



**PALEONTOLOGICAL RESOURCES ASSESSMENT,  
BOEING ADMINISTRATIVE AREAS I, III and SOUTHERN  
UNDEVELOPED LAND  
SANTA SUSANA FIELD LABORATORY (SSFL)  
SIMI HILLS, VENTURA COUNTY, CALIFORNIA**

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## EXECUTIVE SUMMARY

This Paleontological Resources Assessment Report documents the findings of a Paleontological Resource Assessment conducted by John Minch and Associates, Inc. for the Boeing Company's portion of the Santa Susana Field Laboratory (SSFL), Ventura County, California. The 1940± acre project site is located in northern Ventura County in the undeveloped Simi Hills, north of the town of Chatsworth and Interstate Route 101, and south of the City of Simi Valley and Highway 118, as depicted on the Simi USGS 7.5' Topographic Quadrangle.

The investigation included: a prior project site walkover, literature review, records search at the Los Angeles County Museum of Natural History (LACM) and databases from the University of California Berkeley Museum of Paleontology (UCMP), and this report. All components of this study were completed using currently accepted paleontologic methods that satisfy mitigation requirements for paleontological resources. The survey and investigation was performed in order to: 1) evaluate existing paleontological resources, 2) determine the impact to identified and/or anticipated paleontological resources resulting from the proposed project, and 3) to determine appropriate mitigation measures necessary to minimize anticipated adverse impacts, if any, to paleontological resources resulting from completion of the project.

The project area is largely underlain by the upper member of the upper Cretaceous Chatsworth Formation. The lower member of the upper Cretaceous Chatsworth Formation outcrops along the southern edge and southeast corner of the site. Santa Susana formation outcrops along the western edge and southwest corner of the site and Quaternary Alluvium is scattered over the project. The detailed project site walkover during an associated archaeological survey determined that the sediments are properly assigned to the Chatsworth Formation with a local thin covering of Quaternary sediments. Quaternary Alluvium partially fills some of the drainages. No recorded fossil localities are known from the project site.

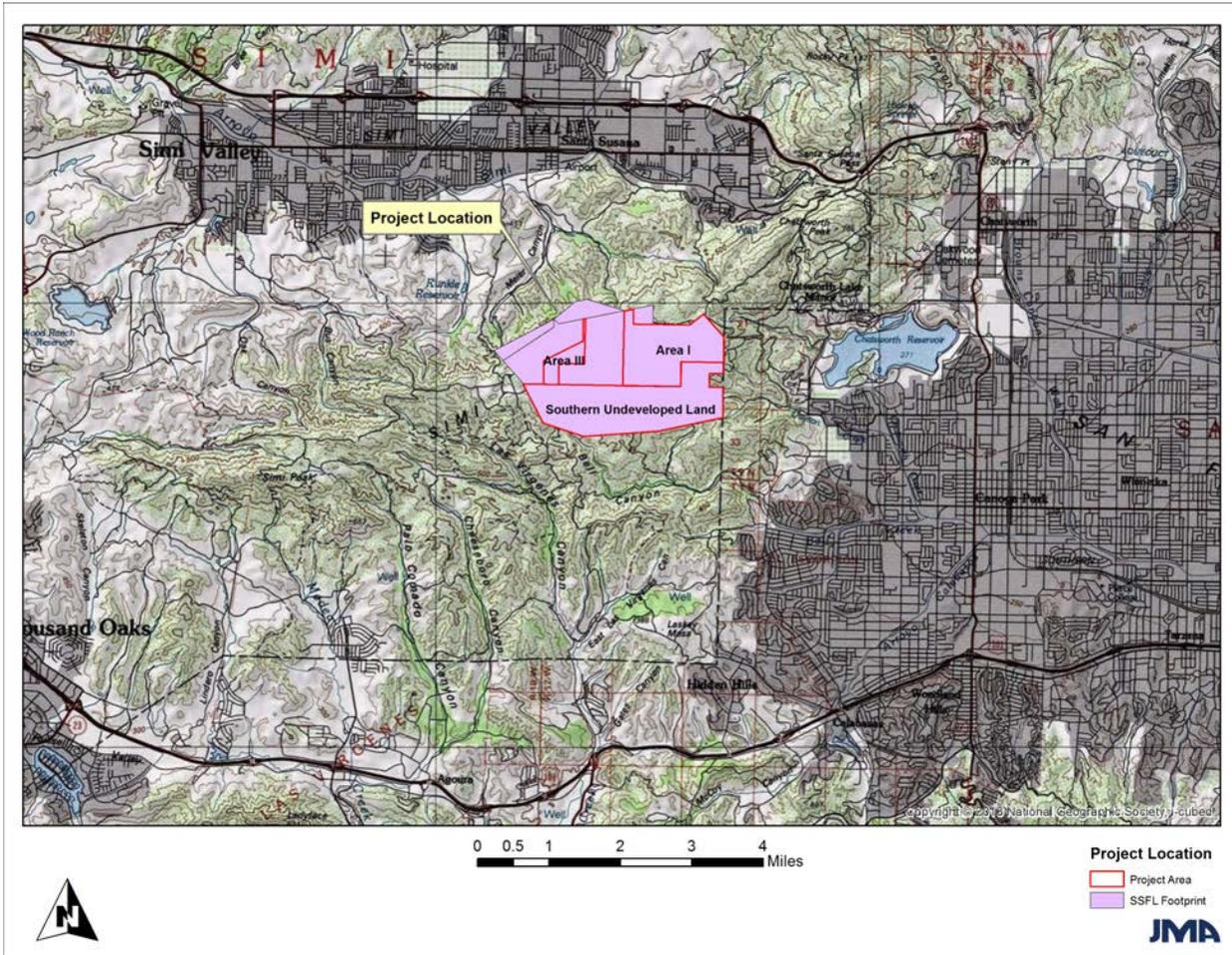
The upper member of the upper Cretaceous Chatsworth Formation has a low to moderate potential. The lower member of the upper Cretaceous Chatsworth Formation has a moderate to high potential. The Santa Susana formation has a high potential and Quaternary Alluvium has a low potential to contain significant paleontological resources.



