995. Operations included servicing and filling Peacekeeper missiles with monomethyl hydrazine, nitrogen tetroxide, nitrogen and helium in two loading cells located in Building 224. X-ray and welding operations as part of the missile servicing program were also performed at the PLF.

**Recommendations in the Group 4 RFI Report**
The Group 4 RFI Report recommends that the shaded areas shown in figure above should be further evaluated in the corrective measures study. The majority of these shaded areas are the test stands and spillways, where TCE was extensively used.
Group 6 RFI – Santa Susana Field Laboratory

**Sodium Reactor Experiment (SRE) Complex**

The SRE facility consisted of a group of over 15 buildings and structures related to the support and operation of the reactor. During SRE operations, these buildings and support activities included: a toluene process/tetralin heat exchanger area, a former SCE steam power plant including a cooling tower, a box shop, a sanitary leach field, sodium cleaning areas, three former fuel USTs, and four transformer locations. Solvents were likely discharged to the ground north of the box shop. Some of these buildings were used for non-SRE activities after facility de-activation and before demolition.

The SRE was a liquid-metal cooled nuclear power reactor built in 1957 (contained within Building 143) and operated between 1957 and 1964. It used sodium as the primary coolant. In 1959, a partial meltdown occurred at the SRE reactor, which was shut down to repair the core due to a cooling failure and resultant damage of the fuel assemblies. In 1964, liquid waste was released from below-ground storage tanks installed near the edge of the hillside north of Building 143 to the SRE Pond. The facility ceased operation in 1967, and subsequently underwent decontamination and demolition.

Decommissioning activities included removal of contaminated building structures, and excavation of soil and bedrock. Excavation activities included areas north and east of the former Reactor Building 143, near the former Engineering Test Building 003, as well as at the SRE Pond. All SRE-related buildings have been removed, including tanks, transformers, and asphalt cover. Current conditions at the SRE RFI site include erosion control measures installed at the mercury-impacted soils and along the drainage below the SRE Pond.

**RFI Objectives**

- Identify sources of chemical contamination, what chemicals are involved, and the extent of their occurrence
- Evaluate where chemical contaminants are, where they go, and how they get there
- Gather data needed to make decisions on interim or final cleanup measures
- Obtain sufficient info to complete a risk assessment

**Preliminary Findings**

- Deficiencies noted – more characterization needed to determine nature & extent of contamination
- RFI identified contaminated areas that will be further evaluated for cleanup options during the CMS
- DTSC will require more areas to be evaluated for cleanup, in addition to those initially proposed by Boeing
What was the Area I Burn Pit?
- Discontinued in 1971 due to "air pollution considerations".
- Operated intermittently from 1971 through 1990.
- Used for burning, dilution, destruction of various materials.
- Six acres, six pits ranging in volume from 200 to 10,000 gallons.
- Number and locations of earlier features evolved through time.
- Burn Pit also had burial/disturbed areas, drum & equipment storage areas, above ground storage tanks and other structures.

What was Burned orDisposed of at the Burn Pit?
Wastes included:
- 450,000 gallons of fuels
- 6,924 igniters
- 13,810 pounds of reactive metals
- 5,121 pounds of explosives
- 31,717 gallons of organic solvents
- 5,121 pounds of explosives
- 32,932 cubic feet of toxic gases
- 191 gallons of heavy metal toxics

Sources of Waste Materials
- On-site sources (site-wide, including Area IV)
- Off-Site sources (i.e., Canoga, Vanowen, Desoto & Science Center)

What Chemicals Were Left Behind?
- Chemicals identified during previous investigations conducted between 1981 through 2006.
- Need to consider initial materials that were burned, destroyed, or diluted in order to evaluate potential by-products.
- Example – waste burned will potentially result in residual thermal decomposition (i.e., burned) products.

Was Radioactive Waste Burned or Disposed of at Burn Pit?
- Based on review to date, no definitive information suggests it has, but questions remain...
- Examples: cesium from Canoga & Desoto (7 pounds in early 1960’s)
- Sodium (Na), potassium (K), NaK, and lithium from Area IV sites
- Materials from radiological buildings in Area IV (i.e., 4003, 4009, 4023, 4020)
- Materials from non-radiological buildings in Area IV (i.e., 4067, 4068)

Supporting Historical Documentation:
- Inventory logs, records, and available invoices;
- Operations files
- Site/facility investigation files
- Regulatory compliance correspondence, audits, permits, monitoring reports, sampling reports, etc.
- Deposition testimonies from former workers

Are We Looking At Relevant Pathways for Contaminant Migration?
Yes. Work Plan addresses the following potential pathways:
- Air dispersion migration from past burning activities
- Groundwater migration
- Surface water and sediment migration
- Soil Vapor migration

How do we deal with the uncertainties?
- Utilize geophysical surveys
- Utilize radiological materials screening survey
- Conduct air dispersion modeling with field validation sampling
- Conduct additional sampling and analyses

Proposed Work for Addressing Deficiencies
Utilizes relevant historical information to better describe & delineate former chemical use areas
Conduct air dispersion modeling w/field validation sampling to evaluate potential pathway of airborne particulates from past burning activities
Will conduct additional multi-media sampling to complete characterization and determine site-related chemicals of concern
Conduct radiological materials screening survey to address uncertainties
Sage Ranch / LOX Area Debris Field Removal

With the assistance of concerned community members, DTSC recently provided regulatory oversight of removal of debris along a portion of the Northern Drainage at Sage Ranch, near the former Santa Susana Field Laboratory (SSFL) Liquid Oxygen (LOX) plant.

