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8 March 2007

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Subject: Post-Fire Vegetation Recovery – Phase 1
Boeing Santa Susana Field Laboratory
Geosyntec Project: SB0363A

Dear Mr. Costa:

Geosyntec Consultants (Geosyntec) is pleased to provide The Boeing Company this initial Phase 1 study regarding post-Topanga-fire erosion recovery at the Santa Susana Field Laboratory (SSFL) (project site). The overall objective of the study was to assess the status of and time to erosion control recovery at the site, subsequent to the September 2005 Topanga fire. The term "recovery" is defined, for the purposes of this analysis, as vegetative and soil conditions that are statistically indistinguishable for comparable burned and unburned areas, therefore indicating that post-Topanga-fire erosion controls and sediment yields will have returned to normal, pre-Topanga-fire conditions.

The specific objective of the Phase 1 study was to provide an initial semi-quantitative assessment of recovery based on literature review and reconnaissance-level survey of conditions at the project site. The 2nd and planned final phase will include a quantitative vegetation survey of the site, timed to occur during the annual species' peak bloom period, which typically occurs in the spring.

The initial findings from this Phase 1 study suggest that watershed recovery time following a fire is highly variable and dependant upon many factors, however the literature reviewed generally describes the breakdown of water repellency (or the hydrologic effect that fire has on soils) in surface soils to occur within one to three years, and the vegetative recovery in chaparral habitats to occur within approximately six years, plus or minus two years. Both the soil and the vegetative conditions need to be restored for a watershed to be considered recovered in the context of erosion control and sediment yield, and therefore six years (plus or minus two years) serves as an appropriate and preliminary – "preliminary" in that it is subject to refinement during the Phase 2 quantitative survey – estimate of recovery time for the site. The Phase 1 reconnaissance-level survey also confirmed that vegetation at the project site appears to be recovering at rates comparable to this literature-derived recovery time range.

As part of phase 1, a post-fire reconnaissance-level vegetation survey was performed by Western Botanical Services, Inc. (WBS). Wright Water Engineers, Inc. (WWE) provided a technical appendix to WBS' Phase 1 vegetation recovery report, specifically addressing the hydrologic and sediment yield recovery of similar habitat-type watersheds following fires. Additionally, WWE provided peer review of the Phase 1 study, contributing input that will also assist in the development of the work plan for Phase 2, which will consist of a detailed field-level survey and quantitative assessment of status of and time to near-complete recovery at the site.

In the context of stormwater quality, wildfires such as the Topanga Fire can increase stormwater runoff volumes, peak runoff flows, discharge frequencies, sediment concentrations, and concentrations of sediment-associated pollutants such as TCDD and total metals. Therefore, the study is focused on measurable parameters -- most notably vegetation type/cover, which affect soil stability and erosion potential, and soil water repellency -- which most directly impact these stormwater-related conditions of concern.

Summaries of WBS' and WWE's findings on anticipated time for post-fire vegetation and hydrologic recovery are included below. The bibliographic references to citations in this letter are included in the attached reports.

Summary of Vegetation Recovery Literature Review and Site Observations (WBS)

The rate of vegetative recovery following fires is somewhat consistent and predictable based on the initial literature reviewed, but varies according to location of plant communities and other site-specific factors (e.g., slope, aspect, elevation, etc.). The rate of recovery for chaparral communities is greatest during the first six years following a fire, then recovery slows down through the eighth year (Hanes, 1971). By the fifth year following a fire, chaparral resprouts and seedlings dominate the vegetative cover (Hanes, 1971), and stands of chaparral are expected to recover 50 percent of their pre-burn biomass by the eighth year (Wright and Bailey, 1982). Studies have also shown that, following a fire, vegetative cover can increase from approximately 65 percent total cover in the first/second year to almost 150 percent cover in the fifth year (Grace and Keeley, 2006). However, as the following sections indicate, total vegetative cover alone does not fully demonstrate the extent to which erosion controls and sediment yields have recovered in a burned watershed.

Beyond total vegetative cover, the presence of annual species is also significant, with observed conditions at the project site being consistent with literature describing the status of post-fire recovery after two years. It is expected that annual grasses and forbs (soft, leafy annuals) will prevail during spring and summer 2007, the second growing season following the fire. Evidence of abundant grass seedlings and newly germinating forbs were present during the February 2007 survey. The presence of annuals (e.g., herbaceous species and grasses) is significant from an erosion control perspective because the shallow-rooted annuals can provide protection against impact erosion on bare soil until the deeper-rooted perennials become established. Perennials such as chaparral, however, return more slowly, yet have root structures that are comprised of both deep and shallow roots and are generally capable of holding more soil in place during runoff-producing storm events.

Overall, all areas observed at the project site show signs of regeneration as resprouts and seedlings, consistent with findings in the literature related to fire and chaparral. In the event that weather patterns are somewhat normal[1] over the next 20-30 years[2], and in the absence of any catastrophic events on the burned areas, it is expected that the burned chaparral on the project areas will follow the growth patterns described in literature for recovery of chaparral and coastal sage scrub communities.

Summary of Hydrologic Recovery and Sediment Yield Literature Review (WWE)

For the purposes of this review, hydrologic and sediment yield recovery is defined as the return of a watershed to its pre-fire condition in terms of its rainfall-runoff and sediment yield relationship characteristics. Though hydrologic and sediment yield recovery of a burned watershed is a function of multiple factors, two variables that have the greatest effect are vegetation type and cover (covered in WBS' literature review and visual observations of the site), and soil water repellency.

Consistent with WBS's findings, WWE's literature review findings suggested that the dominant chaparral community recovery increases rapidly in the first few years following a fire and less rapidly in the years thereafter. The chaparral community is essentially mature about 25 years following the fire.

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[1] It is worth mentioning here that the current rain season of 2006/07 is, to date, the driest on record. Ensuing climatic conditions, such as continued drought, may effect actual time to recovery at the project site.

[2] Prior to the Topanga 2005 fire, the last major fire to burn most of the site was in 1970. Smaller portions of the site, particularly along its eastern and western edges, were burned during other fires that occurred in the early 1980's.

After a fire, soil water repellency can be found as a discrete layer of variable thickness on the soil surface a few centimeters below and parallel to the surface. It is widely recognized that this fire-induced water repellency is a key parameter affecting post-fire runoff and erosion rates. The persistence of this layer is highly variable and little data exist regarding the return of soil water repellency to pre-fire conditions; studies cited in WWE's appendix suggest that pre-fire repellency may be achieved between one and three years post-fire (McDonald and Huffman, 2004; WWE, 2003).

The literature provides little information on the long-term recovery of burned watersheds with respect to hydrology and sediment yield. Generally, hydrologic recovery time is highly variable and some studies cite ranges between four to five years for an Australian grassland watershed (Brown, 1972) to approximately 20 years for a watershed characterized by sage-pinion-juniper vegetation (WWE, 2003). However, no literature was found reporting on sediment yield recovery times for chaparral habitats. Therefore, given this notable uncertainty, the Phase 2 quantitative assessment will be important in evaluating the status of and time to near-complete hydrologic and sediment yield recovery for the site.

Path Forward – Phase 2

Phase 2 of the study will follow in April and will include a quantitative assessment of recovery through the measurement and analysis of selected vegetation and soil characteristics at the project site. Vegetative, hydrologic, and sediment yield recovery will be defined using measurable site-specific metrics as part of the Phase 2 work plan, and will be fundamentally based on statistical comparisons between burned and unburned (control) areas at or near the project site. Phase 2 of the study will be critical for providing a more precise and site-specific estimate of time to recovery for the project site.

Sincerely,

Ronald S. Johnson

Ronald S. Johnson, PE
Associate

Brandon M. Steets

Brandon Steets, PE
Project Manager

Attachments: 1. Post-Fire Vegetation Recovery Reconnaissance Survey Report, prepared by WBS.
2. Technical Appendix G: Hydrologic Recovery of Watersheds Following Fire, prepared by WWE.

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Western Botanical Services Inc.

DRAFT Post-Fire Vegetation Recovery Reconnaissance Survey Report

Boeing Santa Susana Field Laboratory

Prepared for:

Geosyntec, Inc.

924 Anacapa Street, Suite 4A
Santa Barbara, CA 93101

Contact: Brandon Steets, Project Manager

March 8, 2007

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Executive Summary

The 2005 Topanga fire burned nearly the entire approximately 2,850 acres of the Boeing SSFL (project site), located in the Simi Hills of Ventura and Los Angeles Counties. The purpose of this vegetation survey and the subsequent Phase 2 survey is to assess the status of vegetation regeneration at the site, subsequent to the September 2005 Topanga fire. This Phase 1 survey, focused on visually comparing dominant vegetative cover of the areas of the project site that burned in the 2005 Topanga fire to those areas of similar habitat type that did not burn, and performing an initial literature review. A quantitative assessment, including collection and analysis of vegetation field data, will follow as Phase 2 of this study later this spring to evaluate recovery of vegetation on the project site.

A Western Botanical Services Inc. (WBS) biologist conducted a reconnaissance-level botanical survey in February 2007 in order to gain an understanding of the general existing conditions and to evaluate locations and quantities of transects for Phase 2. This survey identified general and specific vegetation common to the project site. This survey also included the measurement of vegetative cover in four transect locations.

Overall, all areas observed show signs of regeneration as resprouts and seedlings as expected based on the findings in the literature related to fire and chaparral. Woody-stemmed plants, which have deeper roots and, therefore, provide greater structure in the soil horizons (i.e., better stabilization of soil), return more slowly than grasses and other rapidly growing, shallower-rooted species. Based on a review of the literature, vegetative recovery occurs most rapidly during the first 6 years of regrowth and less rapidly thereafter. In the event that weather patterns are somewhat normal over the next 20-30 years, and in the absence of any catastrophic events on the burned areas, we expect the burned chaparral on the project areas to follow the growth patterns described in literature for recovery of chaparral and coastal sage scrub communities.

The time frame for vegetation recovery described in the literature is necessarily broad, as the establishment and growth of vegetation is dependant upon several factors, e.g. vegetation type, soil conditions, fire severity, climatic conditions. Quantitative botanical surveys conducted during spring/summer 2007 will provide a more thorough evaluation of species diversity and cover by vegetation in the burned areas, thus providing a more complete picture of how the vegetation is recovering in the different areas throughout the project site.

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Post-Fire Vegetation Recovery Reconnaissance Survey

Report for Boeing Santa Susana Field Laboratory

Purpose and Scope

This report summarizes the results of a Phase 1 reconnaissance-level botanical survey at the Santa Susana Field Laboratory (SSFL) (project site), located in the Simi Hills of Ventura and Los Angeles Counties (Figure 1). The purpose of this survey and the subsequent Phase 2 survey is to assess the status of vegetation regeneration at the site, subsequent to the Topanga fire which burned throughout the site between September 28 and October 5, 2005. A quantitative assessment, including collection and analysis of vegetation field data, will follow as Phase 2 of this study later this spring to evaluate recovery of vegetation on the project site since the fire. Vegetative "recovery" will be defined using measurable site-specific metrics as part of the Phase 2 work plan, and will be fundamentally based on statistical comparisons between burned and unburned (control) areas at or near the project site.

Introduction

The 2005 Topanga fire burned approximately 70 percent of the approximately 2,850-acre project site. In order to gain an understanding of the general existing conditions and to determine locations and quantities of transects to run during the follow-up (Phase 2) quantitative assessment surveys, a Western Botanical Services Inc. (WBS) biologist conducted a reconnaissance-level botanical survey in February 2007. During this survey, the focus was on visually comparing dominant vegetative cover of the areas of the project site that burned in the 2005 Topanga fire to those areas of similar habitat type that did not burn.

February is a suboptimum time for vegetation surveys. The optimum time to conduct botanical surveys is in the spring and summer when both annual and perennial species are present, blooming, and identifiable. Therefore, the reconnaissance survey conducted in February 2007 did not capture a complete picture of the species diversity and cover by species, as many annual species were not present or identifiable. Quantitative botanical surveys conducted during spring/summer 2007 will provide a more thorough evaluation of species diversity and cover by vegetation in the burned areas, thus providing a more complete picture of how the vegetation is recovering in the different areas throughout the project site.

Methodology

On February 5-9, 2007, the field crew conducted a reconnaissance-level field survey during the hours of 7:00 am – 4:30 pm. The field crew for this survey included Jeannette Halderman, a subcontracted botanist to WBS and Ryan Smith, a Geosyntec geologist. A Boeing employee was present during the entire survey to escort the consultants to survey locations and to take photographs at chosen photo points.

Field crews used a 1”=600’ aerial photograph taken prior to the September 2005 fire as a reference in the field and to document vegetation and other information observed during field surveys. Information layers printed on the aerial photograph base included project boundaries, unburned vegetation boundaries, watershed boundaries, outfall locations, post-fire aerial mulch application boundaries, post-fire truck mulch application boundaries, and best management practice treated areas.

Plant community maps of the project site available at the time of the survey included the California Department of Forestry and Fire Protection & US Forest Service (USFS) vegetation map (GIS layer, metadata from 2005), and a GIS layer for plant communities mapped by MWH Americas, Inc. (MWH Americas, Inc., 2005). Soil Conservation Service (SCS) soil maps for Los Angeles and Ventura Counties (1970) were also available as a GIS layer.

Prior to the reconnaissance field survey, WBS botanists reviewed available literature applicable to the project site conditions including books, articles, and scientific papers on fire ecology and post-fire recovery of chaparral, scrub, riparian and oak woodland communities. We also reviewed soil maps, vegetation maps (discussed above), fire history and fire intensity maps of and areas surrounding the project site. A list of literature and maps reviewed is listed in Reference Cited section of this report. This literature and additional literature will be more thoroughly reviewed as part of the Phase 2 survey.

Figure 1. Location Map

Qualitative Survey Methodology

Visual Observation

Field surveys were conducted on foot and by car from accessible roads and trails. Areas were evaluated by watersheds identified on the map as referenced by Outfall number locations. Most of the areas were observed visually from the road or trail. Field crews surveyed some areas on foot, up to 700 feet from the road or trail, to get a general understanding of seedling germination, soil condition, to collect samples of plants for identification purposes, document presence of mulch, and to observe upstream and downstream of drainages that were not visible from roads or trails.

During the surveys, the areas observed were mapped on the aerial photograph by habitat types (excluding microhabitats at this time), based on dominant species present and by cross-referencing USFS and Montgomery Watson vegetation maps. Field crews visually observed approximately 70 percent of the project area (Figure 2). The USFS vegetation GIS layer and the 2005 vegetation community map by MWH Americas, Inc. (Appendix A) were referenced and cross-checked during field surveys. The majority of the areas observed and mapped were as shown on the MWH Americas, Inc. vegetation map. Based on this observation, the assumption was made that the vegetation types for the remaining 30 percent of the project site are approximately as shown on the referenced MWH Americas, Inc. vegetation map (Appendix A).

During the field surveys, plant species present and identifiable were noted (Appendix A). An estimate of percent cover for each identifiable species was estimated visually from accessible roads and trails. The plant root establishment was estimated by visual observation of the above-ground portion of the plants (living or dead), and presence of crown and aerial resprouting in burned areas. In burned areas, field crews noted resprouting vegetation by species (when identifiable), estimated averaged diameter of remaining burned stems, estimated percentage of shrubs resprouting, and height of resprouting vegetation. Remnant vegetative stalks and old flower heads from previous years' growth, perennials, and seedlings were also noted and identified by species when possible.

The diameter of burned branches following a fire were documented in a 1990 study by DeBano (Debano, et al., 1998) looking at loss of biomass and severity of burns. Severity of a fire can often affect the rate of species recovery and species diversity. Therefore, the average diameter of burned branches/stems was estimated for the areas that were observed during the survey.

Presence of mulch was generally noted in areas documented as being aerially and truck mulched following the fire in December 2005. The mulch was a combination of wood and paper fiber mulch combined with organic binders (American Civil Constructors, 2005).

The condition of the surface soil was also documented between vegetation and bare ground, and the presence of remaining mulch or visible erosion was noted.

