National Aeronautics and Space Administration

HISTORIC RESOURCES SURVEY AND ASSESSMENT OF THE NASA FACILITY AT SANTA SUSANA FIELD LABORATORY, VENTURA COUNTY, CALIFORNIA

Prepared for:

National Aeronautics and
Space Administration

George C. Marshall
Space Flight Center,
Huntsville, Alabama

Prepared by:

Archaeological Consultants, Inc.,
Sarasota, Florida
and
Weitze Research,
Stockton, California

May 2008
Revised March 2009

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EXECUTIVE SUMMARY

A historic resource assessment survey of the National Aeronautics and Space Administration (NASA)-owned facilities within Areas I and II of the Santa Susana Field Laboratory (SSFL) in Ventura County, California was conducted in the fall of 2007 by Archaeological Consultants, Inc. (ACI), Sarasota, Florida and Weitze Research, Stockton, California on behalf of NASA's George C. Marshall Space Flight Center (MSFC) in Huntsville, Alabama. NASA-owned real and personal property within the 41.7-acre portion of Area I, acquired by NASA from the Air Force in May 1976, and the 409.5-acre Area II, acquired from the Air Force in November 1973, of the SSFL fall under the jurisdiction of the MSFC's Space Shuttle Main Engine (SSME) Project Office.

The purpose of this survey is to provide an overall historic context for the facility, and to identify and evaluate all NASA-owned facilities at the SSFL in terms of the criteria of eligibility for listing in the National Register of Historic Places (NRHP), as per 36 CFR Part 60.4. This survey was conducted in compliance with Section 110 of the National Historic Preservation Act (NHPA) of 1966 (Public Law 89-665), as amended; the National Environmental Policy Act (NEPA) of 1969 (Public Law 91-190); Executive Order (EO) 11593: Protection and Enhancement of the Cultural Environment; EO 13287: Preserve America; and other relevant legislation. The results of this survey will be used to support any future Section 106 undertakings.

In 2006, CH2MHill completed a preliminary evaluation of the existing facilities, inclusive of water tanks, storage sheds, and other temporary buildings, in Area II of the SSFL for possible eligibility for listing on national and state historic registers. As a result, the initial evaluation indicated that "most or all of the primary structures, sites, and other improvements . . . could be considered potentially eligible for listing on both the National Register of Historic Places and the California Register of Historic Places" (Calvit and Barrier 2006:1). Relevant historic contexts for the SSFL included the U.S. space programs (from Gemini to Space Shuttle) and Cold War defense or missile programs.

Also in 2006, ACI and Weitze Research completed a limited survey of NASA-owned facilities located within Area II in the historic context of the U.S. Space Shuttle Program, circa 1969-2010 (Deming, Slovinac and Weitze 2007b). This survey was part of a NASA-wide survey and evaluation of historic facilities associated with the Space Shuttle Program. The field survey included a limited reconnaissance of Area II, and an in-depth survey and evaluation of 29 buildings, structures, and sites located within the Coca Test Area. As a result, the Coca I Test Stand (Building 733) and the Coca Control House (Building 218) were evaluated as NRHP-eligible under Criterion A for their exceptionally important role in the development and testing of the SSME, and under Criterion C for their specialized engineering and design. The final report was submitted to the California SHPO in February 2008 for review by NASA's MSFC.

The current evaluation of the SSFL included an initial review of a list of 135 NASA-owned buildings, structures, and sites located within Areas I and II of the SSFL, provided to ACI by MSFC HPO, Ralph Allen. With the exception of a single well in Area I, all of the facilities are located within Area II. This initial review revealed that 60 of the facilities within Areas I and II are temporary structures, small storage sheds, roadways, pipelines, or other small objects, such as light fixture poles, which are used for generic purposes, with no specific historic function. The remaining 75 facilities are all located within the Alfa, Bravo, Coca, Delta, Storable Propellant Area (SPA), and Service Area complexes of Area II; field survey focused on these 75 facilities. As a result of archival research and field survey, six test stands (Buildings 727, 729, 730, 731, 733 and 787) located in the Alfa, Bravo and Coca test areas, plus three associated control houses (Buildings 208, 213, and 218) were evaluated as meeting the NRHP criteria of eligibility in the contexts of the Cold War (Military) and Space Exploration, circa mid-1950s to 1991. Because they have achieved exceptional importance within the past 50 years, Criteria Consideration G applies.