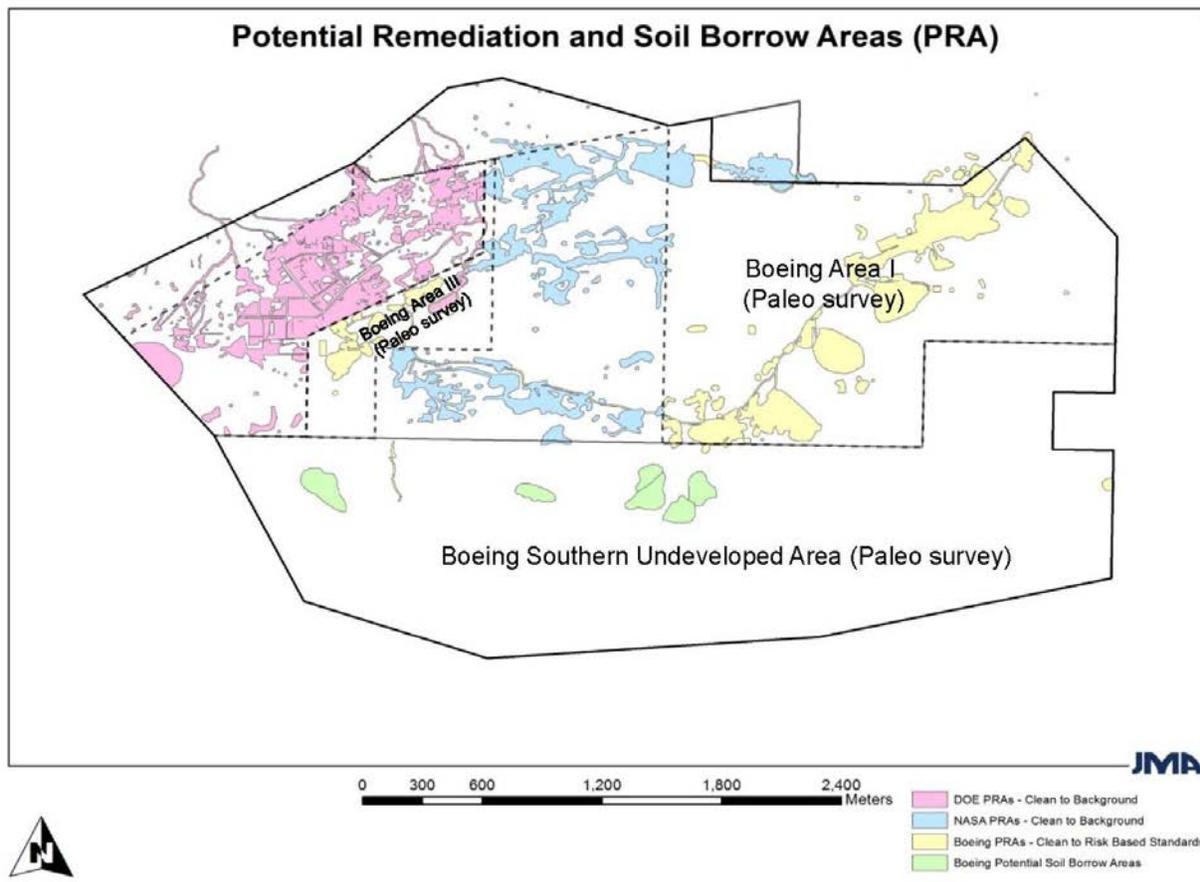
## INTRODUCTION

At the request of Michele Pacanas of The Boeing Company, John Minch and Associates, Inc. (JMA) has undertaken a Paleontological Resources Field Survey for the Boeing Company's portion of the Santa Susana Field Laboratory (SSFL), Simi Hills, Ventura County, California (Figure 1). The SSFL project site is located in northern Ventura County, in the undeveloped Simi Hills, north of Chatsworth and Interstate Route 101 and south of the City of Simi Valley and Highway 118 as depicted on the Simi USGS 7.5' Topographic Quadrangle. Specifically the site occupies a valley/plateau in the summit and upper slopes of the central part of the Simi Hills. Topography is regionally and locally very steep with elevations ranging from about 1,300 to 2,300 feet above Sea Level.