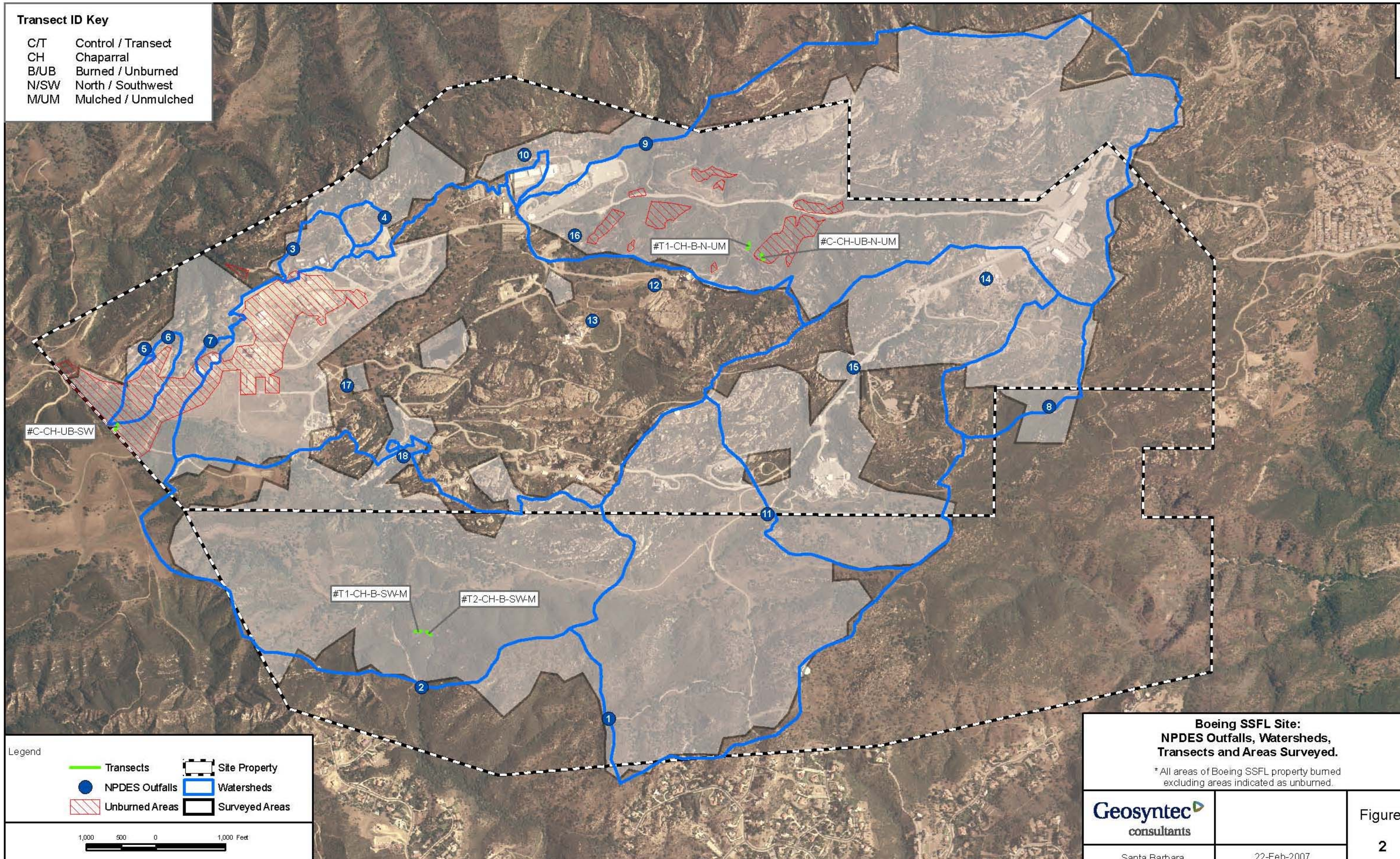
Information collected at each representative location is documented on field forms provided in Appendix B.

Since the goal of this project is to compare the vegetation in burned and unburned areas of the project site, this initial survey also included assessment of potential areas suitable for quantitative data collection during spring 2007 surveys. As part of this assessment, we identified and described the small percentage of unburned vegetation on the project site.

Photographs

Digital photographs were taken of Outfalls 1-11, 14-15 & 18 and surrounding areas, representative plant communities, and along transects. Boeing staff used their Sony digital camera to take photographs where directed by the field crew. The photographs were saved electronically as jpg files. All photographs were recorded on a photo log (see Appendix C).

Figure 2. Site Map



Quantitative Survey Methodology

Transect data were taken solely to get an idea of species composition for burned and unburned areas and to estimate number and locations of transect for data collection as part of Phase 2, to be conducted in Spring 2007. These data were also collected to verify visual estimates of species cover collected throughout the project site. These data were by no means collected to represent statistical findings or to make conclusions of the condition of the post-fire recovery for the entire project site.

Once all qualitative data were collected, two “control” areas were chosen to be used as references of unburned vegetation. These “control” areas were chosen based on presence of unburned chaparral habitat, slope aspect, percent slope, and soil type. Since only a small percentage of unburned vegetation is present within the project site boundaries, all these areas were considered. Those areas that were similar in slope aspect, percent slope, soil type, and vegetation type were chosen to serve as vegetative sample locations. Random transects were chosen within these unburned control and burned sample areas.

Since soil type often is responsible for the presence or absence of plant species, all sample areas were selected in areas with the same soil type: Gaviota rocky sandy loam. Slope aspect is also a known variable to affect the distribution of plant communities, therefore, slopes with southerly aspect were looked at separately than slopes with northerly aspect.

The beginning and end of each 100 foot long transect were marked with fiberglass pinstakes (4’ tall). Compass bearings, Global Positioning System (GPS) coordinates, and photo points at each end of the transects were collected to document each transect (see Figure 2). GPS information was documented on the GPS log provided in Appendix D.

Cover, frequency, and diversity were determined using the point-intercept sampling method. The point-intercept sampling method measures absolute and species-specific cover by vegetation; this method maximizes objectivity and repeatability (Proc. Amer. Soc. Surf. Min. & Recl., 1985 Annual Mtg., Denver, CO). The data recorded include the type of cover (vegetative, non-vegetative, or none) and the species, when applicable, that appear in the vertical plain of each point. Plants intercepted along the transects were identified to the lowest possible taxonomic level. Point data (vegetation, leaf litter, bare ground or rock) were collected at each foot along the transect for a total of one-hundred points per transect. Data were recorded on customized data sheets (Appendix E).

When two or more plant species were present at each point, all were recorded as a hit. When no vegetation was present within the vertical point, bare ground, rock or leaf litter was noted. Bare ground constituted mineral soil and soil/ash. Other qualitative factors noted along the transects included presence of resprouts on burned vegetation and height of resprouting vegetation and existing vegetation.

Table A summarizes each transect.

Table A - Description of Transects

Habitat Type	Transect type	# Transects	Watershed	Soil Type	Slope Aspect	Percent Slope
Chaparral	Control (unburned)	1	Outfall 6	Gaviota rocky sandy loam	S	20
Chaparral	Control (unburned)	1	Outfall 9	Gaviota rocky sandy loam	N	25
Chaparral	Burned (Mulched)	2	Outfall 2	Gaviota rocky sandy loam	S	35
Chaparral	Burned (Unmulched)	1	Outfall 9	Gaviota rocky sandy loam	N	25

Results

Vegetation Community Descriptions

Plant communities used for both the USFS and MWH Americas, Inc. vegetation maps most closely match descriptions of the Terrestrial Natural Communities of California by Holland (1986). Plant communities observed on the project site are described generally since it is too early after the fire to determine the species makeup for each community or put into a vegetation type classified by Holland. Furthermore, because the project site survey was conducted before the majority of the spring annuals germinated and before the peak bloom period for most forbs and shrubs, many key species potentially present were not observed during the survey. An assumption was made as to what vegetation-type was present prior to the fire of September, 2005 based on the USFS and MWH Americas, Inc. vegetation maps.

As stated above, information collected during the reconnaissance survey included visual estimation of vegetation type based on resprouting vegetation, remnant annual plant debris from previous growth, identifiable seedlings, and existing plants that were not severely burned by the fire. Plant species present and most easily identifiable during the surveys were perennial fire-adapted species that resprout within two years after a fire of this degree, dried annual plant species that germinated within the first year after the fire, perennial species that germinated since the fire.

The following plant community descriptions were developed to describe the present condition of the project site following the fire, with the understanding that as the project site recovers, plant communities will become more apparent and will more easily fit into plant communities as described by Holland (1986).

Chaparral/Scrub

Chaparral/Scrub is the predominant plant community on the project site, occurring in differing densities throughout the project site depending on soil type, aspect and age of disturbance, etc. USFS maps identified four chaparral types within the project site including Chamise, Foothill

Mixed Chaparral, Northern Mixed Chaparral and Sumac Shrub. The MWH Americas, Inc. map (2005) identified five chaparral and coastal sage scrub types including Venturan Coastal Sage Scrub, Venturan Coastal Sage Scrub/Chaparral, *Baccharis* Scrub, Chaparral, and Chaparral/Coast Live Oak Woodland. These habitat types appear to be as described by Holland (1986) or of some combination thereof.

Chaparral occurs as dense vegetation dominated by thick-leaved shrubs, growing to approximately 5 to 10 feet tall. Chaparral is typically dominated by scrub oak, chamise (*Adenostoma fasciculatum*) and other thick-leaved species including *Ceanothus* and manzanita species (*Arctostaphylos)*, all of which are typically deep-rooted. The understory is typically very sparsely vegetated or unvegetated, consisting mostly of leaf litter. Chaparral is adapted to repeated fires, responding by crown sprouting following the fire. Seeds of many of the chaparral species also require heat to germinate.

Northern Mixed Chaparral is shown to occur mostly on northerly facing slopes and is pre-dominantly comprised of numerous sclerophyllous-leaved shrub species with no or sparsely vegetated grasses and herbs. This classification most closely represents the stands of unburned chaparral remaining on the north facing slopes of the project site. These areas are dominated by mountain mahogany (*Cercocarpus betuloides*), holly-leaved cherry (*Prunus ilicifolia*), and toyon (*Heteromeles arbutifolia*).

Chamise communities are stands of chaparral vegetation dominated by chamise; one unburned stand was present at the far northwest corner of the project site. Foothill Mixed Chaparral is dominated by a somewhat even mix of various chaparral species, and an occasional coastal sage scrub type species. Sumac communities are areas dominated by laurel sumac; it is difficult to determine location of this habitat type since laurel sumac appears to be present in more than one plant community on the project site. Resprouting laurel sumac and chamise are present in most of the burned areas observed on the project site, but appear to be more abundant in areas described as chaparral on the MWH Americas, Inc. and USFS maps.

Many burned areas observed that had been classified as chaparral on the MWH Americas, Inc. and USFS maps were dominated by those chaparral species that are known to readily resprout after fires including laurel sumac, chamise, scrub oak (*Quercus berberidifolia*), toyon , etc. (Keeley, et al., 2006). Species that are known to regenerate predominantly by seed following fires were also present including hoary-leaved Ceanothus (*Ceanothus crassifoliu*s); it is possible that these species may have been dominant or co-dominant in the community prior to the fire, but are present as seedlings and not highly visible from more than a few feet away. Therefore, during the surveys, seedlings of these species were not always obvious if present in many areas mapped, when the areas were observed from farther than a few feet away.

Venturan coastal sage scrub is comprised of low, soft-wood shrubs, growing to approximately 2 to 6 feet in height. Dominant species often include California sagebrush, buckwheat species (*Eriogonum* spp.), sage species (*Salvia* spp.), lemonade berry (*Rhus integrifolia*), and Our Lord's candle (*Yucca whipplei*). This habitat is also adapted to fire, species commonly resprouting from their crown following a fire.

All subcategories for chaparral and scrub identified on the USFS and MWH Americas, Inc. maps were lumped and described as Chaparral/Scrub since chaparral and coastal sage scrub communities that burned are mostly indistinguishable at this stage of post-fire recovery (Figure 3). This was determined by looking at the only unburned patch of coastal sage scrub observed on the project site, located along the trail in the Sage Ranch area. This area was dominated by California sagebrush, California buckwheat (*Eriogonum fasciculatum*) with co-dominants of black sage (*Salvia mellifera*) and California deerweed (*Lotus scoparius*). Other species included California aster (*Lessingia filaginifolia*), Our Lord's Candle, California everlasting (*Gnaphalium californicum*), and other herbaceous species and grasses typical of coastal sage scrub plant community described by Holland (1986). The coastal sage scrub area also contained many of the same chaparral species including laurel sumac (*Malosma laurina*), coyotebush (*Baccharis pilularis*), Yerba Santa (*Eriodictyon crassifolius*), etc. as adjacent areas classified as chaparral on the USFS and MWH Americas, Inc. vegetation maps. Therefore, areas where these species were predominant were noted as potential coastal sage scrub habitat and are considered chaparral/shrub for this report.

Lastly, the project site is situated on areas of sandstone outcroppings due to historical geologic uplifting. Although present, chaparral and other grasses and herbs are sparse in areas of dense and large outcroppings. These areas are also mapped as chaparral/shrub, with the understanding that these areas also contain microhabitats among the rocks made up of plant species that are known to specifically occupy rocky and sandstone formations such as lichens.

Oak Woodland

Oak Woodland is present along canyon floors, northerly slopes and scattered along many of drainages throughout the project site (Figure 4). This community is dominated by coast live oak (*Quercus agrifolia*) trees. Oak woodlands on the project site occur among sandstone rocky outcrops with a sparse understory of scattered grasses, herbs and shrub. Oak woodlands on the project site also occur on the bottom of canyons where the understory is dominated by non-native grasses. Oak woodlands on northerly facing slopes and adjacent to drainages often have an understory of species common in chaparral and sage scrub habitats.

Oak trees sustained varying amounts of damage from the fire, depending on location. Many oak trees exhibited burned leaves solely around the lower leaf canopy, while the entire canopy of some oak trees appeared to have been burned. Crown sprouting and some above ground branch sprouting was apparent on most of the burned oak trees on the project site.

Coast Live Oak Riparian Forest

Coast Live Oak Riparian Forest was observed along the drainage in the vicinity of Outfall 9 (Figure 4). The canopy cover is dominated by coast live oak with an occasional California bay (*Umbellaria californica*) and willow (*Salix* sp.). The predominant understory species present and identifiable in this plant community include mugwort (*Artemisia douglasiana*), California rose (*Rosa californica*), and poison oak (*Toxicodendron diversilobum*). Other species present include Mexican elderberry (*Sambucus mexicana*), bush monkeyflower (*Mimulus aurantiacus*), and annual grasses. The oak trees is this area sustained little fire damage as only the fringes of the lower canopy were burned; there was no evidence of fire damage to the understory at the time of the survey. Oak trees in the oak woodland areas upstream and downstream from this area sustained more burn damage to their canopies and understory.

Burned Chaparral/Scrub (Aerial Mulched) – Southeast Facing Slope in Outfall 2 Watershed
N 34.21731º, W 11870590º

Unburned Chaparral/Scrub –South Facing Slope in Outfall 6
N 34.22623, W 118.71686

FIGURE 3

Western Botanical Services, Inc.

Boeing Santa Susana Field Laboratory
Representative Chaparral/Scrub Community

SOURCE:

Looking East from Helipad at Outfall 9 Drainage; Oak Woodland up Canyon Burned; Large Patch In Center (Coast Live Oak Riparian Forest) Mild Burn Damage
N 34.23825º, W 118.69604º

Coast Live Oak Riparian Forest – Along Creek at Outfall 9 (Mildly Burned on Edges of Oak Canopy, No evidence of Burn in Understory) N 34.23851º, W 118.69463º

FIGURE 4

Western Botanical Services, Inc.