The Alfa I and III Test Stands (Building 727 and 729) and the Bravo I and II Test Stands (Buildings 730 and 731), as well as their associated control houses (208 [Alfa] and 213 [Bravo]) are considered eligible for listing in the NRHP under Criterion A for their exceptionally important role in the development and testing of various rocket engines, and under Criterion C for their specialized engineering and design, by the architectural-engineering firm of Daniel, Mann, Johnson & Mendenhall, Inc. (DMJM) and German engineer Walter Riedel, a rocket engine expert who had worked with Dr. von Braun's team. The Coca I and IV Test Stands (733 and 787), as well as their associated control house (218) are considered eligible for listing in the NRHP under Criterion A for their exceptionally important role in the development and testing of various rocket engines and space boosters, and under Criterion C for their specialized engineering and design; the Coca Control House was designed by DMJM and Riedel.

In addition to the nine individually eligible historic properties, three historic districts were identified as eligible for listing in the NRHP: the Alfa Test Area Historic District, the Bravo Test Area Historic District, and the Coca Test Area Historic District. Each is considered eligible for listing in the NRHP in the contexts of the Cold War (Military) and Space Exploration under Criteria A and C. Because they have achieved exceptional importance within the past 50 years, Criteria Consideration G applies. The relevant areas of significance are Military, Engineering, Transportation, and Space Exploration.

The **Alfa Test Area Historic District** contains 10 contributing resources and four noncontributing resources. Constructed during 1954-1955, the Alfa test site featured the first cluster of static test stands operational for Air Force Plant (AFP) 57 at Santa Susana. Beginning in the mid-1950s, the Alfa test site supported early rocket engine static testing, and provided pivotal data for the development and improvement of many weapons and space vehicle booster systems (Criterion A). The Alfa Test Area Historic District is also considered eligible under Criterion C for the design and engineering of the test site, by the Los Angeles architectural-engineering firm of DMJM, with the assistance of Walter Riedel, which is inclusive of the test stands and blockhouse, the ancillary buildings and structures, and the elements of the natural and man-made landscape.

The **Bravo Test Area Historic District** contains eight contributing resources and one noncontributing resource. Constructed during 1955-1956, the Bravo test site featured the second cluster of static test stands operational for AFP 57 at Santa Susana. Under Criterion A, it is considered eligible for its underlying associations with multiple static engine tests run between 1956 and 1991, beginning with tests of Atlas thrust chambers in 1956, and also supporting testing of F-1 components, Lunar Module Rocket Engine assemblies, as well as Atlas and Delta RS-27 vernier engines and turbopumps. Like the Alfa Test Area, the Bravo Test Area Historic District is also significant under Criterion C for the design and engineering of the test site, by DMJM, with Walter Riedel, which is inclusive of the test stands and blockhouse, the ancillary buildings and structures, and the elements of the natural and man-made landscape.

The **Coca Test Area Historic District** contains 18 contributing resources and four noncontributing resources. Originally constructed during 1955-1956, the Coca test site featured the third cluster of static test stands operational for AFP 57 at Santa Susana. Some of the facilities were modified/redesigned between 1962 and 1964; additional facilities were designed between 1972 and 1978. Under Criterion A, the Coca Test Area Historic District is considered eligible for its underlying associations with multiple static engine tests run between 1956 and 1988, beginning with tests of Atlas and Navaho engines in the late 1950s; the J-2 engine in the 1960s in support of Saturn/Apollo; and the SSME in the 1970s and 1980s in support of the Space Shuttle Program. Like the Alfa and Bravo Test Areas, the Coca Test Area Historic District is also significant under Criterion C for the design and engineering of the test site, by DMJM, with Walter Riedel, which is inclusive of the test stands and blockhouse, the ancillary buildings and structures, and the elements of the natural and man-made landscape.