On November 1, 2007, DTSC issued an Imminent and Substantial Endangerment Determination and Order and Remedial Action Order to the SSFL.

From November through December 2007, nearly 2,500 cubic yards of debris with asbestos- and antimony-containing material was excavated from the Northern Drainage at Sage Ranch.

DTSC had a daily presence to ensure that appropriate safety precautions were conducted for the duration of the project. These activities included establishing an exclusion zone for the workers, implementing appropriate dust control, and conducting air monitoring for the workers as well as for park users on the trail.

This portion of the Northern Drainage is now restored to its original configuration. Appropriate Best Management Practices are currently applied for monitoring and protection of surface water quality in this portion of the drainage.
EVALUATING THE GROUNDWATER

Over the past several years, core holes have been drilled at the site to investigate the extent of volatile organic compound (VOC) contamination in the fractured bedrock. Approximately 5,000 rock core samples have been collected and analyzed for TCE and other VOCs. The corehole data has provided information into the distribution and movement of contaminants at the site. Vertical profiles showing the distribution of TCE are shown below along with the locations of each corehole.

UPCOMING WORK

In 2005 and 2006, four core holes were drilled (RD-39C, RD-35C, C-10, and C-11) and one existing monitoring well was deepened through coring (RD-31). Coreholes RD-35C, C-10, C-11, deepened RD-31, and existing coreholes RD-35B and C-1 were placed to provide information about the nature and extent of VOC impacts at or near a source zone. Four additional coreholes will be drilled offsite to the northeast beginning this summer. The coreholes (C-12 through C-15) are being located to intercept contaminants downgradient of the source areas. Information from this work will provide details on the movement of contaminants at the site. The locations of the coreholes are shown below.

Additional work is either ongoing or planned. This work includes:
- FLUTE™ liner hydraulic conductivity profiling;
- Straddle packer testing to assess groundwater flow;
- Borehole geophysical logging of coreholes to assess hydrogeologic characteristics;
- Borehole high-resolution fluid temperature logging of several coreholes to assess fractures with active groundwater flow;
- Collection and analysis of rock core samples for chloride to assess groundwater recharge;
- Collection and analysis of water samples from seeps/springs and from multilevel wells.
Groundwater data is collected from over 450 monitoring wells. To date, eighteen (18) contaminants plumes (16 TCE, 1 perchlorate, and 1 tritium) have been identified at the site. The approximate extent of each plume is shown on the figure to the right.

Groundwater data is also collected from over 40 seeps/springs on SSFL and at numerous locations around the site. TCE has only been detected in a couple of locations onsite. Periodic sampling of the seeps/springs is ongoing.
<table>
<thead>
<tr>
<th>Order Section</th>
<th>ASSIGNMENT</th>
<th>Due Date</th>
<th>Due-Date Met</th>
<th>Due-Date Not Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.2.1</td>
<td>Submit Schedule to achieve Site Cleanup by 2017</td>
<td>11/16/07</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>3.3.2</td>
<td>Submit Interim Cleanup Work Plan for Groundwater</td>
<td>8/18/07</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>3.3.3</td>
<td>Submit Report summarizing analytical data collected from areas around SSFL (Offsite Data Report)</td>
<td>12/13/07</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>3.4.5</td>
<td>Submit Transcripts of Depositions related to SSFL Lawsuits</td>
<td>12/16/07</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>3.4.11</td>
<td>Submit geo-referenced Geographic Information System data for SSFL</td>
<td>2/8/08</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>3.4.12</td>
<td>Submit Phase II Groundwater Characterization Work Plan (investigation of the Northeast Plume)</td>
<td>6/15/07</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>3.4.12</td>
<td>Submit Phase III Groundwater Characterization Work Plan</td>
<td>8/31/07</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>3.4.12</td>
<td>Site Wide Investigation Work Plan for Groundwater</td>
<td>1/15/08</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>3.4.12</td>
<td>Submit updated Conceptual Site Model (CSM) Memorandum</td>
<td>8/31/07</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>3.4.12</td>
<td>Submit Site Wide Geology Report</td>
<td>8/31/07</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>3.4.12</td>
<td>Submit 3-D Flow Model Technical Memorandum</td>
<td>11/1/07</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>3.4.12</td>
<td>Submit Phase 2 Northeast Area Groundwater Characterization Report</td>
<td>2/1/08</td>
<td>√</td>
<td></td>
</tr>
<tr>
<td>3.4.13</td>
<td>Water Quality Sampling and Analysis Plan</td>
<td>12/16/07</td>
<td>√</td>
<td></td>
</tr>
</tbody>
</table>