Boeing Santa Susana Field Laboratory
Representative Coast Live Oak Communities

SOURCE:

Southern Willow Scrub, Mulefat Scrub, and Freshwater Marsh

Southern Willow Scrub occurs along many drainages on the project site; vegetation density in this plant community varies by location, soil type, frequency and length of water inundation, and degree of slope in the drainage. Southern Willow Scrub is dominated by several willow species including arroyo willow (*Salix lasiolepis*) and red willow *(Salix laevigata*) with an occasional Western sycamore tree (*Populus racemosa*).

Mulefat Scrub and Freshwater Marsh plant communities are present with and adjacent to areas where southern willow scrub is present within the project site. Mulefat Scrub is dominated by mulefat (*Baccharis salicifolia*) with an occasional willow and scattered rushes and sedges in more wet areas. It is also present in intermittent drainage channels on the project site. Mulefat scrub also occurs independently of southern willow scrub and freshwater marsh communities in drier drainages on the project site.

Freshwater Marsh is dominated by sedges, rushes, cat-tails and water-loving grasses and forbs. This plant community occurs along the waters edge of the ponds on the project site and in pockets in drainages where moisture is present closer to the surface year-round.

The Southern Willow Scrub, Mulefat Scrub and Freshwater Marsh areas observed to have burned on the project site, are naturally revegetating primarily by crown sprouting.

Drainages and Open Water

Areas described as drainages on the project site vary widely in width and vegetation cover. Many of the drainages at the base of steep slopes dominated with chaparral are narrow (2-4 feet wide) unvegetated soft bottom channel. Species present occasionally include curly dock (*Rumex crispus*), rabbits foot grass (*Polypogon monspeliensis*), western ragweed (*Ambrosia psilostachya*), mugwort, and grasses. Other drainages on the project site are 5-8 foot wide, soft bottom channels with intermittent areas of sandstone along the sides and channel bottom. Vegetation is more prevalent in these drainages and include curly doc, rush (*Juncus* spp.), umbrella sedge (*Cyperus* sp.), mulefat, and mugwort. The sparse vegetation along the bottom of these drainages did not appear to have sustained significant burn damage.

Open water is present primarily in ponded areas on the project site; no vegetation is present in these areas. These open water areas appear to become vegetated with freshwater marsh species as the water recedes with evaporation, drainage flow, and percolation.

Burned Southern Willow Scrub – Drainage above Outfall 11 (Burned Willow in Front Represents High Heat of Fire in this Area) *N 34.22726º, W 118.68668º*

Burned Southern Willow Scrub – Drainage above Outfall 2 (Burned Sycamore Shown on Front Left) *N 34.21750º, W 118.70519º*

FIGURE 5

Western Botanical Services, Inc.

Boeing Santa Susana Field Laboratory
Representative Riparian/Drainage Communities

SOURCE:

Non-Native Grassland/Ruderal

Non-Native Grassland/Ruderal is present on areas surrounding oak woodlands and previously disturbed areas adjacent to dirt roads and developed areas on the project site (Figure 6). This plant community is dominated by non-native annual grass species, none of which were identifiable at the time of the survey. Ruderal species are also common in these areas and include non-native invasive species including tocalote (*Centauria melitensis*), Italian thistle (*Carduus pycnocephalus*), and mustards (*Brassica* spp. and *Hirschfeldia* sp.). An occasional native needlegrass (*Nassella* sp.) and remnant annual wildflower species were also present.

The Non-Native Grassland/Ruderal areas are within the burned area of the project site, however, at the time of the survey, there was no evidence of the burn as there were few perennial species present that would exhibit identifiable resprouting and remnant burnt branches following the fire.

Burned Shrub Stem Diameter

For burned Chaparral/Scrub areas observed during the survey, the diameter of burned shrub branches ranged in size from 1/4"-1”, when measured at the tallest point. Based on the 1990 DeBano study (mentioned in the methodology section above), size of stems remaining are consistent with a fire of moderate severity.

Burned Shrub Regeneration

Primary evidence of post-fire vegetation regeneration included presence of crown sprouts and seedlings. The presence of this regeneration varied by location. Only native species are listed below, even though numerous non-native species were presently germinating on the project site. Non-native species present included tree tobacco (*Nicotiana glauca*), mustards, Russian thistle (*Salsola tragus*), tocalote, non-native grasses, Italian thistle, etc. Table B summarizes evidence of regeneration that was documented at locations observed during field surveys. Not all species observed are listed; this is intended to represent the most commonly species observed during the survey.

Table B - Summary of Vegetative Regeneration Observed

Scientific Name	Height of Crown Sprouts (Feet)	Presence of Seedlings	Visually Estimated Percent Cover Range in Burned Areas
Adenostoma fasciculatum	2-4	X	0-30
Artemisia californica		X	0-5
Baccharis pilularis	2-5		0-5
Calystegia macrostegia		X	20-40
Ceanothus crassifolius		X	0-5
Cercocarpus betuloides	7-10		0-30
Dudleya pulverulenta	0.5-1		0-5
Eriodictyon crassifolium	2-4		0-50
Eriogonum fasciculatum		X	0-5
Gnaphalium sp.		X	0-5
Hazardia squarrosa			0-5
Heteromeles arbutifolia	1.5-9		0-10

Keckiella cordifolia	1-3		0-5
Lotus scoparius		X	0-5
Malacothamnus fasciculatus		X	0-5
Malosma laurina	3-4		0-40
Marah macrocarpa	2-8		0-5
Mimulus aurantiacus		X	0-10
Phacelia sp. (annual)		X	0-10
Phacelia ramosissima	1-3		0-30
Platanus racemosa	6-8		0-5
Prunus ilicifolia	4-12		0-20
Rhus integrifolia			0-5
Rhus ovata			0-5
Quercus agrifolia			20-90
Quercus berberidifolia	3-5	X	0-5
Salix sp.	3-5	X	0-10
Salvia mellifera		X	0-5
Sambucus mexicana	5-7		0-5
Yucca whipplei	1-2		1-5

Burned Non-Native Grassland/Ruderal – West of Outfall 2
N 34.22230º, W 118.71117º

Residual Mulch on Rock and Plant from December 2005 Aerial Mulching – Happy Valley
N 34.23096º, W 118.67420º

FIGURE 6

Western Botanical Services, Inc.

Boeing Santa Susana Field Laboratory
Representative Non-Native Grassland/Ruderal Community *& Mulch*

SOURCE:

Mulched Areas

Mulch is still present in patches of varying densities in burned areas that received truck and aerial-applied mulch. The mulch is mostly visible on rock outcroppings (Figure 6), but patches of mulch are still present in some of the areas. Wood fiber mulch over cryptogrammic species as lichen can inhibit growth by reducing photosynthesis and transpiration.

Transect Data

Relative vegetative cover was tallied as the percentage of vegetation intercepted by the projected point. Percent coverage of litter, rock, and bare area were calculated separately.

Table C summarizes relative cover data collected along each transect (locations shown on Figure 2).

Table C - Summary of Relative Cover by Transect

Habitat Type	Transect type	Percent Cover				
		Shrub	Dead Shrub	Bare/Rock	Litter	Herb Layer
Chaparral – S facing	Control (unburned)	60	20	13	7	0
Chaparral – N facing	Control (unburned)	70.3	0.9	4 bare	14	11.4
Chaparral – S facing	Burned (Mulched)	2.5	0	21	1.5	75.5
Chaparral – N facing	Burned	19.3	15.4	7	14	44.9

The chaparral control transect on the south facing slope (Figure 7) was randomly placed. This location of unburned chaparral constitutes an approximately 1,800 square foot area of the project site and is located at the northwestern corner of the project site. The 60 percent scrub cover in this transect is comprised of approximately 48.7 percent relative cover by chamise, 4.4 percent relative cover by Our Lord's candle, 2.6 percent relative cover of black sage, and 1.7 percent relative cover by hoary-leaved ceanothus (*Ceanothus crassifolius*). The shrub layer along this transect is approximately 4-5 feet tall. Dead branches of chamise constitute approximately 20 percent relative cover of the vegetation along the transect. Bare ground constitutes approximately 12 percent relative cover of the transect; approximately 7 percent of the transect is covered with leaf litter. There is evidence of a previous fire as old burned shrub stumps were present adjacent to the transect. This is most likely remnant vegetation that burned during the 1982 fire (California Department of Forestry/FRAP, 2006). Other species present adjacent to the transect include woolly blue curls (*Trichostema lanatum*) and bigberry manzanita (*Arctostaphylos glauca*).

The chaparral control transect on the north facing slope (Figure 8) was randomly set in a north to south direction. This location is one of six (6) pockets of unburned chaparral on the north facing slopes that are part of the Outfall 9 watershed. This pocket of chaparral is approximately 10 acres in size. The soil type in this area is Gaviota rocky sandy loam. The shrub layer on this transect constitutes approximately 70.3 percent relative cover of this transect, of which approximately 34 percent relative cover is by mountain mahagony, 19 percent relative cover is by toyon, 19 percent relative cover is by holly-leaved cherry, and 1 percent relative cover is by sugarbush (*Rhus ovata*). The shrub layer along this transect is approximately 7-9 feet tall on average. Dead branches of holly-leaved cherry comprise approximately 1 percent relative cover of the transect. Approximately 4 percent relative cover of the transect is bare ground and 13 percent is covered with leaf litter. This transect has an herb layer of approximately 13 percent relative cover and includes approximately 4 percent relative cover by golden yarrow (*Eriophyllum confertiflorum*), 5 percent relative cover by grass seedlings, 1 percent relative cover by chaparral nightshade (*Solanum xantii)*, and 3 percent relative cover by tocalote (a nonnative invasive weed). Other

Control Transect – Unburned South Facing Slope Chaparral/Scrub
N 34.22725º, W 118.72001º

Transect 1 – Burned South Facing Chaparral/Scrub, Aerial Mulched Area
N 34.21935º, W 118.70536º

FIGURE 7

Western Botanical Services, Inc.

Boeing Santa Susana Field Laboratory
South Facing Chaparral/Scrub Transects

SOURCE:

Control Transect – Unburned North Facing Chaparral/Scrub (burned up front)
N 34.23631º , W 118.68769º

Transect 1 – Burned North Facing Chaparral/Scrub, Unmulched Area
N 34.23462º , W 118.68996º

FIGURE 8

Western Botanical Services, Inc.

Boeing Santa Susana Field Laboratory
North Facing Chaparral/Scrub Transects

SOURCE:

species present in this area outside the transect include black sage & chia (*Salvia columbariae*). The area surrounding this transect also contained old burned stumps, evidence of a previous historical fire, potentially that occurred around 1970, according to available fire history maps (California Department of Forestry/FRAP, 2006).

The data from the two transects in this area were averaged. The burned (aerial mulched) south facing slope transect (Figure 7) is dominated by California morning glory with an average of 74 percent relative cover. California deerweed and wild cucumber (*Marah macrocarpa*) each occur on less than 1 percent relative cover (average) on the transect, bare ground constitutes 21 percent relative cover (average) of the transect areas, and litter averages less than 2 percent relative cover. The shrub layer is comprised of 2.5 percent relative cover on average by chamise along these transect. The chamise shrubs have resprouted and are approximately two feet tall on average, with burned stems ranging in width from ¼-1" in diameter. Mulch is still present and constitutes approximately 1.5 percent relative cover of the transect not covered by vegetation. Other species present in the surrounding areas include hoary-leaved ceanothus, toyon, laurel sumac, Yerba Santa, scrub oak, and annual phacelia. Numerous native shrub seedlings are also present in pockets surrounding the transects.

The north facing slope chaparral burned transect areas has a shrub layer of approximately 19.3 percent relative cover which is comprised of resprouting toyon shrubs, averaging four (4) feet in height. Approximately 15.4 percent of the transect is covered by burned toyon branches with stems ranging in width from ¼ - 1 inch in diameter. The 44.9 percent understory layer on this transect is comprised of non-native species including tocalote (16.2 percent relative cover) and thistle (5.4 percent relative cover). These two species are annuals and therefore only dead stalks were present at the time of the survey. Native species include heart-leaved snapdragon (*Keckiella cordifolia*) with 6.2 percent relative cover, grass seedlings with 8.5 percent relative cover, yellow yarrow with 3.9 percent relative cover, chaparral nightshade with 0.8 percent relative cover, and phacelia with 0.8 percent relative cover. Approximately 7 percent of the transect area is bare ground and 14 percent is covered with leaf litter. Other species present adjacent to the transect include chamise, black sage, chaparral bush mallow (*Malacothamnus fasciculatus*), California deerweed, laurel sumac, California buckwheat, and red brome grass (*Bromus madritensis rubens*).

Summary of Preliminary Findings of Post-Fire Vegetation Recovery

Fire has been a common occurrence in California's history, and in particular, has occurred frequently in the project area over the course of the last 60 years, as represented by the fire history perimeter maps and substantial literature reviewed. Native plants occurring in these areas of frequent fire have become adapted to fire, as evidenced by survival and regeneration mechanisms including resprouting and seeding strategies.

Strategies that perennial plant species use to recover from fires include crown sprouting, seeding, and branch sprouting. Plants that are adapted to fire are classified as "obligate resprouters", "facultative seeders", or "obligate seeders". Obligate resprouters are plants that depend on resprouting from their underground root systems (including some bulbous plants) and lower stems or burls (lignotuber) to survive after a fire. Facultative seeders both resprout and produce seeds that germinate after a fire. Obligate seeders are destroyed in the fire and depend on seedlings to replace their populations. The seeds of many of obligate seeder species are fire dependent, meaning their seeds require some fire cue (heat, charred wood, smoke) to germinate.

The rate of regeneration of vegetation following a fire is dependent on numerous factors including severity of the fire, the amount of vegetation in the overstory and understory burned, heating of the soil, proportion of area burned, and length of fire intervals, etc. (DeBano, et al., 1998). Severity of the burn was qualitatively evaluated for discussion purposes only and appeared to vary throughout the project site and were estimated based on visual observations described in (DeBano, et al., 1998) and in Table D.

Table D - Visual Factors Used to Evaluate Fire Intensity

Severity	Litter Present Following Fire	Ash Present Following Fire	% canopy biomass consumed	Diameter (inches) charred plant stems remaining
Low	Yes (10-15% of pre-fire litter lost)	Gray ash	40	<0.2 (most with leaves)
Moderate	No	None	40-80	0.2-0.5
Severe	No	White ash	90	0.5+

Low Severity (soil temperature estimated at 225 degrees Celsius at the soil surface and 125 degrees Celsius at 2.5 cm depth) – charred leaf litter, grayish ash most like present immediately following the fire, but soon became inconspicuous.

Moderate Severity (maximum soil temperature at mineral surface at almost 430 degrees Celsius, and 200 degrees Celsius at 2.5 cm depth) – bare soil present as leaf litter and fine woody material was consumed by fire. Ash is inconspicuous immediately after the fire. Between 40 and 80 percent of the plant canopy is consumed by the fire; remaining charred twigs would be greater than 0.6 to 1.3 cm in diameter.

High Severity (surface soil temperatures just over 700 degrees Celsius and nearly 250 degrees Celsius at 2.5 cm deep) – Fluffy white ash layer present following the fire as a result of the main stems of trees and shrubs that burned.

Based on the burn history of the project site and visual observations, the majority of the Chaparral/Scrub on the project site appears to have burned at a low to moderate severity, varying by location, leaving somewhat of a mosaic of burned and unburned vegetation in some areas. Based on fire history maps, the vegetation was estimated at 25-37 years old at the time of the 2005 fire, and likely contained more than 25 percent dead plant material (fuel). Qualitative data and cursory transect data in the unburned chaparral/scrub communities on the project site represent an example of what the vegetation may have looked like at the time of the fire of 2005. The chaparral were most likely dominated by any combination of chamise, toyon, sugarbush, holly-leaved cherry, and mountain mahogany, approximately 10-12 feet tall, covering approximately 60-70+ percent of the ground surface, with an herb layer of approximately 0-12 percent cover. Leaf litter may have comprised approximately 7-14 percent of the ground in areas not covered with vegetation; approximately 4-13 percent may have been bare soil or rock. This is consistent with descriptions of chaparral and scrub of this age class in other areas researched.