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LIST OF ACRONYMS AND ABBREVIATIONS

AAF	Army Air Forces
ACH	Alfa Control House
ACHP	Advisory Council on Historic Preservation
ACI	Archaeological Consultants, Inc.
AEC	Atomic Energy Commission
AFHRA	Air Force Historical Research Agency
AFP	Air Force Plant
AFPRO	Air Force Plant Representative Office
AI	Atomics International
ATA	Alfa Test Area
BCH	Bravo Control House
BTA	Bravo Test Area
CCH	Coca Control House
CTA	Coca Test Area
COCO	Contractor-owned, Contractor-operated
CTL	Component Test Laboratory
DMJM	Daniel, Mann, Johnson & Mendenhall
DoD	Department of Defense
ECS	Electrical Control Station
EFL	Edwards Field Laboratory
EO	Executive Order
FY	Fiscal Year
GALCIT	Guggenheim Aeronautical Laboratory, California Institute of Technology
GE	General Electric
GH2	Gaseous Hydrogen
GN2	Gaseous Nitrogen
GOCO	Government-owned, Contractor-operated
hp	Horsepower
HPO	Historic Preservation Officer
ICBM	Intercontinental Ballistic Missile
IMDB	Internet Movie Database
IRBM	Intermediate Range Ballistic Missile
ISTB	Integrated Subsystems Test Bed
JP4	Jet Fuel
JPL	Jet Propulsion Laboratory
K	Thousand
KEWB	Kinetic Experiment for Water Boilers
KSC	Kennedy Space Center
LH2	Liquid Hydrogen
LN2	Liquid Nitrogen
LOX	Liquid Oxygen
LVSD	LOX Vessel Service Deck
MSFC	Marshall Space Flight Center

LIST OF ACRONYMS AND ABBREVIATIONS (cont.)

MTF	Mississippi Test Facility
MX	Missile Experiment
NAA	North American Aviation
NASA	National Aeronautics and Space Administration
Nativ	North American Test Instrumentation Vehicle
NEPA	National Environmental Policy Act
NFL	Nevada Field Laboratory
NHPA	National Historic Preservation Act
NPS	National Park Service
NRHP	National Register of Historic Places
NSTL	National Space Technology Laboratories
PFL	Propulsion Field Laboratory
PWR	Pratt & Whitney Rocketdyne
SAC	Strategic Air Command
SHHDC	Shuttle History Historical Documents Collection (at Marshall)
SHPO	State Historic Preservation Officer
SNAP	System for Nuclear Auxiliary Power
SPA	Storable Propellant Area
SRE	Sodium Reactor Experiment
SSFL	Santa Susana Field Laboratory
SSME	Space Shuttle Main Engine
START	Strategic Arms Reduction Treaty
STL	Space Test Laboratory
TDY	temporary duty
US	United States
USAF	United States Air Force
USSR	Union of Soviet Socialist Republics
VTS	Vertical Test Stand
WBNS	Water Boiler Neutron Source

1.0 INTRODUCTION

1.1 Project Summary and Objectives

A historic resource assessment survey of the National Aeronautics and Space Administration (NASA)-owned facilities within Areas I and II of the Santa Susana Field Laboratory (SSFL) in Ventura County, California was conducted in the fall of 2007 by Archaeological Consultants, Inc. (ACI), Sarasota, Florida and Weitze Research, Stockton, California on behalf of NASA's George C. Marshall Space Flight Center (MSFC) in Huntsville, Alabama. NASA-owned real and personal property within the 41.7-acre portion of Area I and the 409.5-acre Area II of the SSFL fall under the jurisdiction of the MSFC's Space Shuttle Main Engine (SSME) Project Office.

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The following report contains the study methods, historic context, and description and evaluation of NASA-owned facilities.