The purpose of this study is to identify the potential paleontological resource impacts associated with the proposed Boeing Company's portion of the Santa Susana Field Laboratory project site on 1940± acres in eastern Ventura County (County). This study has been prepared in conformance with the California Environmental Quality Act (CEQA) Guidelines (Guidelines) that implement CEQA and the County's implementation procedures for CEQA. The survey was performed in order to: (1) evaluate existing paleontological resources of the site and surrounding area, (2) determine if the proposed Project poses any significant adverse impact to existing paleontological resources, and (3) to outline appropriate mitigation measures (if any) in order to minimize adverse impacts to the paleontological resources of the project area.



**Figure 1.** - Regional Location Map of the Boeing Company's portion of the Santa Susana Field Laboratory project site



**Figure 2.** Potential Remediation and Soil Borrow Areas of the Boeing Company's portion of the SSFL Project Site

## **METHODOLOGY OF LITERATURE AND RECORDS SEARCH**

- Review of available geologic and paleontologic literature pertinent to the site, including existing lists of fossils and fossil localities.
- Review of available environmental impact and/or geotechnical reports pertinent to development of the site.
- Review of records searches at the Los Angeles County Museum of Natural History (LACM) and databases of the University of California Berkeley Museum of Paleontology (UCMP).
- A walkover survey of the Boeing Company's portion of the Santa Susana Field Laboratory project site area.

## **RESULTS OF LITERATURE AND RECORDS SEARCH**

A comprehensive literature search was conducted in order to determine pertinent geologic and paleontologic site information, as well as the paleontologic sensitivity of the geologic units underlying the site. The literature search included a review of all available data pertinent to the site, including environmental reports, professional geological publications, paleontological consultant reports, and other unpublished documents related to regional and/or detailed geologic studies. The review also included the location of geologic maps delineating the geology of the rock formations underlying the project site (Dibblee, 2008).

There are a number of publications on the Chatsworth Formation and its predecessor the Chico Formation. Early geologists lumped all of the upper Cretaceous strata in California into the Chico Formation (Kew, 1924). In 1981 Colburn and others, 1981, named the Cretaceous strata in the Simi Hills the Chatsworth Formation (Colburn, 1981, Dibblee, T.W., Jr., 1982, Dibblee, T.W., Jr., 1993 & 2009, Link, M. H., R. L. Squires, and I. P. Colburn, 1981, Welton, B. J. and J. M. Alderson. 1981).

In addition to the literature review, JMA conducted records searches at the LACMNH, which includes the California Institute of Technology and the University of California Berkeley Museum of Paleontology (UCMP) fossil locality data. A thorough review of online databases from the UCMP provided additional data and insured that the JMA review of the literature and records was complete. Pertinent sections of the LACMNH records review report are included in this document. For security purposes, the specific locations of the fossil localities are not included in this report.

The Boeing Company's portion of the SSFL project area is largely underlain by the upper member of the upper Cretaceous Chatsworth Formation. The lower member of the upper Cretaceous Chatsworth Formation outcrops along the southern edge and southeast corner of the site, and the Santa Susana formation outcrops along the western edge and southwest corner of the site and Quaternary Alluvium is scattered over the project. The project site walkover survey was conducted in several phases: 1)

during an associated intensive archaeological survey of the entire project area, and 2) during several short-term paleontological walkovers of critical areas of the site. Scattered traces of marine shells were found in several areas.

## **GEOLOGY / BIOSTRATIGRAPHY**

The northwesterly movement of the part of California that is on the Pacific Plate has compressed and folded the area of the Transverse Ranges Province into an east-west series of folded and faulted ranges and valleys. The Simi hills are an east-west range within this province. The site has been a marine basin from the Cretaceous to the Miocene. The SSFL area is underlain by the Cretaceous Chatsworth Formation, the Paleocene Santa Susana Formation including the Simi Conglomerate member, the Las Virgines Sandstone Member, an unnamed claystone/siltstone member, with Quaternary Alluvium filling some of the low areas.