The patchy burn pattern throughout the project area is consistent with descriptions of burn patterns for chaparral and scrub communities that are 25-35 years old (without disturbance).

Chaparral/scrub within the age class are expected to present a mosaic burn pattern, with the north facing moister slopes remaining partially unburned with the drier south facing slopes burning with higher intensity. Similar patterns are observed on the project site as the majority of the burned Chaparral/Scrub areas observed on the southern facing slopes of the project site revealed litter, ash and vegetation characteristics as described for moderate severity burn. However, burned areas on the northern facing slopes appeared to have burned less severely in most areas.

Time to Recovery: Literature Review

Chaparral is a dynamic ecosystem that requires disturbance, primarily in the form of fire, in order to persist; hence, the state of recovery following a fire, can be evaluated by looking at the life stages as the community develops back to its pre-burn form (dominated by woody shrubs). Hanes (1971) defines chaparral succession as follows "Chaparral succession is not a series of vegetational replacements, but a gradual ascendance of long-lived species present in the pre-fire stand."

The life expectancy for a healthy mature chaparral community is between 20-35 years. A fire every 20-30 years keeps chaparral healthy. Following a fire, it can take 20 to 30 years for chaparral to return to its pre-fire physiognomy (form and structure of natural communities) (Hanes, 1971). In the absence of fire for 20 years, chaparral shrubs begin to senesce. Without fire, a large proportion of non-sprouting shrubs eventually die and the community becomes non-productive (Wright and Bailey, 1982).

The rate of recovery is somewhat consistent and predictable based on literatures reviewed, but varies among location of plant communities. **The rate of recovery for chaparral communities is greatest during the first six years following a fire, then slows down through the eighth year (Hanes, 1971). By the fifth year following a fire, chaparral resprouts and seedlings dominate the vegetative cover (Hanes, 1971), and stands of chaparral are expected to recover 50 percent of its pre-burn biomass by the eighth year (Wright and Bailey, 1982).** Between 18 and 23 years following a fire, chaparral continues to grow but begins to level off by the time it is 20 to 25 years old. At approximately 37 years old, many chaparral plants (i.e., chamise) stops growing and senescence begins; the chaparral community then declines until the next fire.

The effect of slope angle, aspect, and elevation (distance from coast) on rate of recovery of chaparral and coastal sage scrub communities has also been repeatedly studied. Aspect was found to have the greatest influence on rate of recovery (Hanes, 1971; Guo, 2001). For example, the rate of succession was found to be slowest on south-facing slopes below 3,000 feet elevation; the fastest rate of succession was found to be on north-facing slopes above 3,000 feet elevation (Hanes, 1971). Additionally, the north-facing slopes tended to have fewer, if any, coastal sage scrub species present in the chaparral communities, compared to south-facing chaparral communities. In these north-facing areas, the dominant resprouting shrubs and seedlings were primarily responsible for the rapidly closing cover.

Literature also reveals similar results on changes in species composition, species diversity and species richness, responsible for increasing cover during the first eight years follow a fire. Species richness is greatest in the second year, with the presence of annuals and forbs being the biggest contributors; species richness then declines through the forth year, as perennial species begin to dominate the cover (Guo, 2001; Grace and Keely, 2006). **This is significant from an erosion control perspective because the much greater root depth and area of perennial species (e.g., chaparral) provide greater soil stabilization compared to that of dominant annuals (e.g., annual grasses).** The increasing total vegetation cover over time following a fire, resulting in high biomass production (Grace and Keely, 2006), is comprised of differing life forms during the each of the first five years. During the first to third growing seasons following a fire, the chaparral community is typically comprised of resprouting woody vegetation and post-fire adapted annual and forb species. During the second to fourth year, seedlings of fire adapted perennials are prevalent amongst the annual forbs and grasses. Studies have shown that the vegetative cover during this time increases from approximately 65 percent total cover in the first/second year, to almost 150 percent cover in the fifth year (Grace and Keeley, 2006). For comparison, total vegetative cover measured in the unburned stands of chaparral during the site reconnaissance were 92 and 94 percent[1] for each transect surveyed on a south and north-facing slope, respectively (Table C). In these transect areas it is estimated that the vegetation is approximately 25 to 35 years old. Vegetation recovery is not necessarily defined as having reached 100 percent or more of total vegetative cover (perennials and annuals), but rather attaining cover types and percentages that are representative of pre-fire conditions.

Time to Recovery: Preliminary Evaluation of Project Site

Recovery of the burned vegetation on the project site was primarily evaluated by visual observation of the presence of regeneration by documenting the presence of resprouting vegetation and seedlings in the burned areas. Species composition and vegetative structure of the unburned areas were also documented to get an understanding of what the burned areas may have looked like prior to the fire.

Based on numerous studies on recovery of chaparral and sage scrub communities following a fire, the vegetation on the project site is expected to produce vegetation from resprouts and seed at a high rate for the first five years following the fire. The burned vegetation appears to be regenerating as would be expected after one growing season following a fire. For example, some of the obligate and facultative resprouters that are present and have resprouting vegetation from 1 to 10 feet tall include laurel sumac, chamise, toyon, holly-leaved cherry, scrub oak, Yerba Santa, lemonadeberry, and mountain mahogany. Many of the burned areas that face south/southwest and west are dominated by California morning glory (*Calystegia macrostegia*); this is consistent with a study conducted on the recovery of chaparral following the 2003 Santa Monica Mountain fire (Guo, 2003). Many of these areas also contain many coastal sage scrub species including Our Lord's candle, annual phacelia (*Phacelia sp*.), California aster, and California deerweed seedlings. Resprouting appears to be present on approximately 90 percent of shrubs observed in most areas, with the exception of the burned shrubs on the slope just north of Well 12 that appear to be experiencing approximately 70 percent resprouting (based on visual estimation). This could either be a result of higher fire severity and/or intensity in this area, or the presence of a higher percentage of shrub species (unidentifiable) that do not readily resprout after a fire.

Seedlings of perennial obligate seeders are also present on the burned areas and include hoary-leaved ceanothus, chamise, California deerweed, scrub oak, California sagebrush, and California buckwheat. The average seedling height is 2-10" and varies in density depending on location.

[1] Percent dead cover was 23 and 1 percent for the south and north-facing slope transects, respectively.

The presence of annual species on the project site is also consistent with literature describing the vegetation likely to be observed within two years following a fire. For example, the residual skeletons of annual forbs (dominants are Phacelia and California morning glory) are present from the first years' growth following the fire in most of the burned Chaparral and scrub areas observed. We would expect annual grasses and forbs to prevail during spring and summer 2007, as it will be the second growing season following the fire. Evidence of abundant grass seedlings and newly germinating forbs were present during the February 2007 survey. The presence of annuals (e.g., herbaceous species and grasses) is important because the shallow-rooted annuals can provide protection against impact erosion on bare soil until the deeper-rooted perennials become established. Perennials such as chaparral, however, have root structures that are comprised of both deep and shallow roots and are generally capable of holding more soil in place during runoff-producing storm events.

Literature suggests that the vegetation composition of the grassland areas can be expected to be similar to pre-fire conditions within three years following a fire (Brown, etal., 2000). This quick recovery of vegetation cover is apparent on the project site. During the February 2007 surveys, at nearly two years following the 2005 fire, non-native grassland/ruderal areas appear to already have approximately 90-100 percent cover of remnant vegetative cover consisting of last growing season's annual grasses and forbs. Remnant stalks from last year's growth and newly germinating seedlings were present and include non-native grasses, tocalote, Italian thistle, milk thistle (*Silybum marianum*), doveweed (*Eremocarpus setigerous*), and mustards.

Oak Woodlands throughout the project site burned differently depending on aspect, location, intensity of the fire, type of plant community, and closeness to rocks and riparian areas. Many of the oak woodlands that appeared to have an understory dominated by annual grasses did not appear to have burned as hot or as high up the trunk and canopy as other areas on the project site, that potentially consisted of woody herbs and perennials. Oak trees and oak woodlands that were surrounded by or adjacent to mature chaparral shrubs sustained more intensive fire damage, some experiencing complete canopy burn. Most of these severely burned oaks are resprouting at the branch nodes, however, a few oaks were seen with little or no resprouting in the areas that appeared to have sustained more burn damage.

Riparian habitats including oak woodland riparian, southern willow scrub, mulefat scrub and freshwater marsh communities that burned mostly appear to be recovering by crown sprouting. However, some of the large willow trees and few sycamore trees in the drainage across from Outfalls 15 and 11 appear to have sustained intensive burn damage as the entire canopy is burned and no vegetation remains above the crown.

Overall, all areas observed show signs of regeneration as resprouts and seedlings as expected based on the findings in numerous literature related to fire and chaparral. Based on a review of the literature, vegetative recovery occurs most rapidly during the first 6 years of regrowth and less rapidly thereafter. In the event that weather patterns are somewhat normal over the next 20-30 years, and in the absence of any catastrophic events on the burned areas, we expect the burned chaparral on the project areas to follow the growth patterns described in literature for recovery of chaparral and coastal sage scrub communities. The time frame for vegetation recovery described in the literature is necessarily broad, as the establishment and growth of vegetation is dependant upon several factors, e.g. vegetation type, soil conditions, fire severity, and climatic conditions. Vegetative recovery will be defined using measurable site-specific metrics as part of the Phase 2 work plan, and will be fundamentally based on statistical comparisons between burned and unburned (control) areas at or near the project site.

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APPENDIX A: FIGURE 2A - VEGETATION COMMUNITY MAP (MWH AMERICAS, INC)

Vegetation Map with Sensitive Species

Santa Susana Field Laboratory

- VENTURAN COASTAL SAGE SCRUB
- VENTURAN COASTAL SAGE SCRUB/CHAPARRAL
- BACCHARIS SCRUB
- CHAPARRAL
- CHAPARRAL/COAST LIVE OAK WOODLAND
- NONNATIVE GRASSLAND
- NATIVE GRASSLAND
- COAST LIVE OAK RIPARIAN FOREST
- COAST LIVE OAK WOODLAND
- FRESHWATER MARSH
- MULEFAT SCRUB
- SOUTHERN WILLOW SCRUB/MULEFAT SCRUB
- SOUTHERN WILLOW SCRUB
- OPEN WATER
- RUDERAL HABITAT
- ROCK OUTCROP
- DEVELOPED
- DISTURBED VEGETATION OVERLAY
- VEGETATION WITH ROCK OUTCROPS OVERLAY
- Drainages

Legend

Sensitive Wildlife

MD	MULE DEER
BC	BOBCAT
TUVU	TURKEY VULTURE
RSHA	RED-SHOULDERED HAWK
BTJ	S.D. BLACK-TAILED JACKRABBIT
RTHA	RED-TAILED HAWK
GBH	GREAT BLUE HERON
GHOW	GREAT HORNED OWL
SSHA	SHARP-SHINNED HAWK
RCSP	RUFOUS-CROWNED SPARROW
DCCO	DOUBLE-CRESTED CORMORANT
TSGS	TWO-STRIPED GARTER SNAKE
COHA	COOPER'S HAWK
LOSH	LOGGERHEAD SHRIKE

Sensitive Plants

HM	SANTA SUSANA MOUNTAIN TARPLANT
BW	SOUTHERN CAL. BLACK WALNUT
QA	VALLEY OAK
QL	COAST LIVE OAK

MAP NOTES:
1. AMEC Earth and Environmental. 2003. Standardized Risk Assessment Methodology Workplan, Surficial Operable Unit, Revision 1, Santa Susana Field Laboratory, Ventura County California. (Biological Conditions Report, Appendix C.) In preparation.
2. Map coordinates in Stateplane, NAD 27, Zone V.
3. Species locations not necessarily to scale.

FEET
0 250 500 1000 1500 2000

DATE: 07/30/04
FILE: /yap/rock/plots/plotamls/eco.aml

MWH

FIGURE
3-1

APPENDIX B: VASCULAR PLANT SPECIES OBSERVED

APPENDIX B

VASCULAR PLANT SPECIES OBSERVED

The following vascular plant species were observed in the study area by biologist(s) Jeannette Halderman during site surveys conducted on February 5-9, 2007.

* Introduced, nonnative species

PTERIDOPHYTA		**FERNS AND FERN-ALLIES**	
Polypodiaceae		**Wood Fern Family**	
	Polypodium californicum		California polypody fern
Pteridaceae		**Brake Family**	
	Pellaea sp.		Coffee fern
Selaginellaceae		**Spike-moss Family**	
	Selaginella bigelovii		Bigelow's spike-moss
ANGIOSPERMAE: DICOTYLEDONAE		**DICOT FLOWERING PLANTS**	
Aizoaceae		**Carpet-weed Family**	
*	*Carpobrotus aequilateralus*		Sea-fig
Anacardiaceae		**Sumac Family**	
	Malosma laurina		Laurel sumac
	Rhus integrifolia		Lemonade berry
	Rhus ovata		Sugar bush
	Toxicodendron diversilobum		Poison oak
Asteraceae		**Sunflower Family**	
	Ambrosia psilostachya		Western ragweed
	Artemisia californica		California sagebrush
	Artemisia douglasiana		Mugwort
	Baccharis pilularis		Coyote bush
	Baccharis salicifolia		Mulefat
*	*Carduus pycnocephalus*		Italian thistle
*	*Centaurea melitensis*		Tocalote
*	*Conyza bonariensis*		Flax-leaved horseweed
	Conyza canadensis		Common horseweed
	Encelia californica		California encelia
	Eriophyllum confertiflorum var. *confertiflorum*		Golden yarrow

	Gnaphalium bicolor	Bicolored cudweed
	Gnaphalium californicum	California everlasting
	Hazardia squarrosa	Saw-toothed goldenbush
	Hemizonia minthornii	Santa Susana tarplant
	Heterotheca grandiflora	Telegraph weed
	Heterotheca sessiliflora	Golden aster
*	*Lactuca serriola*	Prickly lettuce
	Lessingia filaginifolia	California aster
	Malacothrix saxatilis var. *tenuifolia*	Cliff malacothrix
*	*Silybum marianum*	Milk thistle
*	*Sonchus asper* ssp. *asper*	Prickly sow-thistle
Boraginaceae		**Borage Family**
	Amsinckia menziesii	Fiddleneck
Brassicaceae		**Mustard Family**
*	*Brassica nigra*	Black mustard
*	*Hirschfeldia incana*	Shortpod mustard
Caprifoliaceae		**Honeysuckle Family**
	Lonicera subspicata var. *denudata*	Southern honeysuckle
	Sambucus mexicana	Mexican elderberry
Chenopodiaceae		**Goosefoot Family**
*	*Salsola tragus*	Russian-thistle
Convolvulaceae		**Morning-glory Family**
	Calystegia macrostegia	Morning-glory
Crassulaceae		**Stonecrop Family**
	Dudleya lanceolata	Lance-leaved dudleya
	Dudleya pulverulenta ssp. *pulverulenta*	Chalk dudleya
Cucurbitaceae		**Gourd Family**
	Marah macrocarpus	Wild cucumber
Ericaceae		**Heath family**
	Arctostaphylos glauca	Bigberry manzanita
Euphorbiaceae		**Spurge Family**
	Eremocarpus setigerus	Doveweed
Fabaceae		**Legume Family**
	Astragalus brauntonii	Braunton's milk-vetch
	Lotus scoparius	California deerweed
	Lupinus sp.	Lupine
	Vicia sp.	Vetch