1.2 Santa Susana Field Laboratory

The SSFL is located in the Simi Hills area of Ventura County, California, approximately 7 miles northwest of Canoga Park and approximately 30 miles northwest of downtown Los Angeles (Figures 1.1-1.3). The 2,668-acre site is divided into four administrative areas, I, II, III and IV, as well as undeveloped buffer zones to the northwest and south. The Boeing Company owns and maintains roughly 671 acres in Area I, as well as the entirety of Areas III and IV, for a total of 2216.8 acres. NASA owns approximately 451.2 acres at the SSFL: the 409.5-acre Area II, formerly Air Force Plant (AFP) 57, which were acquired from the Air Force in November 1973, and approximately 41.7-acres of Area I, formerly AFP 64, which were acquired from the Air Force in 1976.

As completed in 1957, Area II of the SSFL included six distinct elements, from north to south: the Service Area, Components Test Laboratory (CTL) II, the Alfa Test Area, the Bravo Test Area, the Coca Test Area, and the Delta Test Area. The various structures in the Service Area, including a substation and water wells located separately to the

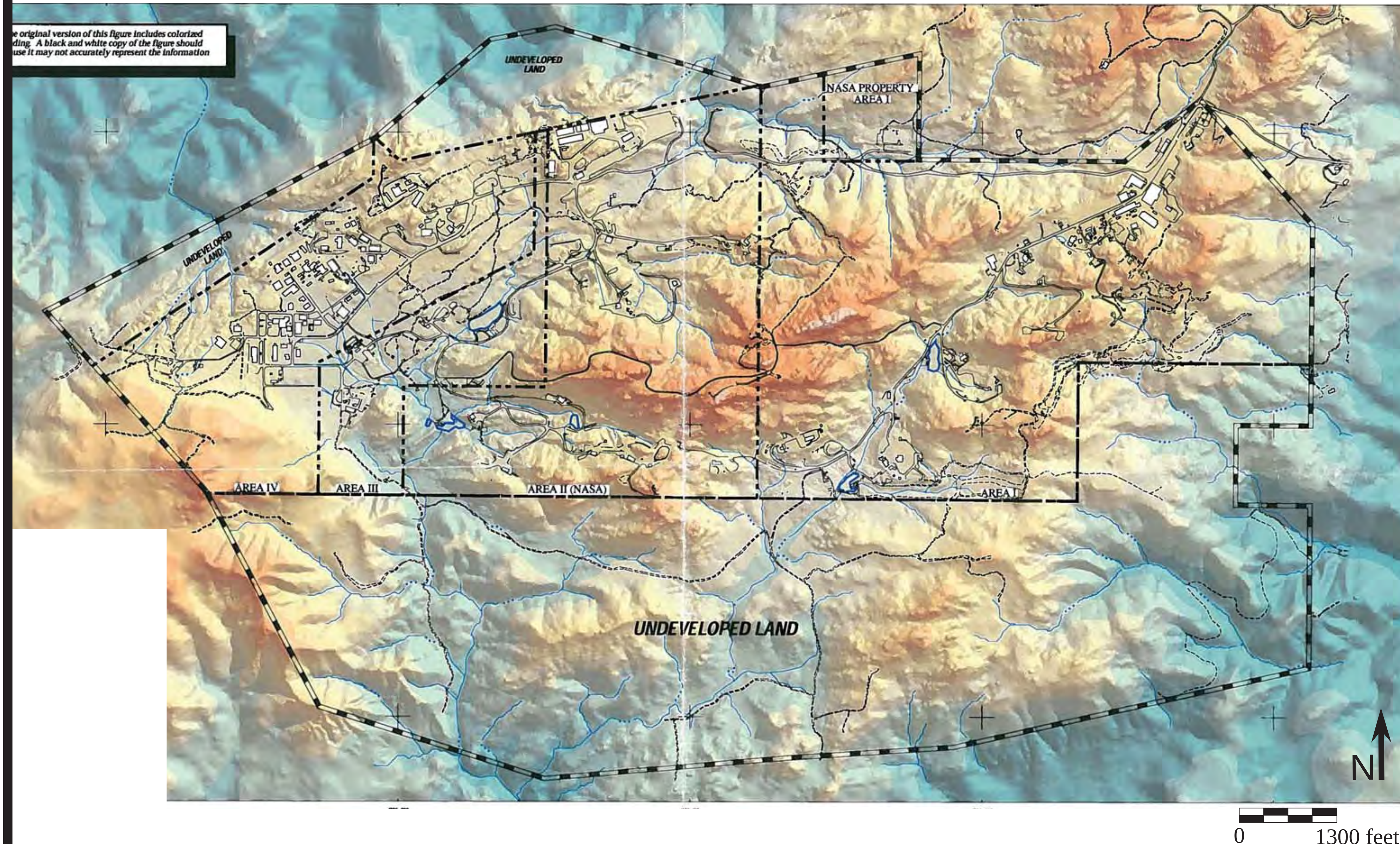

Figure 1.1. General location of Santa Susana Field Laboratory (Courtesy of Boeing Corporation; inset by American Automobile Association, 2007).