## **GEOLOGIC UNITS ON SITE**

The geologic units, in ascending order, are the Cretaceous Chatsworth Formation, the Paleocene Santa Susana Formation including the Simi Conglomerate member, the Las Virgines Sandstone Member, and an unnamed claystone/siltstone member, and Quaternary Alluvium (Dibblee, 2008).

### **Chatsworth Formation**

The Chatsworth Formation, named by Ivan Colburn (Colburn et al. 1981); is a late Cretaceous age (Maastrichtian and Campanian Stages) clastic marine formation noted for its light gray to light brown bouldery sandstone outcrops in the Simi Hills. It is hard, coherent arkosic, micaceous, mostly medium-grained, in thick strata separated by thin parings of siltstone. Locally it contains lenses of a gray conglomerate of cobbles of metavolcanic and granitic detritus in a hard sandstone matrix. Although the thick sandstone beds are prominently exposed, other bedding types are present as topographically weak intervals consisting of interbedded mudstone and thin-bedded fine sandstone. These weak intervals generally form the slopes of Bell and Dayton Canyons and appear to underlie the developed low-relief surfaces in the upper parts of the range. The sharp boundary between the steep slopes of Dayton Canyon and the low relief area above it consists of a thin sequence of the hard boulder sandstones. The bouldery part of the Chatsworth Formation is a classic example of a proximal (near the source turbidite sequence) submarine fan with thick sandstone beds separated by thin layers of mudstone/siltstone. The sandy-shaly lower part of the Chatsworth Formation is a classic example of a distal (far from the source turbidite sequence) submarine fan. Changing directions of sedimentation as well as faulting and folding along with the varying thickness of individual beds limits the subdivisions of the Chatsworth Formation. The thicker beds of siltstone in the lower part of the Chatsworth indicates that this part of the formation was more distal from the source and thus contained more silt and mud. This caused this part of the formation in this area to form less of the bouldery outcrops.

The strata identified as the Chatsworth formation is a massive turbidite fan complex. Close to the source, and in the fan channel, the sediments consist of massive-thick coarse sand and gravel beds with little to no thin silt/mudstone layers. Further out on the fan the sandstone beds are thinner and the silt/mudstone beds are thicker until in the distal end of the fan complex there are only silt/mudstone layers. The fan-channel shifts over the fan resulting in the deposition of thicker beds over thinner beds in any given area. The changing thickness of the beds in the SSFL represents a change in the position of the fan-channel and thus is only locally a mappable unit.