	Fagaceae	**Beech Family**
	Quercus agrifolia var. *agrifolia*	Coast live oak
	Quercus berberidifolia	California scrub oak
	Geraniaceae	**Geranium Family**
*	*Erodium cicutarium*	Red-stemmed filaree
	Grossulariaceae	**Gooseberry Family**
	Ribes indecorum	White-flowered gooseberry
	Ribes malvaceum	Chaparral currant
	Hydrophyllaceae	**Waterleaf Family**
	Eriodictyon crassifolium	Thick-leaved yerba santa
	Phacelia sp.	Phacelia
	Phacelia ramosissima	Branching phacelia
	Lamiaceae	**Mint Family**
*	*Marrubium vulgare*	Horehound
	Salvia columbariae	Chia
	Salvia leucophylla	Purple sage
	Salvia mellifera	Black sage
	Salvia spathacea	Hummingbird sage
	Trichostema lanatum	Woolly blue-curls
	Lauraceae	**Laurel Family**
*	*Persea americana*	Avocado
	Umbellularia californica	California bay laurel
	Malvaceae	**Mallow Family**
	Malacothamnus fasciculatus	Chaparral bush mallow
	Myrtaceae	**Myrtle Family**
*	*Eucalyptus spp.*	Gum
	Nyctaginaceae	**Four O'clock Family**
	Abronia maritima	Red sand-verbena
*	*Bougainvillea* sp.	Bougainvillea
	Mirabilis californica	California wishbone bush
	Onagraceae	**Evening Primrose Family**
	Epilobium sp.	Willow-herb

Paeoniaceae	**Peony Family**
Paeonia californica	California peony
Papaveraceae	**Poppy Family**
Dicentra sp.	Ear-drops
Eschscholzia californica	California poppy
Platanaceae	**Sycamore Family**
Platanus racemosa	Western sycamore
Polygonaceae	**Buckwheat Family**
Eriogonum sp.	Buckwheat
Eriogonum fasciculatum	California buckwheat
* *Rumex crispus*	Curly dock
Primulaceae	**Primrose Family**
* *Anagallis arvensis*	Scarlet pimpernel
Rhamnaceae	**Buckthorn Family**
Ceanothus crassifolius	Hoaryleaf ceanothus
Rhamnus ilicifolia	Holly-leaved redberry
Rosaceae	**Rose Family**
Adenostoma fasciculatum	Chamise
Cercocarpus betuloides var. *betuloides*	Mountain mahogany
Heteromeles arbutifolia	Toyon
Prunus ilicifolia ssp. *ilicifolia*	Holly-leaved cherry
Rosa californica	California rose
Rutaceae	**Rue Family**
* *Citrus* sp.	Citrus tree
Salicaceae	**Willow Family**
Salix laevigata	Red willow
Salix lasiolepis	Arroyo willow
Scrophulariaceae	**Figwort Family**
Antirrhinum sp.	Snapdragon
Keckiella cordifolia	Heart-leaved bush-penstemon
Mimulus aurantiacus	Bush monkey flower
Solanaceae	**Nightshade Family**
* *Nicotiana glauca*	Tree tobacco
Solanum xanti	Chaparral nightshade
Verbenaceae	**Vervain Family**
Verbena lasiostachys	Western verbena

ANGIOSPERMAE: MONOCOTYLEDONAE **MONOCOT FLOWERING PLANTS**

	Cyperaceae	**Sedge Family**
	Cyperus sp.	Umbrella-sedge
	Scirpus sp.	Bulrush
	Juncaceae	**Rush Family**
	Juncus sp.	Rush
	Liliaceae	**Lily Family**
*	*Agave americana*	American century plant
	Chlorogalum pomeridianum	Wavy-leaved soap plant
	Dichelostemma capitatum ssp. *capitatum*	Blue dicks
	Yucca whipplei	Our Lord's candle
	Poaceae	**Grass Family**
*	*Bromus diandrus*	Ripgut grass
*	*Bromus hordeaceus*	Soft chess
*	*Bromus madritensis* ssp. *rubens*	Foxtail chess
	Leymus condensatus	Giant wild-rye
	Muhlenbergia rigens	California deergrass
	Nassella sp.	Needlegrass
*	*Polypogon monspeliensis*	Rabbitsfoot grass
	Typhaceae	**Cat-tail Family**
	Typha sp.	Cat-tail

Taxonomy and scientific nomenclature conform to Hickman (1993). Common names for each taxa generally conform to Roberts (1998), although Abrams (1923, 1944, 1951) and Abrams and Ferris (1960) are used, particularly when species specific common names are not identified in Roberts (1998).

APPENDIX C: QUALITATIVE FIELD DATA SHEETS

Field Data Sheet for Monitoring Vegetation and Erosion Control Projects (Reconnaissance Level)

Project/Location: Boeing - Happy Valley

Date: 2/5/07 Surveyors: J

Treatment Type(s):

Performed by:

Date of Treatment/ Age of Project:

Slope: 0-5% along bottom of site

Aspect:

Soil Type: fill - silty sand

Percent Litter Cover:

Percent Rock Cover:

Percent Bare:

Condition of Drainage Improvements:

Infiltration trenches:

Drop Inlets:

Collection Systems:

Runoff Source (onsite or offsite):

PIX 14 & 15 & 16 17, 18, 19

Road has rills & dominated by tocolote & mustard

PIX 22-25 > from road looking @ stepped fill

* 20 & 21 hydromulch photos

Dominant Plant Species	Native	Non-Native	% Cover
Tocolote - Centaurea melit.		X	
Silybum marianum		X	
Gnaphalium cal.	X		
(c) mustard - Hirschfeldia?		X	
Salvia mellifera	X		
Nicotiana glauca		X	
Elymus sp.	X ?		
Bromus ruben			0-1%
Lotus scoparius			0-5%
(c) purple aot. ~~[illegible]~~ Lessingia			
Chlorogalum	X	~~X~~	0-5%
Encelia calif.	X		0-5%
Baccharis pilularis	X	~~X~~	0-5%
Yerba santa	X		0-10%
Nassella lepida ? (bunch)	X		toe of slope

seedling on road

seedlings on road 3 (5-7' tall)

Slopes also include

Malosma laurina X 10-15% on sloped

Malacothamnus sp X 0-1%

Disturbances (e.g. wildlife, foot traffic, neighboring uses, etc.):

Phacelia ramosa?

Notes:

Disturbance by vehicle 10' wide along top of silt riprap filters (pix 26-28)

* Flat area above silt riprap filter dom by tocolote, milk thistle w/ bunch grasses & conyza sp?

Bacc pil on dirt road (vehicle area)

Field Data Sheet for Monitoring Vegetation and Erosion Control Projects
(Reconnaissance Level)

Project/Location: Boeing well 13
Date: 2/5/07 Surveyors: Jeannette Halderman
Treatment Type(s):
Performed by:
Date of Treatment/ Age of Project: Chaparal - East & north facing

Slope: ~~[illegible]~~ 45° slope

Aspect: E facing

Soil Type: Chatsworth formation

Percent Litter Cover: ~~[illegible]~~ 50-70% now dead grass stalks = will be nng

Percent Rock Cover: 10-20%

Percent Bare: 10-20%

Condition of Drainage Improvements:
Infiltration trenches:
Drop Inlets:
Collection Systems: Visual Observation
Runoff Source (onsite or offsite): slope

Dominant Plant Species	Native	Non-Native	% Cover
Eriog fasc.	X		0-5%
Cercocarpus	X		0-5%
Keckiella			0-10%
mimulus aurantiacus			0-10%
Heteromeles arbut.			0-10%
Baccharis pilularis			0-5%
Yerba Santa			0-10%
Holly leaved cherry			10-20%
artem calif.			1-3%
Hirschfeldia			1%
NN G (lower slopes - toe) & see back page			~~[illegible]~~ 15%
adenostoma fasc. (resprouts 4')	X		10-30%
scattered Quercus ag.			0-10%

(c) Malacothrix 0-5%

Disturbances (e.g. wildlife, foot traffic, neighboring uses, etc.):

(c) Phacelia ramosissima ? 10-30%

Notes:

Marah macrocarpa 0-5%
Hazardia squarrosa? or Isocoma 0-5%
umbellof. calif (burned 8-10' resprout) 0-10%
(large burned no resprouts) - ? (madrone?) = 10-15%
~~[illegible]~~ Isocoma
Mexican elderberry (resprouted - 7' new growth) 0-10%
Lonicera subsp. 0-5%

Continue

Field Data Sheet for Monitoring Vegetation and Erosion Control Projects
(Reconnaissance Level)

Project/Location: Outfall 9 - well 13
Date: 2/5/07 Surveyors:
Treatment Type(s):
Performed by:
Date of Treatment/ Age of Project:

pix 11

Slope:

Aspect: E facing

Soil Type:

* truck Mulched

Percent Litter Cover:

Percent Rock Cover:

Percent Bare:

Condition of Drainage Improvements:
Infiltration trenches:
Drop Inlets:
Collection Systems:
Runoff Source (onsite or offsite):

Dominant Plant Species	Native	Non-Native	% Cover
Bromus diandrus		X	50-70%
Lotus scoparius	X		0-5%
(C) Ribes (white fl) indicor?	X		0-5%
Vulpia ?		X	60-70%
Dudleya pul (white)	X		0-1%

NNG combined

Disturbances (e.g. wildlife, foot traffic, neighboring uses, etc.):

Notes:

Field Data Sheet for Monitoring Vegetation and Erosion Control Projects (Reconnaissance Level)

Project/Location: Boeing Well 13

Date: 2/5/07 Surveyors:

pix 4

Treatment Type(s):

Performed by: Jeannette Halderman

Date of Treatment/ Age of Project:

Slope: 60% - 70° slope

Aspect: South facing

Soil Type: Chatsworth Formation to 80% Large sandstone Rock face

Percent Litter Cover: 0-5%

30-50% Veg Cover

Percent Rock Cover: 80-90%

Percent Bare: 60-70%

Condition of Drainage Improvements:

Infiltration trenches:

Drop Inlets:

Collection Systems: __________

Runoff Source (onsite or offsite): __________

Dominant Plant Species	Native	Non-Native	% Cover	
Malosma laurina	x		20-40%	resprouting 3-4' tall
Adenostoma	x		10-20%	resprouts 2-4' tall
Yucca whip	x		1-5%	
Mimulus aurantiacus	x		0-1%	
Dudleya pulverulenta	x		0-1%	
grasses (dormant)			10-30%	
Salvia sp or Yerba Santa (?)	x		1-5%	resp. 2-4' tall

Disturbances (e.g. wildlife, foot traffic, neighboring uses, etc.): Burned

Notes: dead/dormant stalks - low growing shrubs 20-30% mid-lower slope

Field Data Sheet for Monitoring Vegetation and Erosion Control Projects
(Reconnaissance Level)

Project/Location: Boeing-Well 13 - out fall 9
Date: 2/5/07 Surveyors:
Treatment Type(s):
Performed by: Jeannette Halderman
Date of Treatment/ Age of Project:

Slope:

Aspect:

oak woodland Riparian on bottom drainage - on average most with trunks (oaks) 30-40' off bottom of stream - not burned badly (crowns not burned - understory intact)

Soil Type:

Percent Litter Cover: N facing) • patchy pockets w/ 50% cover litter leaf under oaks to 60% rng w/ herbs

Percent Rock Cover:

Percent Bare: north facing slopes - under oaks some areas dom by pockets of poison oak

Condition of Drainage Improvements:
Infiltration trenches:
Drop Inlets:
Collection Systems: visual
Runoff Source (onsite or offsite):

Dominant Plant Species	Native	Non-Native	% Cover
overstory: Quercus Agrifolia	x		80-90
Salix umbellcal	x		1-3%
understory: Caly rose	x		1-3%
dormant) mugwort	x		
Tox div.	x		
Lonicera kecklella	x		
~~[illegible]~~ Cerco bet	x		
Marah mac	x		
bracken fern	x		
Bottom of drainage - ponded water			
cobbles (boulders)			
Rumex Crispus			
thistle Seedlings			
Slopes under oak wood rip			
Heteromeles arb.			
no grass			
Marah macr.			

mulefat, polypogon

litter
mim aurantiacus (seedlings - occassional)

Disturbances (e.g. wildlife, foot traffic, neighboring uses, etc.):
Epilobium

Notes: Nemophila or phacelia
Eriophyllum
bracken fern
Lonicera
Holly leafed cherry
mustard
malacothamnus

Field Data Sheet for Monitoring Vegetation and Erosion Control Projects
(Reconnaissance Level)

Project/Location: Boeing-Happy Valley-outfall 8
Date: 2/5/07 Surveyors:
Treatment Type(s):
Performed by: Jeannette Haldeman
Date of Treatment/ Age of Project:

Slope: 20-25°

Aspect: south facing

Soil Type: Chatsworth formation

Percent Litter Cover: 0-5%

Percent Rock Cover: 10-20%

Percent Bare: 20-30%

Condition of Drainage Improvements:
Infiltration trenches:
Drop Inlets:
Collection Systems:
Runoff Source (onsite or offsite):

~~[illegible] treatment~~

pix 12 & 13 - slopes

mixed chaparral - Burned

lots of bare along flat areas - Malosma's near drainage & flat not resprouting as much as those higher up on slope

Quercus agrifolia along bottom - 40' apart - burned - m[illegible] resprouting

(Strawwattles - BMP area) along drainage & on slope

Dominant Plant Species	Native	Non-Native	% Cover	
Malosma laurina	X		0-20%	
Adenostoma fasc (resprouts) 2-4'	X		0-20%	
Yerba santa	X		0-5%	
Convolvulus or Calystegia ?	~~X~~	X	20-40%	-lots mounded
Mimulus aurantiacus	X		0-10%	
Marah macrocarpa	X		0-5%	
Russian thistle seedlings		X	0-1%	
Scrub oak sprouts	X		0-5%	
Nicotiana glauca		X	1 tree 4-5'	tall
Conyza bonariensis		X	0-5%	
mustard seedlings		X	0-5%	
Phacelia ramosis ? seed	X		0-5%	
Epilobium sp.			0-5%	

Disturbances (e.g. wildlife, foot traffic, neighboring uses, etc.):

Notes: Hydromulch scattered - still present
grasses germinating (1-2")
Chlorogalum (sprouting) X 0-5%
Salvia mellifera X 0-5% seedlings

Field Data Sheet for Monitoring Vegetation and Erosion Control Projects
(Reconnaissance Level)

Project/Location: Boeing Outfall 1
Date: 2/6/07 Surveyors:
Treatment Type(s):
Performed by:
Date of Treatment/ Age of Project:

Drainage more soft bottom with slopes - less sandstone than outfall 2

Slope:

Aspect:

Soil Type: Soft sandy bottom => Sand silty on slopes (cut)

Percent Litter Cover:

Percent Rock Cover: occassional sandstone rocks on bottom = mostly soft

Percent Bare: bottom 90-95%

Condition of Drainage Improvements:
Infiltration trenches:
Drop Inlets:
Collection Systems:
Runoff Source (onsite or offsite):

Dominant Plant Species	Native	Non-Native	% Cover (Drainage)
nng germinating on slopes			10-50%
Rumex crispus		X	0-5%
Conyza sp.			0-5%
Baccharis pilul	X		0-5%
Polypogon monsp.		X	0-5%
(c) (hand grass) ?		X	0-5%
Juncus sp.	X		0-5%
Baccharis salic	X		0-5%
Cyperus umbell		X	

Disturbances (e.g. wildlife, foot traffic, neighboring uses, etc.):

Notes:

Field Data Sheet for Monitoring Vegetation and Erosion Control Projects
(Reconnaissance Level)

Project/Location: Boeing outfall 2 (cow pond) Western Flow
Date: 2/6/07 Surveyors: Jeannette Halderman
Treatment Type(s):
Performed by:
Date of Treatment/ Age of Project:

PIX 34 - 37

NNG/Ruderal

Slope:

Aspect:

Soil Type: Sandy Silt - Tertiary Santa Susana formation

Percent Litter Cover:

Percent Rock Cover:

Percent Bare:

Condition of Drainage Improvements:
Infiltration trenches:
Drop Inlets:
Collection Systems:
Runoff Source (onsite or offsite):

Dominant Plant Species	Native	Non-Native	% Cover	
Eremocarpus setig	X		0-5%	- along road
Silybum marianum		X	15-35%	
mustard - summer		X	20-80%	depends on location
Centaurea melitensis		X	5-15%	
(scattered) Malosma laurina (burned)	✓		5-15%	
Isocoma menziesii ?	X		0-5%	
Italian thistle ? small head		X	5-15%	
Lupinus sp			0-5%	
thick stalked grass - no regrowth			20-30%	
Bromus madritensis rubens			5-15%	
Malocothamnus fasc	X		0-5%	
Nassella sp. (pockets)	X		0-5%	

Disturbances (e.g. wildlife, foot traffic, neighboring uses, etc.):

Salvia leucophylla X 0-5%

Notes:

Field Data Sheet for Monitoring Vegetation and Erosion Control Projects (Reconnaissance Level)

Pix 32

Project/Location: Boeing outfall 2

Riparian drainage Chap on both sides

Date: 2/6/07 Surveyors:

BMP's - straw wattles m slopes not shown on map. (w/straw bales on north side)

Treatment Type(s):

Performed by:

Date of Treatment/ Age of Project:

Slope: draining south

Aspect: Drainage 0-5%

Soil Type: well graded sand in botton on sandstone bedrock

Some ponded water holes in rock drops as go upstream

Percent Litter Cover:

Percent Rock Cover:

Lemonade berry branch in creek

Percent Bare:

Condition of Drainage Improvements:

Infiltration trenches:

Drop Inlets:

Collection Systems:

Runoff Source (onsite or offsite):

Dominant Plant Species	Native	Non-Native	% Cover
cobble lined botton (natural) with sandstone outcrops & drops.			
Quercus agrifolia (couple)	X		0-1%
Rumex crispus		X	0-5%
Ambrosia psillostachya			0-5%
Phacelia ramosissima			
Polypogon monspeliensis		X	0-5%
Sonchus asper		X	0-5%
~~Verbena californica~~ lasiostachys	X		0-5%
(C) Juncus sp.	X		0-5%
Cyperus umbell		X	
mulefat (Bacc salic)	X		
Lonicera subspicata	X		
anagallis arvensis		X	
Silybum marianum		X	
Marah macro	X		

Resprouts 6-8' > Platanus racemosa X

Nicotiana glauca X

Rock

Dudleya lanceolata

Antirrhinum

Dichelostemma

Calochortus?