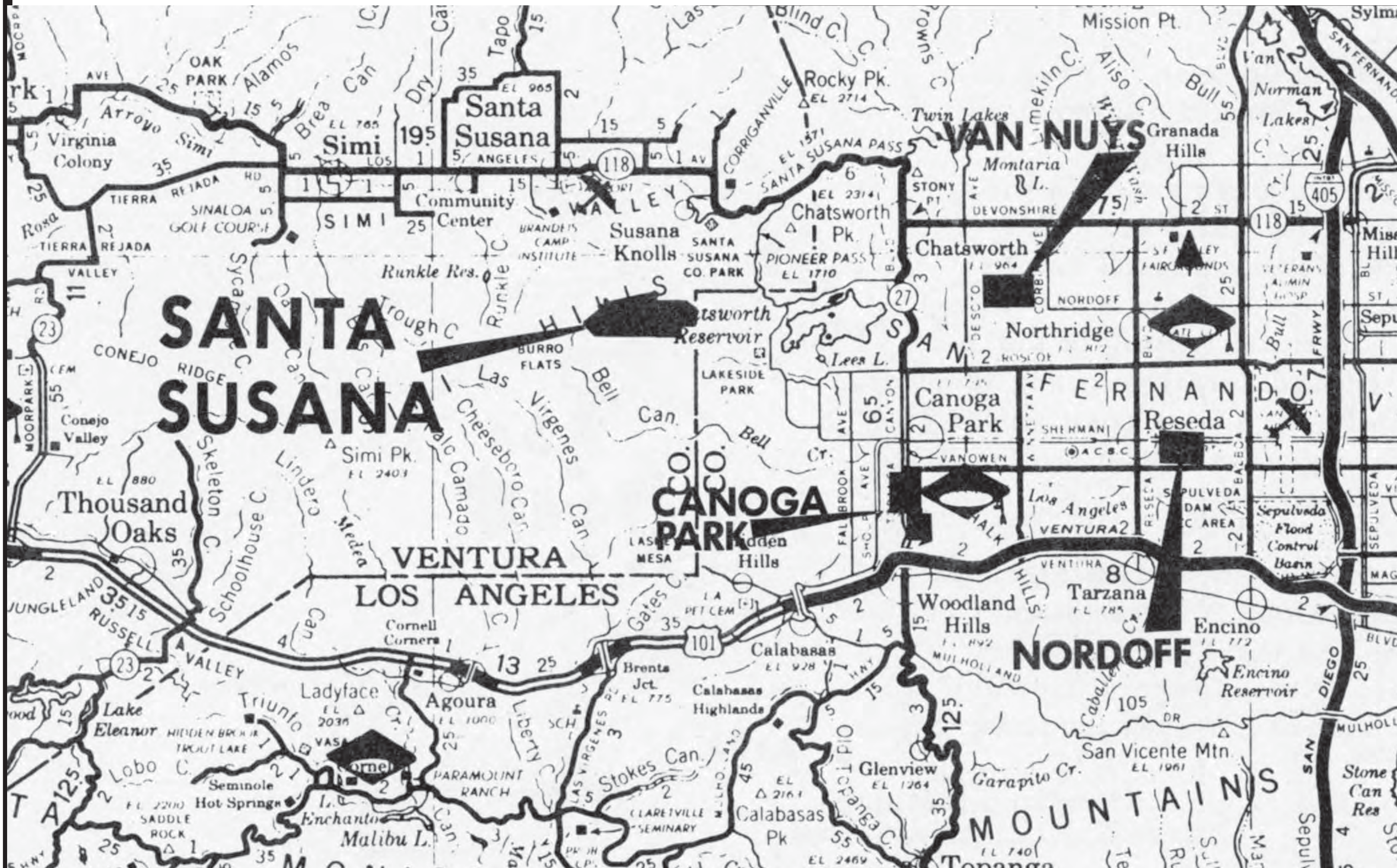

Figure 1.2. Location of the Santa Susana Field Laboratory and Relationship to Canoga Park (Map from 1965 