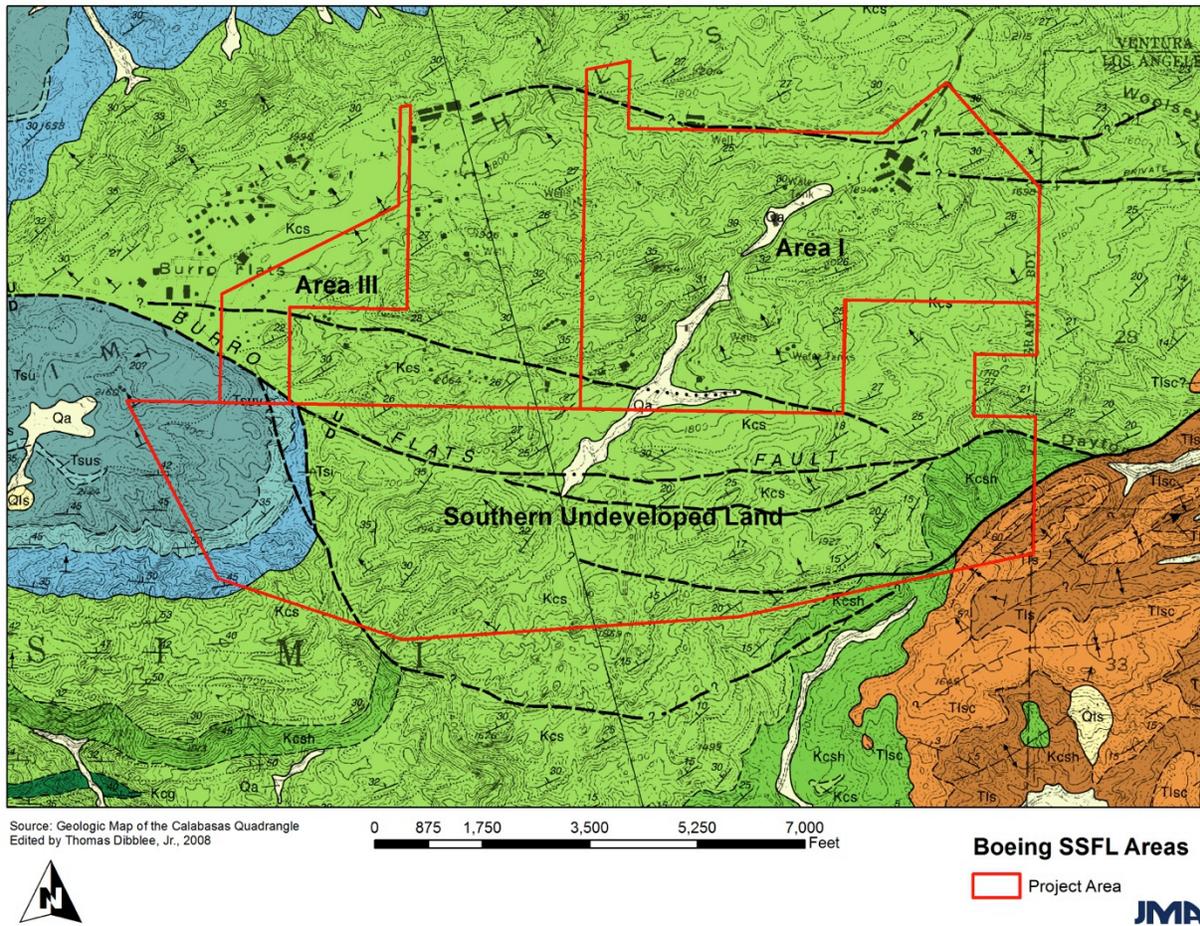
### **Santa Susana Formation**

The lower Eocene and Paleocene Santa Susana Formation unconformably overlies the Chatsworth Formation. Dibblee (2008) included the Simi Conglomerate, the Las Virgines Sandstone, and an unnamed claystone/siltstone as members of the Santa Susana Formation. The formation varies from non-marine to marine. This formation outcrops in the west side of the Southern Undeveloped Land (SUL) and will not be affected adversely by the proposed remediation activities. It is, however, highly fossiliferous and any activity on this area will need to be carefully monitored.

### **Quaternary Alluvium**

Surficial gravel, sand, and clay sediments mapped (lumped) as Quaternary Alluvium cover many of the broad valley floors, and is present in the secondary canyon floors. They are typically 5 feet thick or less in thickness. These sediments typically represent ephemeral lakes and ponds in the otherwise dry local area.

In a personal communication to John Minch, editor of the Dibblee (2008) Calabasas 7.5' geologic map, Dibblee described the main project area as being thinly mantled with Quaternary Alluvium in many areas (Personal Communication, 2008).



**Figure 3.** Geologic Map of SSFL Project Site (Dibblee, 2008)

*(Project Geologic Map Units)*

**Qa** – Quaternary Alluvium

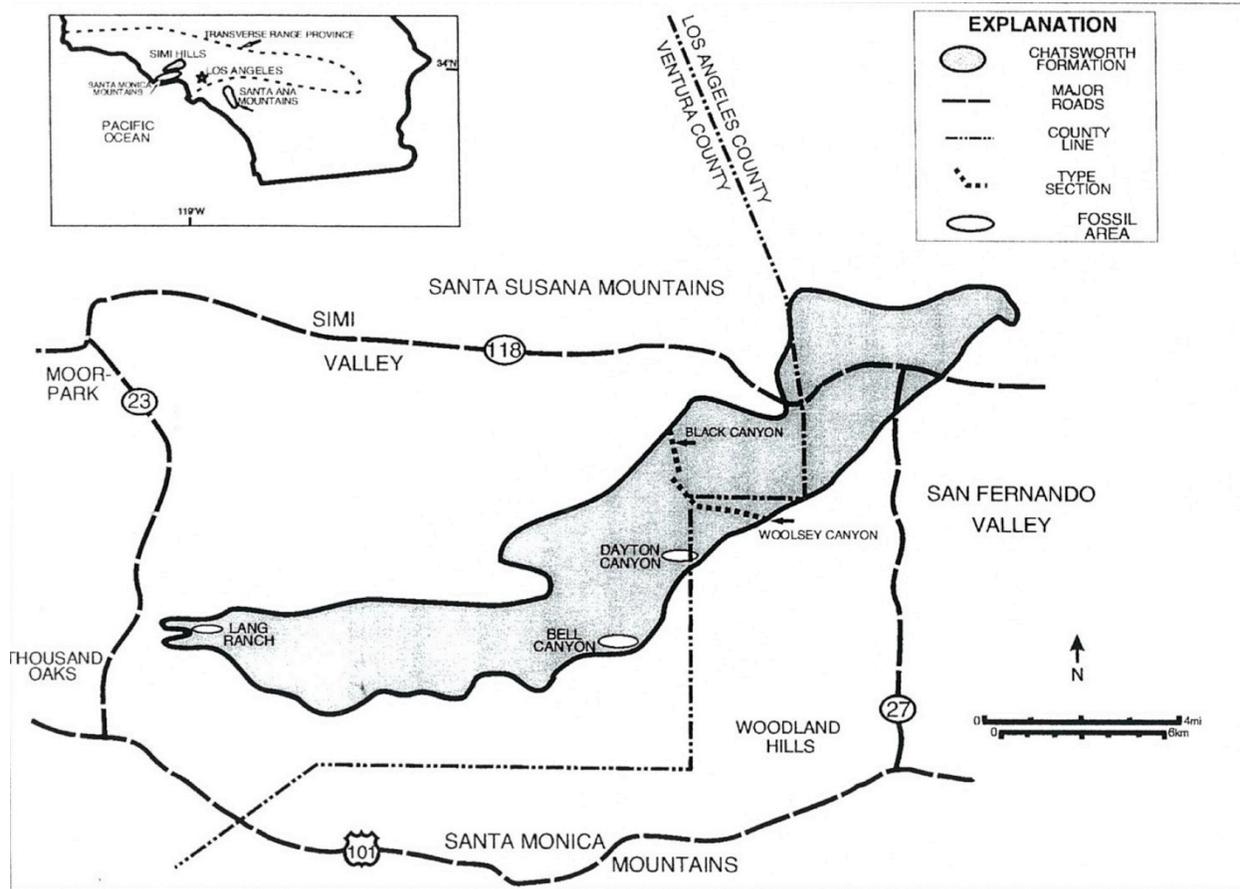
**Tsu** – Santa Susana Formation (Upper unit)