On banks - Chap. plus

Elymus condensatus

Lactuca serriola

Black mustard

Bromus rubens

Artemisia douglas

Disturbances (e.g. wildlife, foot traffic, neighboring uses, etc.):

Artemesia douglasiana X

muehlenbergia rigens X

Notes:

Eremocarpus set X 0-1%

Bromus madritensis rubens X

X

Rosa californica X

(C) Ribes

Salix laevigata (small 1' seedling) X

Conyza

(C) hand grass

Field Data Sheet for Monitoring Vegetation and Erosion Control Projects (Reconnaissance Level)

Project/Location: Boeing outfall 2
Date: 2/6/07 Surveyors: Jeannette Halderman
Treatment Type(s):
Performed by:
Date of Treatment/ Age of Project:

Burned Chaparral

Slope: 40°

Aspect: SE facing

Soil Type: Chatsworth formation

Percent Litter Cover:

Percent Rock Cover:

Percent Bare:

Condition of Drainage Improvements:
Infiltration trenches:
Drop Inlets:
Collection Systems:
Runoff Source (onsite or offsite):

Dominant Plant Species	Native	Non-Native	% Cover	
Adenostemma fasc	X		5-15%	Burned
(c) ~~Convolvulus~~ Calystegia macro int.	X		60-80%	
~~del~~ Lotus scoparius	X		5-10%	
Eriodyction crass	X		0-5%	
Ceanothus crass (seedlings)	X		0-5%	
Malosma laurina (resprouts)	X		5-15%	
Hazardia squarrosa			0-5%	
Quercus berberidifolia	X		0-5%	resprouts 3-5'
Phacelia ~~ramos~~ (annual)	✓		0-5%	
Salvia mellifera	X		0-5%	seedlings
Baccharis pilularis	✓		0-5%	

Disturbances (e.g. wildlife, foot traffic, neighboring uses, etc.):

Notes:

Field Data Sheet for Monitoring Vegetation and Erosion Control Projects (Reconnaissance Level)

Project/Location: Boeing Outfall 9 Sage Ranch ~~Conservancy Area~~

Date: 2/7/07 Surveyors: [Truck scales]

Treatment Type(s):

Performed by: Jeannette Haldeman

Coastal Sage scrub

Date of Treatment/ Age of Project:

Some burned - some small strips didn't burn

Slope:

Aspect:

Soil Type: Sedimentary Rock Land (SnG)

Percent Litter Cover:

Percent Rock Cover:

Percent Bare:

Condition of Drainage Improvements:

Infiltration trenches:

Drop Inlets:

Collection Systems:

Runoff Source (onsite or offsite):

Dominant Plant Species	Native	Non-Native	% Cover
Salvia mellifera	X		10-20%
Artemisia californica	X		20-40%
Lotus scoparius	X		5-15%
Gnaphalium californica	X		0-5%
Gnaphalium bicolor	X		0-5%
Malosma laurina	X		10-30%
Adenostemma fascic	X		10-30%
Bromus madritensis ruben		X	0-5%
Yucca whipplei			0-5%
Eriodyction	X		20-50%
Calyst. macrostegia			10-20%
Solanum xanti	X		0-5%
Mustard		X	5-20%
(c) Phacelia ram	X		0-5%
Rhamnus ilicifolia	X		0-5%
~~Melilotus~~ Centaurea melit.		X	5-15%
Selaginella - on rock	X		—
Mimulus aurantiacus	X		0-5%
Corethrogyne fill			0-5%

Disturbances (e.g. wildlife, foot traffic, neighboring uses, etc.):

Chlorogalum

Notes:

Field Data Sheet for Monitoring Vegetation and Erosion Control Projects (Reconnaissance Level)

Project/Location: Boeing Well 12 > outfall 9

Date: 2/7/07 Surveyors:

Treatment Type(s):

Performed by:

Date of Treatment/ Age of Project:

Pix 57-60

Chaparral - slope burned

30-40% shrub cover

30-40% understory cover

Shrub regrowth - post fire = not as many are resprouting as other areas (60-70% resprouts approx)

Slope: 70°

Aspect: South facing

Soil Type:

Percent Litter Cover:

Percent Rock Cover: 20-30%

Percent Bare: 20-30%

Condition of Drainage Improvements:

Infiltration trenches:

Drop Inlets:

Collection Systems:

Runoff Source (onsite or offsite):

Dominant Plant Species	Native	Non-Native	% Cover
Malosma laurina	X		5-20%
Adenostoma fasc.	X		5-10%
Quercus berberid	X		5-10%
Phacelia ~~ramosissima~~ (annual?)	X		15-20%
~~Adeno~~ Heteromeles arb	X		0-5%
Prunus ilic	X		0-5%
Calystegia macrostegia	X		10-25%
Eriodictyon crass	X		0-5%
Malacothamnus fasc	X		0-5%

Disturbances (e.g. wildlife, foot traffic, neighboring uses, etc.):

Notes:

Field Data Sheet for Monitoring Vegetation and Erosion Control Projects
(Reconnaissance Level)

Project/Location: Boeing Between Well 12 E B   unburned mixed chaparral
Date: 2/7/07   Surveyors:
Treatment Type(s):   pix 61
Performed by: Jeannette Halderman
Date of Treatment/ Age of Project: 10-15' tall

Slope: (north facing) 60°

Aspect: drainage below has mulefat patch at bottom

Soil Type: SnG

Percent Litter Cover:

Percent Rock Cover:

Percent Bare:

Condition of Drainage Improvements:
Infiltration trenches:
Drop Inlets:
Collection Systems:
Runoff Source (onsite or offsite):

Dominant Plant Species	Native	Non-Native	% Cover
Heteromeles arbutifolia	X		5-10%
Prunus ilicifolia	X		10-20%
Ribes sp (lg shrub	X		0-5%
Rhamnus ilicifolia	V		?
Rhus integrifolia	V		0-5%
Cercocarpus ~~or~~ betuloides	V		20-30%
Adenostoma fasc.	X		0-5%
Quercus berberidifolia	X		0-5%

Disturbances (e.g. wildlife, foot traffic, neighboring uses, etc.):

Notes:

Field Data Sheet for Monitoring Vegetation and Erosion Control Projects (Reconnaissance Level)

Project/Location: Boeing - by entrance drainage
Date: 2/7/07 Surveyors:
Treatment Type(s):
Performed by:
Date of Treatment/ Age of Project:

oak woodland riparian and southern willow scrub

Slope:

* doesn't look burned

Aspect: drainage

5 - 20' wide channel all vegetated

Soil Type: drainage

Percent Litter Cover:

Percent Rock Cover:

Percent Bare:

Condition of Drainage Improvements:
Infiltration trenches:
Drop Inlets:
Collection Systems:
Runoff Source (onsite or offsite):

Dominant Plant Species	Native	Non-Native	% Cover	
Baccharis salicifolia	X			Bottom
Salix	X			Large tree
Quercus agrifolia	X			Banks
Rhamnus ilicifolia	X			under / adj oaks
Sambucus mexicana	X			"
Baccharis pilularis	X			"

Disturbances (e.g. wildlife, foot traffic, neighboring uses, etc.):

Notes:

Field Data Sheet for Monitoring Vegetation and Erosion Control Projects (Reconnaissance Level)

Project/Location: Boeing outfall 15 drains into pond across road

Date: 2/8/07 Surveyors: Jeannette Halderman

Treatment Type(s):

Performed by:

Date of Treatment/ Age of Project:

Pond - drains into Outfall 11

SWS

Freshwater marsh

Slope:

Aspect:

Soil Type:

* spotty burned

Percent Litter Cover:

Percent Rock Cover:

Percent Bare:

Condition of Drainage Improvements:

Infiltration trenches:

Drop Inlets:

Collection Systems:

Runoff Source (onsite or offsite):

Dominant Plant Species	Native	Non-Native	% Cover	
Scirpus americanus sp?	X		70-100%	along bottom - upper end & around
Salix lasiolepis	X		60-80%	
Prunus ilicifolia	X		0-5%	
Baccharis pilularis	X		0-10%	
Phacelia ramosissima	X		0-5%	
Quercus agrifolia	X		0-10%	
Malosma laurina	X		0-15%	- not resprouting - burned
Platanus racemosa	X		~~0-5%~~ 0-5%	1 burned below dam
Sambucus mex	X		0-5%	
Baccharis salic	X		30-60%	

slopes

Disturbances (e.g. wildlife, foot traffic, neighboring uses, etc.):

Notes:

APPENDIX D: PHOTOGRAPH LOG

Photo Log

Project Name: Boeing
Photographer: John Cruz \ Cornelius Chisolm

Date: 2/5/07, 2/6/07

Waypoint	Photo #	Description
	1	well 13 - look NW outfall 9 - drainage oak woodland
#001	2	well 13 " " - slope above - burned mix chap
	3	well 13 - " " "
	4	well 13 " " " burned sandstone mix chap
	5	well 13 look SE outfall 9 → oak woodland understory - east drainage
#002	6	well 13 " " " west drain
	7	well 13 - " up center to stairs -
	8	well 13 - " West @ outfall 9 oak woodland, looking down stream
#003	9	well 13 " "
	10	well 13 " "
#004	11	well 13 Looking East , chapparal, hydromulch, track sprayed
#005	12	outfall 8 looking NW , looking @ confluence of outfall 8
	13	outfall 8 looking WNW , looking up towards perchlorate remedial site
	14	outfall 8 looking NE , " " " " " "
006	15	outfall 8 " N , " " " " " "
	16	outfall 8 " NW , " " " " " "
	17	outfall 8 " S , looking @ silt dam @ tobacco plant
007	18	outfall 8
008, 009	19	outfall 8
010	20	outfall 8 " South Hydromulch
	21	outfall 8 Hydromulch
	22	outfall 8 looking West , looking at upper part of exc., vehicle disturbance
	23	" " " " " " " " " "
011	24	" " " " " " " " " "
	25	" " " " "
	26	" " stepped fill
012	27	" "
	28	"
009	21A	outfall 8 Hydromulch
	21B	outfall 8 Hydromulch
013	29	Outfall 2 looking @ SE facing slope, bindweed scrub oak in CH zone
014	30	Outfall 2 view looking E, of BMPs @ outfall 2, wattles 2/6/07
	31	Outfall 2 " " NE " "
016	32	Outfall 2 View looking NW @ sycamore tree in wash
017	33	Outfall 2 View of Aerial hydromulch on S. facing hillslope
	34	Outfall 2 area up water tank cyn, NNGrass, CH, & OW habitat.
018	35	Outfall 2 area " " " " " " "
	36	Outfall 2 area
	37	Outfall 2 area " " "
	38	Outfall 2 area Panorama shots of NNG, CH, & OW habitat
	39	Outfall 2 area " " " " " "
	40	Outfall 2 area " " " " " "
	41	Outfall 2 area " " " " " "
	42	Outfall 2 area " " " " " "
	43	Outfall 2 area View looking East, @ H_2O tank canyon, looking @ OW
	44	Outfall 2 area " " " " " " " "
	45	Outfall 2 area " " " " " " " "

Photo Log

Project Name: Boeing, SSFL
Photographer: Cornelius Chisolm

13, 14, 15, 16, 17

waypoint **Date:** 2/6 –

Waypoint	Photo #	Description
	46 ✓	Outfall 1, View looking W @ BMPs & CH
021	47	Outfall 1, " " NW upcanyon
	48	Outfall 1, " " SW down Canyon
020	49 ✓	Outfall 1, View looking NW, up the main channel from flume
	50 ✓	Outfall 1 " " S down main channel from flume
	51	Outfall 11, ~~View~~ View looking SE, @ N facing hillslope, CH, NNG, & OW
022	52	Outfall 11, " " S, @ " " "
	53	Outfall 11, " " SE, @ " " "
	54	Outfall 11 " " E, @ " " "
023	55	Outfall 9, View looking N @ cliff above truck scales
024	56	Outfall 9, View looking South @ road w/ Coastal ~~scrub brush~~ shrub
	57	Outfall 9 View looking N, Panorama of S facing hillslope, good cover
025	58	Outfall 9 " " NW, " well 13 road
	59	Outfall 9 " " " " "
	60	Outfall 9 " " W " " "
026	61	Outfall 9 looking WSW @ unburned section near road well 13
	62	Outfall 9, looking SW @ CH, and unburned OW, from Sage Ranch Trail
~~[illegible]~~	63	Outfall 9 " " " " " " "
	64	Outfall 9 " " " "
	65	Outfall 9 looking SE @ trail in Sage Ranch, erosion on trail
027	66	Outfall 9, S.A.A.
	67	Outfall 9, Unmarked blue line drainage channel
028	68	Outfall 9, SAA
	69	Outfall 9 SAA
	70	Outfall 14 looking @ stormwater drainage channels & sample point 2/8/07
029	71	Outfall 14 looking down chute of concrete channel
	72	Outfall 15 looking at sample location for outfall 15
030	73	Outfall 15 looking @ stream channel up stream from Outfall 15
	74	Outfall 15 looking @ pond down stream from outfall 15
031	75	Outfall 15 " " " " " " @ wetland hab.
	76	Outfall 15 looking @ overflow/spillway for holding pond
032	77	Outfall 11 looking downstream @ hot barn area @ split in road
	78	Outfall 11 looking SE and upstream @ sample point and valley
33	79	Outfall 11 " E " "
	80	Outfall 11 " NE " "
~~[illegible]~~	81	Outfall 11 View looking south @ sample point
	82	Outfall 11 ~~looking~~ @ actual sample point
	83	Outfall 11 View looking downstream of Outfall 11 @ x-sec
	84	Outfall 11 " " " @ x-sec. of stream channel
	85	Outfall 9 Adjacent to guard shack @ ~~[illegible]~~ riparian unburned
	86	Outfall 9 View of N facing hillslope, of unburned CH
038	87	Outfall 5 View of sample location and mitigation basin
	88	Outfall 5 View of unburned section WSW of outfall 5
039	89	Outfall 5 " " " " " "
	90	Outfall 5 " " " SW " "
	91	Outfall 6 mitigation equipment @ Outfall 6
	92	Outfall 6

Photo Log

Project Name:
Photographer:

Date:

Photo #	Description
93	Outfall 6 Shooting range area & mitigation area
94	Outfall 6 Shot of potential S facing Unburned control area
95	Outfall 6 Looking down on 5, 6, & 7
96	Outfall 6 " " " " "
97	Outfall 6 Burned, Hydromulch, aerial, borrowsite road, astibra
98	Outfall 6 " " " " " "
99	Outfall 6
96	Panorama of entire site from borrow site
97	
98	
99	
100	Outfall 7, View of pump
101	Outfall 7, View of retention basin above sample point
102	Outfall 3, Mitigation equipment & flume, sample point
103	Outfall 3, " " " " "
104	Outfall 3, " " " " "
105	Outfall 4, View of mitig. equip. & plastic tarp area,
106	~~Outfall~~ 4, View of lower mit. equip & " " "
107	Outfall 4, " " " " " & " " "
108	Outfall 10, View of sand & carbon mitigation & flume
109	Outfall 10, View of Oak Woodland Riparian, down-stream from sample loc
110	Outfall 10, View down canyon N of helipad
111	Outfall 10 View above canyon of Outfall 9 sample location
112	Outfall 10 10 "
113	Outfall 10 "
114	Outfall 10 "
115	Outfall 10
116	Outfall 18 View of flume & mitigation equip
117	Outfall 18 View of BMPs above Pond KD2A
118	Outfall 18 View down stream of sample loc. OWR, w/ mudflat
119	~~Outfall~~ Unburned transect, CH S.W. facing slope on eastern end Outfall 6 3/9/09
120	Unburned transect, CH S.W. facing slope on western end Outfall 6
121	Burned Transect 1 in CH, western end of transect 1 Outfall 2
122	" " " " eastern " " " Outfall 2
123	Burned Transect 2 in CH, western end looking east, Outfall 2
124	" " " " eastern " " west Outfall 2
125	Burned Transect 1 in CH, ~~South~~ Northern end looking Outfall 9
126	" " " " Southern End " North Outfall 9
127	Unburned Control CH southern end look north Outfall 9

APPENDIX E: GPS COORDINATE LOG

Geosyntec consultants

Page ____ of ____

Written by: RS Date: __/__/__ (DD MM YY) Reviewed by: ________ Date: __/__/__ (DD MM YY)

Client: Boeing Project: SSFL NPDES Compliance Project/Proposal No. ________ Task No. ________

GPS Waypoints

001 - N 34.23827 W 118.69447°, elevation 1669' - Outfall 9, looking NW towards confluence, @ top of stairs

002 - N 34.23851°, W 118.69463°, elevation 1632', outfall 9 towards

003 - N 34.23835°, W 118.69350°, elevation 1707, outfall 9, down-canyon

004 - N 34.23822°, W 118.69440°, " 1686',

005 - N 34.22823°, W 118.67542°, 1756' outfall 8, stream confluence

006 - N 34.22773°, W 118.67494°, 1739' outfall 8, unburned portion north facing slope

007 - N 34.23088°, W 118.67522, 1830' in Perc removal area, rem. excavation

008 - N. 34.23035°, W 118.67551, in southern Perc. rem. exc. area

009 - N. 34.23070°, W 118.67513°, 1824' " " " " " "

010 - N. 34.23096°, W 118.67420° - 1913' - Picture of hydromulch

011 - N. 34.23129°, W 118.67432° - 1925, upper mitigation area, looking west

012 N. 34.23156°, W 118.67551° - 1897, " " "

013 N. 34.21731°, W 118.70590 1517' Outfall 2

014 N. 34.21719°, W 118.70546° 1566' Outfall 2 BMPs

015 N. 34.21720°, W 118.70528°, 1549' Outfall 2, Flume + Sample point

016 N. 34.21750°, W 118.70519°, 1553' outfall 2, Sycamore tree

017 N. 34.21719°, W 118.70552°, 1564' outfall 2, hydromulch on hillslope

018 N. 34.22299°, W 118.71278°, 1901' outfall 2, NNG, CH, + OW habitat, tank

019 N 34.22230°, W 118.71117°, 1864' canyon panorama shots of Outfall 2 area

020 N 34.21602°, W 118.69640° 1584' Outfall 1 Flume and sample point

021 N 34.21591°, W 118.69587° 1599' " 1 Looking @ BMPs + CH

Page ____ of ____

Geosyntec consultants

Written by: ______________ Date: ___/___/___ (DD MM YY) Reviewed by: ______________ Date: ___/___/___ (DD MM YY)

Client: ______________ Project: ______________ Project/Proposal No. ______________ Task No. ______________

GPS Waypoints

022 - N34.22458°, W 118.68656°, 1784' Outfall 11

023 - N34.23801°, W 118.68571, 1797' Outfall 9 above truck scales

024 - N.34.23846°, W 118.68536° 1846', Outfall 9

025 - N.34.23753°, W118.69008° 1737', Outfall 9, well 13 road

026 - N 34.23772, W 118.69164°, 1725' Outfall 9, unburned section

027 - N. 34.23895, W 118.67476°, 1923' Outfall 9, Sage Ranch, erosion

028 N. 34.23969°, W 118.67471° 1941' Outfall 9, unmarked drainage channel

029 N. 34.23369, W 118.67912 1881' Outfall 14, sample location

030 N 34.22974°, W 118.68497°, 1809' Outfall 15, sample location

031 N. 34.22946°, W 118.68484° 1806' Outfall 15, pond & wetland habitat

032 N 34.22726°, W 118.68668° 1778' Outfall 11, split in road

033 N 34.22421°, W 118.68961° 1756' Outfall 11, pix loc. looking to valley upstream

034 N. 34.22385°, W 118.68906 1723' Outfall 11, stream transect

035 N. 34.22408°, W118.68892° 1738' Outfall 11 sample location

036 N. 34.23780°, W 118.67354° 1909' Outfall 9, unburned riparian

037 N 34.23631°, W 118.68769° 1767' Outfall 9, unburned CH

038 N. 34.23022°, W 118.71839° 1848' Outfall 5, sample location

039 N 34.22979°, W 118.71870° 1879' Outfall 5, unburned pix loc

040 N 34.23095°, W 118.71745° 1821' Outfall 6, post mitigation sample pt

041 N. 34.23058°, W 118.71742° 1823' Outfall 6, pre-mitigation sampling

042 N34.22623°, W 118.71686° 2073' on borrow site road

043 N. 34.23056°, W 118.71558° 1817' Outfall 7 sample location

Page _____ of _____

Geosyntec consultants

Written by: __________ Date: ____/____/____ (DD MM YY) Reviewed by: __________ Date: ____/____/____ (DD MM YY)

Client: __________ Project: __________ Project/Proposal No. __________ Task No. __________

044 N. 34.23450°, W 118.71201°, 1776', Outfall 3 post mitigation + flume sample
045 N 34.23448°, W 118.71144° 1779'. Outfall 3, pre-mit. sample loc
046 N. 34.23577°, W 118.70789° 1844' Outfall 4, pre mitigation sample
047 N. 34.23563° W 118.70754° 1841' Outfall 4, pix loc. of lower outfall
048 N. 34.23589°, W 118.70730°, 1815' Outfall 4, lower, post-mitigation sample loc
049 N 34.23792°, W 118.69970° 1848' Outfall 10, upper, or pre-rem. sample loc,
050 N 34.23806°, W 118.70044° 1804' Outfall 10, lower, post-mit. sample loc,
051 N 34.23819°, W 118.69822° 1821' Outfall 10, ~~to~~ pic loc. down cyn. of hiding pad
052 N 34.23825, W 118.69604° 1812' Outfall 9 pix above @ heliport
053 N 34.22643° W 118.70605° 1694' Outfall 18, pix of flume + filter unit, future upstream sample loc
054 N. 34.22610°, W 118.70623° 1680' Outfall 18, post-mitigation sample location

2/9/07

055 N. 34.22748°, W 118.71989 2012' C-CH-UB-SW, eastern control transect
056 N. 34.22725°, W 118.72001° 2023' C-CH-UB-SW, western control transect pt.
057 N 34.21934°, W 118.70567°, 1666' T1-CH-B-SW-M, western transect outfall 2
058 N. 34.21935°, W 118.70536°, 1633' " eastern ", outfall 2
059 N 34.21933°, W 118.70513°, 1638' T2-CH-B-SW-M, western transect, outfall 2
060 N 34.21919°, W 118.70489° 1603' T2- eastern transect end, Out
061 N. 34.23462°, W 118.68996° 1916' T1-CH-B-N-UM, ~~Southern~~ southern end trans. Out. 9
062 N. 34.23484°, W 118.68990° 1884' " " " " " Northern end of trans, Out. 9
063 N 34.23418°, W 118.68922 1977' C-CH-UB-N-UM, southern end of trans, out 9
064 N. 34.23441°, W 118.68932 1934' " North end of trans. Out 9

APPENDIX F: TRANSECT DATA SHEETS

C-CH-UBNNM

Cover Data

Project Boeing Recon Post Fire Date 2/9/07 Time 2:05 pm

Study Area CH non-burn N facing (N of outfall 9) Sampler's Initials JH, RS

Camera:Make Sony digital Model

			understory ⇒ leaf litter	
Reference Point	Waypoint #63 & 64			
Direction of Photo	N/S			
Soils	Gaviota Rocky sandy loam		# Occassional old remnant	
Resolution			fire burned stumps	
Height of Dom Veg				
Transect Number	CCHUBN-NB			
Location	Outfall 9 watershed			
Bearing and Aspect	0°			
Slope (%)	25%			

		Hits	Total	Hits	T	Hits	T	Hits	~~T~~	~~Hits~~	T
Bare Soil	1	||||							%	Rel cover	
Litter	2	~~||||~~ ~~||||~~ ||||							13%		
Rock	3										
Water	4										
Standing Dead	5								83		

								Height			
Cer bet	6	~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ||					37	10', 7'	32.5%	34%	
Rhus integ	7	|					1	12'	0.9%	[illegible]	
Prun ilic	8	~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ |					21	4', 12	18.5%	[illegible]	
Het arb	9	~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ |					21	9', 4', 6'	18.5%	[illegible]	
Cen mel	10	|||					3		2.6%	[illegible]	
grass	11	~~||||~~					5		4.4%	5%	
Prun ilic (dead)	12	|					1		0.9%	1	
Sol xan	13	|					1		0.9%	1	
Erioph conf	14	||||					4		3.5%	4%	
	15										
	16						94				
	17										
	18										
	19										
	20										
	21										
	22										
	23										
	24										
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	40										
	41										
	42										
	43										
	44										
	45										

Control Chap. Unburned Southw
C-CH-UB-SW Facing

Cover Data

S of outfall 5

Project Boeing Recon Post-burn Date 2/9/07 Time 9:45am

Study Area Control - unburned Chamise Chaparral SW facing slope Sampler's Initials JH, Ryan Smith

Camera:Make Sony disk Camera (digital) Model

Transect 1

Reference Point	Waypoint #55 & 56		Note: Evidence of old burn		
Direction of Photo	SW	~~old~~			
Soils	Soper gravelly loam				
Resolution					
Height of Dom Veg	4-5'				
Transect Number	1				
Location	S of outfall 5				
Bearing and Aspect	200°				
Slope (%)	20%			total	Rel cover

	#	Hits	Total	Hits	T	Hits	T	~~Hits~~	T	Hits	T
Bare Soil	1	𝍸𝍸 𝍸 III					13%				
Litter	2	𝍸 𝍸 II					7%				
Rock	3										
Water	4										
Standing Dead	5										

(80) = 0.87x

	#	Hits	Total	Hits	T	Hits	T	Hits	T	Hits	T
Aden fasc. (adult)	6	𝍸 𝍸 𝍸 𝍸 𝍸		𝍸 𝍸 𝍸 𝍸 𝍸		𝍸 I	54	48.7			
Aden fasc (dead)	7	𝍸 𝍸 𝍸 𝍸 III					23	20.01			
Aden fasc. (seedling)	8										
	9										
Yucca whip	10	𝍸					5	4.4			
Sal mel	11	III					3	2.6			
Rha ili (C)	12	III					3	2.6			
Cea. Cra	13	II					2	1.7			
	14										
Other Spp	15						92				
(C) Tricostemma sp ?	16										
(adj)	17										
(C) Arctostaph sp	18										
	19										
	20										
	21										
	22										
	23										
	24										
	25										
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	39										
	40										
	41										
	42										
	43										
	44										
	45										

TI-CH-B-SW-Mulch

Cover Data

Project Boeing Recon Post-Burn Date 2/9/07 Time 11:00 am

Study Area Ch. ~~Un~~burned SW facing (above outfall 2) Sampler's Initials JH, RS

Camera:Make Model

	Transect 1					
Reference Point	Waypoint #	57 & 58				
Direction of Photo	~~S~~W & E					
Soils						
Resolution						
Height of Dom Veg						
Transect Number	T CH B SW. M					
Location	outfall 2					
Bearing and Aspect	270°					
Slope (%)	25%					

Total & Rel cover same

		Hits	Total	Hits	T	Hits	T	~~Hits~~	T	Hits	T
Bare Soil/Ash	1	~~||||~~ ~~||||~~ ||||					14				
Litter	2	||					2				
Rock w/mulch	3	~~||||~~ ~~||||~~ ~~||||~~					15				
~~Water~~ ~~Ash~~ Mulch	4										
Standing Dead	5										

69

		Hits	Total	Hits	T	Hits	T	Height	T	Hits	T
Aden fasc	6	|||					3	3.2, 2.6			
~~Cal mac~~ Aden (seed)	7										
	8										
Cal mac	9	~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~		~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~		~~||||~~ ~~||||~~ ~~||||~~ ~~||||~~	65				
Lot sco	10							1				
	11										
	12										
others sp.	13										
Eriod cras	14										
Quer ber - sdlgs	15										
Cea cras sdlgs	16										
	17										
	18										
	19										
	20										
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	22										
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	43										
	44										
	45										

T2 CH B SW M

Cover Data

Project: Boeing Recon Post Burn Date: 2/9/07 Time: 11:45am

Study Area: Ch ~~b~~burn SW facing - above outfall 2 Sampler's Initials: JH, RS

Camera: Make: Sony digital (disk) Model:

Reference Point	Waypoint #	59 & 60	Note: no	survey st	icks with
Direction of Photo	W & E			this transect	
Soils					
Resolution			~~Bent~~ Chemise	(burned) diameter	is approx 1" diameter
Height of Dom Veg					
Transect Number	T2CHBSWM				
Location	outfall 2				
Bearing and Aspect	270°				
Slope (%)	35%				

		Hits	Total	Hits	T (Total Cover)	Hits (Rel Cover)	T	Hits	T	Hits	T
Bare Soil / ash	1	HHT HHT II			12	12%			12%		
Litter	2										
Rock	3	I			1	1%					
~~Water~~ mulch	4	I			1	1%					
Standing Dead	5										
						86 = 0.98		Height		Rel.	
Aden fasc (regrowth) (adult)	6	II			2			2', 9", 1'2"			
~~Aden~~	7										
	8										
Calis mac	9	HHT HHT HHT	HHT	HHT HHT HHT	HHT	HHT HHT HHT	HHT HHT	HHT HHT HHT	85%	83.3	
Mar mac	10	I			1						
	11										
	12										
	13										
	14										
	15										
	16										
	17										
	18										
	19										
	20										
	21										
~~Other spp~~	22										
Mar mac	23										
Cea cras	24										
Het arb	25										
Mal laurina	26										
Phacelia cic?	27										
Que ber	28										
	29										
	30										
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	32										
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	39										
	40										
	41										
	42										
	43										
	44										
	45										