**Tsus** – Santa Susana Formation (Upper Sandstone)

**Tsi** – Santa Susana Formation (Simi Conglomerate Member)

**Kcs** – Chatsworth Formation –Sandy facies (Upper Member)

**Kcsh** – Chatsworth Formation – Shaley facies (lower Member)



**Figure 4** – Distribution of Chatsworth Formation Outcrops with Major Fossil Areas

## **PALEONTOLOGIC RESOURCES ON THE PROJECT SITE**

The review of the LACMNH and UCMP records, fossil lists, published and unpublished literature indicated that no known paleontologic resource localities are recorded from the project area. However, one fossil locality is right on the boundary of the SSFL (LACMIP locality 10716). This locality contains a well-preserved and significant invertebrate fauna. The lack of fossil localities on the SSFL site may be a function of the restricted access nature of the SSFL.

## **RESULTS OF WALKOVER SURVEY**

A paleontological walkover survey of the SSFL project area was conducted during an archaeological survey by a field crew under the direction of Mr. Richard Guttenberg and Dr. Ray Corbett (archaeologists) assisted by Dr. John Minch (paleontologist) in September 2013. A brief paleontological field survey was conducted in September 2014 under the direction of Dr. John Minch (paleontologist) assisted by Mr. Richard Guttenberg. Paleontological resources were encountered in the thin siltstone layers in several locations on the site during the walkover surveys. No recorded fossil localities were located within the boundaries of the Boeing Company's portion of the Susana Field Laboratory project site during the review of the LACM and UCMP records, fossil lists, published and unpublished literature.

## **REGIONAL PALEONTOLOGICAL RESOURCES OF SITE UNITS**

The review of the LACM and UCMP records, fossil lists, published and unpublished literature indicated that a number of paleontologic resource localities are recorded from the Chatsworth Formation. JMA found extensive references in the literature to the fossiliferous nature of the Chatsworth Formation. JMA also interviewed and conferred with several of the local experts on the Chatsworth Formation.

### **Chatsworth Formation Fossils in the Literature**

The dividing of the Chatsworth Formation into an upper sand rich unit and a lower shale rich unit is a locally mappable division. The upper part of the Chatsworth in this area is more proximal to the source area and thus contains thick sandstone beds. The shaley (generally more fossiliferous) beds in the upper unit are thin making any fossils difficult to find. The lower part of the Chatsworth in this area is more distal to the source area and thus contains thicker shale/siltstone beds making fossils easier to find.

Early discussions of the presence of fossils of Middle Campanian, Upper Campanian, and early Maestrichtian age in the Cretaceous strata and discussions of the faunas are found in Anderson (Anderson 1902:26), Waring (1917), Kew (1924), Popenoe (1936, 1942), Zebal (1943) and Popenoe (Popenoe 1955:212). A guidebook and a number of papers on the Chatsworth Formation were published in 1981.

Fossils in the upper part of the Chatsworth Formation are rare and often referred to as being non-existent. Few assemblages were deposited on the upper slopes. However they are there and would be significant if found.