T1-CHB N um

Cover Data

Project Boeing Recon Post Burn Date 2/9/07 Time 1:10 pm

Study Area CH burn N facing (N of across outfall 9) Sampler's Initials JH, RS

Camera:Make Sony digital Model

Reference Point	Waypoint #61862		Need telescoping measuring stick			
Direction of Photo	N/S					
Soils	Gaviota rocky Sandy Loam					
Resolution						
Height of Dom Veg	5-6'					
Transect Number	T1CHBNum					
Location	Outfall 9 watershed					
Bearing and Aspect	0°					
Slope (%)	25%		Total	Relat cover		

		Hits	Total	Hits	T	Hits	T	Hits	T	Hits	T
Bare Soil	1	𝍸 ||	7%		7%						
Litter	2	𝍸 𝍸 ||||	14%		14%						
Rock	3	|									
Water	4										
Standing Dead	5										
					79/103=.77			Stem		Height	
~~Mal Laur.~~	6										
Heter arb	7	𝍸 𝍸 𝍸 𝍸 𝍸			25	19.3 ✓				1'9", 1'9", 5.0' (23 plants)	
Hetrom arb (dead stick)	8	𝍸 𝍸 𝍸 𝍸			20	15.4 ✓		1/4", >1"			Resp.
	9										
Thistle Italian (dead)	10	𝍸 ||			7	5.4 ✓					
Mara. Mac (dead)	11	||||			4	3.1					
Sol Xan	12	|			1	0.8					
grass (germ)	13	𝍸 𝍸 |			11	8.5					
~~Pe~~ Cen. mel (dead)	14	𝍸 𝍸 𝍸 𝍸 |			21	16.2					
Eri. con	15	𝍸			5	3.9					
Rec. Cor	16	𝍸 |||			8	6.2					
Pha. ci (dead)	17	|			1	0.8					
	18										
	19										
	20										
Other spp	21										
Sal mel	22										
Aden fasc	23										
Malac fasc	24										
Lot Scop	25										
Prun ilic	26										
Brom madri. rubens	27										
Mal Laur.	28										
Erio fasc	29										
	30										
	31										
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APPENDIX G: LITERATURE REVIEW ON HYDROLOGIC RECOVERY OF WATERSHEDS FOLLOWING FIRE (WRIGHT WATER ENGINEERS)

HYDROLOGIC RECOVERY OF WATERSHEDS FOLLOWING FIRE

TECHNICAL APPENDIX TO THE POST-FIRE VEGETATION RECOVERY RECONNAISSANCE SURVEY REPORT FOR THE BOEING SANTA SUSANA LABORATORY

Prepared for:

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MARCH 2007

071-013.000

HYDROLOGIC RECOVERY OF WATERSHEDS FOLLOWING FIRE

TECHNICAL APPENDIX TO THE POST-FIRE VEGETATION RECOVERY RECONNAISSANCE SURVEY REPORT FOR THE BOEING SANTA SUSANA LABORATORY

1.0 INTRODUCTION

This appendix provides a review of literature related to the hydrologic recovery of watersheds following the occurrence of fire. Emphasis is placed on the chaparral ecosystem that exists at the 2,700-acre Boeing Santa Susana Field Laboratory site where, in 2005, the Topanga fire burned much of the property. The site is located in the Simi Hills area of Ventura and Los Angeles Counties in southern California, and is dominated by hilly topography and dense chaparral/scrub vegetation, including chamise, scrub oak, and other thick-leaved, deeply rooted species.

For the purposes of the discussion in this appendix, hydrologic recovery of a watershed is defined as the return of a watershed to its pre-fire condition in terms of its rainfall-runoff relationship characteristics. Though hydrologic and sediment yield recovery of a burned watershed is a function of multiple factors, two variables that have a marked effect are: 1) vegetation type and cover, and 2) soil water repellency. For both of these factors, the return to pre-fire conditions has a large bearing on the hydrologic and sediment yield recovery of the watershed.

A brief literature review is presented that addresses vegetation recovery, soil water repellency, and general hydrologic and sediment yield recoveries of watersheds following fire. Studies referenced are for chaparral vegetation unless otherwise noted.

2.0 VEGETATION RECOVERY

Succession of the chaparral vegetation community, in terms of composition and rate of change, is influenced most by aspect, particularly north- and south-facing slopes. Slope steepness is of lesser importance. The rate of coastal chaparral regrowth after fire is slowest on south-facing slopes below 3,000 feet and is most rapid on north-facing slopes above 3,000 feet (Hanes 1971). Keeley also observed that, at the lowest elevation, site shrub cover was twice as great on the north and east-facing slopes as on the south and west-facing slopes (Keeley 1981).

Chaparral plant species that develop after a fire can be predicted reasonably well based on knowledge of the plant growth present at the time of the fire (Biswell 1974). However, some "new" plant species may appear, as a result of germination of seeds stored in the litter and soil, with the plants themselves having died long before. Some shrubs will stump-sprout after fire nearly 100 percent of the time, while other species, such as chamise chaparral, will produce sprouts in only 70 to 75 percent of plants.

In a Portuguese Mediterranean maquis environment, two years after fire, cover and aboveground biomass was half of the amount found in unburned stands. The rapid recovery was mainly attributed to resprouting species. Herbaceous species were abundant during the first two years after the fire but became scarce in older communities (Clemente et al. 1996).

In the first four years following a fire in California chaparral, annual species were the largest floristic group, but herbaceous perennials and shrubs were the major contributors to community biomass (Guo 2001). Keeley (2005) found that by the fifth year post-fire, approximately half of the species observed were not present in the first year following the fire, but these species compromised only about 10 percent of the cover.

During a four-year study of chaparral shrub succession after a fire in southern California, involving the four major slope faces at three elevations, total cover fluctuated from year to year, and shrub cover increased annually through the third year. There was little or no increase in shrub cover between the third and fourth years (Keeley 1981).

Fire severity affects the recovery of different species in different ways. Some woody species exhibit improved recovery under high intensity burning, whereas others are inhibited by high severity fires. Sites where the immediate post-fire recovery was inhibited by high severity fire exhibited no effect five years after the fire (Keeley 2005). In addition to the variability of different species, vegetation recovery is significantly controlled by patterns of precipitation (Keeley 2005). On fire-free sites, a chamise-chaparral climax community develops within 25 to 30 years after fire (Biswell 1974 and Hanes 1971).

3.0 FIRE EFFECTS ON SOIL

After a fire, water repellency can be found as a discrete layer of variable thickness on the soil surface a few centimeters below the mineral soil surface and parallel to the soil surface (DeBano 1998). A hypothesis regarding the formation of the water-repellent layer has been developed by DeBano (1998). Heat produced by combustion of the litter layer on the soil surface vaporizes organic substances, which are moved downward in the soil along the temperature gradients until they reach cooler underlying soil layers, where they condense. Organic particles coat and are chemically bonded to mineral soil particles. The final result is a water repellent layer located below and parallel to the soil surface on the burned area. The precise chemical composition of the hydrophobic substances has not been determined, perhaps because of the large number of organic substances that can be altered by soil heating during a fire (DeBano 1998, 2000).

The effects of fire on soil are a function of several factors (DeBano 1998), including:

- Fire severity – More severe fires produce a deeper water repellent layer in the soil, unless the fire is so hot that it destroys all organic matter in the soil.
- Type and amount of organic matter present in the soil - Sufficient organic matter must exist in the soil to provide hydrophobic substances.
- Temperature gradients that develop in the upper mineral soil – Steep temperature gradients foster translocation of hydrophobic substances.
- Soil texture - Sandy and coarse-textured soils are more susceptible to water repellency than more fine-grained soils.
- Soil water content - Water in the soil affects heat transfer and condensation of hydrophobic substances.

Doerr et al. (2003) notes the importance of knowing the soil temperature reached during a wildfire to understand post-fire soil properties, which in turn affect the short- and medium-term erosion susceptibility of burnt slopes. The litter layer present in chaparral is thin, which provides less efficient insulation against heat radiated downward than found with fires in other types of vegetation. Consequently, chaparral fires create temperatures at and beneath the soil surface which are generally higher than corresponding temperatures caused by prescribed fires in forests (USDA 1981). For the southern California chaparral, different fire severities are described by DeBano (1998).

- Low severity burns are characterized by charred leaf litter, with some grayish ash after the fire that soon becomes inconspicuous. Low severity burns reach temperatures of approximately 225 ^{o}C at the soil surface and 12.5 ^{o}C at 2.5 cm below the surface. When soils are heated to less than approximately 175^{o}C, DeBano (2000) indicates little change in water repellency occurs.
- Moderate severity burns consume leaf litter and fine woody material on the ground and produce a bare-soil seedbed. Moderate severity burns reach a maximum temperature of approximately 430^{o}C at the soil surface and approximately 200 ^{o}C at 2.5 cm below the surface. Intense water repellency is formed when soils are heated between 175^{o}C and 200^{o}C (DeBano 2000), and as high as 250^{o}C (Doerr et al. 2003).
- High severity burns are characterized by a fluffy, white ash seedbed. High severity burns reach a temperature of slightly more than 700^{o}C at the soil surface and approximately 250 ^{o}C at 2.5 cm below the surface. Destruction of water repellency occurs when soils are heated between 280^{o}C and 400^{o}C (DeBano 2000, Letey 2001).

While it is widely recognized that fire-induced water repellency is a key parameter affecting post-fire runoff and erosion rates (Robichaud 2000; DeBano 1998), few data exist related to the persistence of soil water repellency. McDonald and Huffman (2004) assessed water repellency in the field in a northern Colorado Front Range ponderosa and lodgepole pine forest, following a June 2000 fire, using the critical surface tension (CST) test. The CST involves applying droplets of deionized water to the soil and adding increasing concentrations of ethanol if the droplets are not absorbed into the soil within five seconds. The CST quantifies the surface tension associated with the lowest concentration of ethanol required to be absorbed into the soil and is a measure of soil water repellency, which has a direct bearing on runoff and sediment yield from a watershed. Soil water repellency was strongest at sites burned at high and moderate severity, and decreased with increasing depth in the soil. Spatially, the repellency was highly variable. The fire-induced soil water repellency progressively weakened over time and within one year post-fire was statistically nondetectable.

For the Cerro Grande watershed near Los Alamos, New Mexico, it was determined that areas initially measured to have high hydrophobicity after the fire that were intensively rehabilitated (including raking, seeding and mulching) were approximately back to pre-fire conditions within three years (WWE 2003). Soil hydrophobicity was measured using a water drop penetration test.

4.0 FIRE EFFECTS ON RUNOFF AND WATERSHED HYDROLOGY

Increases in water yield from wildfires and prescribed fires are highly variable and extrapolation of study findings to watershed scales is difficult because of the high temporal and spatial variability that occurs in the field (Letey 2001). In the fire-prone interior chaparral shrublands, annual streamflow discharge from their watersheds can increase by varying magnitudes, at least temporarily, as a result of wildfires of high intensity (USDA 2005).

Hydrologic recovery of a watershed can be quantified by evaluating the Curve Number (CN) ratio that compares post-fire and pre-fire CNs (WWE 2003) (CN ratio = post-fire CN/pre-fire CN). As the watershed recovers following the fire, and vegetation and soil characteristics gradually return to the pre-fire condition, the hydrologic response transitions toward its natural condition. For the Cerro Grande watershed, a CN ratio of 1.1 indicates a watershed has generally recovered to within approximately 10 percent of the pre-fire condition in terms of hydrologic response. If pre-fire management practices were continued, the watershed would eventually transition toward a CN ratio of 1.0, representing full recovery to pre-fire hydrologic conditions. For perspective on the CN ratio evaluation approach and hydrologic recovery, portions of the Cerro Grande fire area with the most severe burn effects, in Upper Pueblo

Canyon, had a CN ratio of 1.63 immediately following the fire (post-fire CN of 91/pre-fire CN of 56). Three years following the fire, large portions of the Upper Pueblo Canyon watershed with minimal rehabilitation still had a CN ratio of 1.55 (three-year post-fire CN of 87/pre-fire CN of 56), suggesting that complete hydrologic recovery of those areas would take much longer.

As described in WWE 2003, little published data exist regarding the time required for hydrologic recovery of a burned area. Brown (1972) indicates streamflow data show a recovery period of 4 to 5 years for some Australian watershed following brushfires. Helvey (1980) reported that large increases in runoff occurred during years two through seven following fire in a Ponderosa Pine/Douglas Fir forest.

In Mesa Verde National Park in southwestern Colorado, evaluation of vegetation, infiltration rates, and sediment transport in the Prater and Morefield Canyon watersheds indicated the basins exhibited limited recovery, with a CN of 87 immediately post-fire in August 2000 to a CN of 80 in May 2003 (compared with an estimated pre-fire CN of 60 or less in these watersheds). Furthermore, it was estimated that significant watershed recovery would not occur until 2010, with full recovery not occurring until approximately 2020 (WWE 2003). The Prater/Morefield Canyon watersheds are comprised of valley floors covered with sagebrush, grass and small plant growth; steep canyons; and upland areas covered with pinions and junipers interspersed with rock outcroppings and clusters of scrub oak.

5.0 EROSION AND SEDIMENT YIELDS

Sediment yields are often highest in the first year following a fire. Nearly all fires increase sediment yield, but wildfires in steep terrain produce the greatest amounts. Sedimentation usually declines in subsequent years as a protective vegetation layer becomes established (DeBano 1998). Post-fire sediment yields are largely indicative of the partial or complete consumption of litter and other decomposed organic matter on the soil surface and a reduction in infiltration, with consequent increase in overland flow (DeBano 1998).

A wildfire on the San Dimas Experimental Forest that burned over an ongoing sediment flux study provided an opportunity to document and quantify the effects of fire on hillslope erosion in small watershed units in a semiarid, chaparral-covered, steepland environment (Wohlgemuth 2003). In chaparral watersheds, post-fire dry season erosion was 2 to 3 times greater than unburned levels and post-fire wet season erosion was 9 to 18 times greater than prior to the fire. In the grass watershed, post-fire wet season erosion was more than 300 times greater than comparable unburned values. The dramatic increase in sediment flux attests in particular to the watershed protection provided by the grass vegetation prior to the fire. This study did not, however, address the time required for watershed recovery in terms of sediment yields returning to pre-fire rates.

Sediment yields from a low severity ponderosa pine wildfire recovered to normal levels after three years, but moderate and severely burned watersheds took 7 and 14 years, respectively (Robichaud 2000).

6.0 SUMMARY

Based on the literature reviewed, in can be inferred that the rate of return of chaparral vegetation in a watershed is based in large part on the precipitation conditions in the years following the fire, and on the slope aspect, with north facing slopes having a more rapid rate of return than south-facing slopes. The highest rate of chaparral shrub growth is expected to occur within approximately the first five years, with a climax chaparral plant community developing two to three decades later.

Soil water repellency is likely to be highest in areas with moderate to high burn severity, though extremely high temperatures (above approximately 300^{o}C) may destroy the water repellent layer. Little data exist regarding the return of soil water repellency to pre-fire conditions; the studies cited indicated pre-fire repellency was achieved between one and three years post-fire. This is very dependent on rehabilitation measures and on precipitation during the post-fire period.

Increases in water and sediment yield from fires, and the return to pre-fire conditions, are highly variable. Hydrologic recovery periods in studies cited ranged from approximately 4 to 5 years for an Australian grassland watershed to approximately 20 years for a watershed characterized by sage-pinion-juniper vegetation.

The greatest rate of hydrologic and sediment yield recovery at the Boeing Santa Susana Laboratory project site is anticipated to occur within the first one to three years, as the hydrophobicity of the soil diminishes and vegetation cover returns. The highest rate of chaparral growth is expected to occur for five to six years post-fire, which will further benefit the hydrologic recovery of the watershed and its corresponding effect on sediment yield. Complete return of the watershed to its pre-fire hydrologic and sediment yield condition could take longer, as chaparral vegetation may take decades to return to its pre-fire state, depending on climatic conditions. This estimated time to recovery is based on information available in the literature. Many variables will have a bearing on the actual recovery time, including climate conditions, severity of burn effects in areas of interest, and watershed rehabilitation efforts.

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