Fossils in the lower part of the Chatsworth Formation are also referred to as rare. However, there are numerous vertebrate and invertebrate fossils, including gastropods, cephalopods, pelecypods, echinoderms, and brittle stars which tend to be found in the thicker shales. Saul and Alderson reported gastropods, cephalopods, and pelecypods and estimated that more than 100 species of not yet described mollusks have been found the lower part of the Chatsworth Formation (Saul and Alderson, 1981). Bottjer (1981) reported trace fossils. PaleoBiology Database records four gastropod species (*Perissitys colocara*, *Perissitys pacifica*, *Murphitys Madonna*, and *Murphitys corona*) from the Chatsworth Formation. Stecheson completed a significant work on the Systematic Paleontology of the gastropods in the Chatsworth Formation (Stecheson, 2004). Welton and Alderson recorded shark teeth and fish bone in two locations within the lower member of the Chatsworth Formation in association with mollusks. The fish remains were recovered by dissolving the rock in formic acid, which produced teeth, vertebrae, and placoid scales (Welton and Alderson, 1981). The majority of these fossils have been found within the lower member of the Chatsworth Formation in Dayton and Bell Canyons (Link et al., 1981; Saul and Alderson, 1981; Waring, 1917; Welton and Alderson, 1981). Several microfossil sites are located in the upper and lower members of the Chatsworth Formation. These include benthic foraminifera (Almgren, 1981) and calcareous nanofossils (Filewicz, 1981), which have contributed to identifying the age and depositional setting of the formation (Colburn et al., 1981a).

## **LACM Fossil Locality Records Search and Personal Interviews:**

### **Chatsworth Formation**

LACM records produce: “Most of the Boeing proposed project area has exposures of the marine late Cretaceous Chatsworth Formation. Our closest vertebrate fossil localities from the Chatsworth Formation are LACM 4913-1914, in Dayton Canyon just outside the eastern boundary of the proposed project area, that produced fossil shark specimens including sand sharks, *Carcharhiniformes*, mackerel shark, *Cretolamna appendiculata*, crow shark, *Squalicorax kaupi*, dogfish shark, *Squalus*, and angel shark, *Squatina hassei*. Specimens of all of these sharks from localities LACM 4913-4914 were figured in the scientific literature by Welton and Alderson (1981)” (McCloud, 2014, Written Communication).

The author personally visited with and interviewed the following: Lindsey Groves, Los Angeles County Museum Institute of Paleontology (LACMIP) Malacology Collections Manager; Mary Stecheson, LACMIP Collections Manager, (Retired); Louella Saul, Research Associate (Cretaceous) at LACMIP; and John Alderson, Research Associate (Cretaceous) at LACMIP. Each one of these people are considered an expert on the Cretaceous and the Chatsworth Formation.

The consensus of the group is that the lower member of the Chatsworth Formation is moderate to locally highly fossiliferous. There was also a concurrence that the Lang Ranch Fauna in siltstone facies of the Chatsworth Formation in the western Simi Hills is lower Maastrichtian and the same age as the sandstone facies of the upper Chatsworth Formation unit in the Boeing Administrative area of the SSFL. However, the fossils are typically found in the shales, which are thin and tight in the upper Chatsworth Formation.

### **Santa Susana Formation**

LACM records produce: “In the far western and northwestern portions of the proposed project area there are exposures of the marine Paleocene Santa Susana Formation. Our closest vertebrate fossil localities from the Santa Susana Formation area LACM 3216 and 4157. Locality LACM 3216 is on the tip of the main ridge which forms the west side of Meier Canyon just west of the northwestern-most portion of the proposed project area. Locality LACM 3216 has produced a fossil shark fauna containing the sharks *Lamna*, *Isurus*, *Synechodus*, the eagle ray *Myliobatis*, and several chimaeroids (‘ratfish’ - shark relatives). Of particular note, LACM 3216 produced the holotype (name bearing specimen) of the *chimaeroid Ischyodus zinsmeisteri*, published by S. P. Applegate (1975. A New Species of Paleocene Chimaeroid from California. Bulletin of the Southern California Academy of Sciences, 74(1):27-30). Locality LACM 4157 also occurs on the western side of Meier Canyon, but further to the southwest of locality LACM 3216, and produced specimens of the uncommon fossil shark *Deania*.” (McCloud, 2014, Written Communication)

No activity is expected in this area, therefore, this area will have no paleontologic sensitivity with regards to this project. However, there will be paleontologic sensitivity if one of the borrow areas of the Boeing Company’s portion is within the Santa Susana Formation.

### **Quaternary Alluvium**

The Recent Alluvium (10,000 years or less), at or near the surface, is too young geologically to contain significant fossils. However, the Recent Alluvium frequently overlies and is confused with Older Quaternary Alluvium which is known to contain significant fossils in many places in southern California.

Older Quaternary alluvial sediments, mapped as Qa and Qoa, elsewhere in California (principally in southern California) have been reported to yield significant fossils of extinct animals from the Ice Age. Fossils vertebrates recovered from these Pleistocene sediments represent extinct taxa including mammoths, mastodons, ground sloths, dire wolves, short-faced bears, saber-toothed cats, large and small horses, large and small camels, and bison (Jefferson, 1991; Reynolds and Reynolds, 1991; Scott, 1997; Springer and Scott, 1994; Springer et al., 1998, 2007; Woodburne, 1991).

## The Value Of Fossils And Their Usefulness In Determining Ancient Environments

The presence of different fossil species in a deposit can all help reveal details of the paleoenvironments under which particular rock units were deposited. In addition to simply revealing which species of animals were present, the fossil record can also give indications of previous climates and paleo-temperatures, topography, geography, rainfall, and proximity to water bodies.

### PALEONTOLOGIC SENSITIVITIES, SIGNIFICANCE AND IMPACTS

Potential impacts to paleontological resources are directly related to the potential for the discovery of fossils in a rock unit. 1) Rock units with a known record of discovery of fossils have a likelihood that additional fossil resources will be discovered during excavations in the rock unit. 2) Rock units with environments of deposition that typically produce fossils have the likelihood that additional fossil resources will be discovered during excavations in the rock unit.

Geologic Unit	Paleontologic Sensitivity Rating
Upper Chatsworth Formation	Low-to-Moderate
Lower Chatsworth Formation	Moderate-to-high
Santa Susana Formation	High
Quaternary Alluvium	Low

**Table 1 - Paleontologic Sensitivity of Geologic Units.**

#### **Upper Sandstone Member of Chatsworth Formation – Low to Moderate Paleontologic Sensitivity**

The Upper sandstone Member of the Chatsworth Formation underlies the majority of the area covered by the project. The Upper sandstone Member of the Chatsworth Formation sediments of the area are not known to locally contain significant fossils, therefore, there is a low to moderate potential for significant paleontological resources on the portion of the site underlain by the Chatsworth Formation. The upper Chatsworth Formation is considered to be of low-to-moderate paleontologic sensitivity.

#### **Lower Shale Member of Chatsworth Formation – Moderate to High Paleontologic Sensitivity**

The lower shale Member of the Chatsworth Formation underlies the southern part of the area covered by the project. The Chatsworth Formation sediments of the area are known to regionally and locally contain significant fossils, therefore, there is a moderate



to high potential for significant paleontological resources on the portion of the site underlain by the Chatsworth Formation. The lower Chatsworth Formation is considered to be of moderate-to-high paleontologic sensitivity.

### **Santa Susana Formation - High Paleontologic Sensitivity**

The lower Eocene to Paleocene Santa Susana Formation unconformably overlies the Chatsworth Formation. The Santa Susana Formation sediments of the area are known to regionally and locally contain significant fossils, therefore, there is a high potential for significant paleontological resources on the portion of the site underlain by the Santa Susana Formation. The Santa Susana Formation is considered to be of high paleontologic sensitivity. This formation outcrops in the western portion of the Southern Undeveloped Land. It contains no developed area and will not be affected adversely by the proposed remediation activities.

### **Quaternary Alluvium - Low Paleontologic Sensitivity**

Quaternary Alluvium on the site covers or partially covers a number of the broad valley floors, and is locally present in the secondary canyon floors. It is largely exposed in isolated outcrops and is typically 5 feet or less in thickness.

Younger Quaternary alluvial deposits found in all the drainages typically do not contain significant vertebrate fossils, at least in the uppermost layers, but they may well contain significant vertebrate fossil remains at depth in older deposits. "Shallow excavations in the younger Quaternary Alluvium sand and gravels exposed are unlikely to encounter any significant vertebrate fossils. Any shallow excavations in alluvium in the proposed project area have a low paleontologic sensitivity. Deeper excavations in the proposed project area may have a moderate paleontologic sensitivity."

## **RECOMMENDATIONS**

### **Paleontological Resources Monitoring and Mitigation Plan (PRMMP)**

JMA recommends that a Paleontological Resources Monitoring and Mitigation Plan (PRMMP) should be developed in compliance with CEQA and other relevant legislation, and be implemented for activities that would extend to the moderate-to-high (lower Chatsworth Formation), and high (Santa Susana Formation), sensitivity formations. The PRMMP should outline a coordination strategy so that construction disturbances would be monitored adequately. The PRMMP should stipulate the frequency of monitoring, methods of sampling and other appropriate procedures. The PRMMP should detail methods of recovery, post-excavation preparation and analysis of specimens, final curation of specimens at an accredited facility, data analyses, and reporting. The PRMMP should stipulate that paleontological work during this project will be conducted by qualified professionals.



## **Construction Personnel Training**

For activities that extend into the moderate to high, and high, sensitivity lower Chatsworth and Santa Susanna formations construction personnel should be trained in recognizing possible buried paleontological resources and protecting paleontological resources in compliance with CEQA and other relevant legislation. This training should occur before activities that could affect the moderate-to-high (lower Chatsworth Formation) and high (Santa Susana Formation) sensitivity formations. Construction personnel should be trained on the procedures to be followed upon the discovery of paleontological materials. Personnel should be instructed that unauthorized collection or disturbance of fossils is unlawful.

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