NASA Master Plan, Volume 4, courtesy of Ralph Allen, MSFC).

Santa Susana Field Laboratory (SSFL)

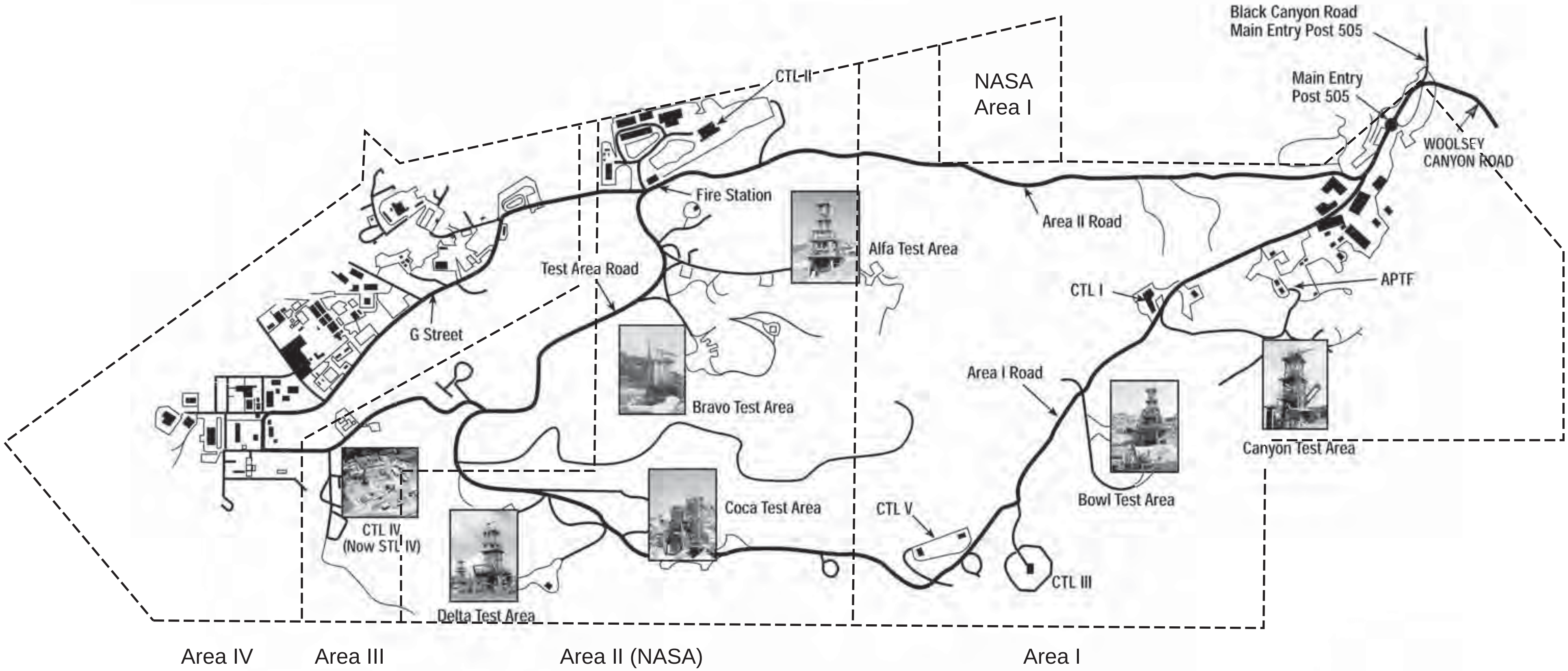

Figure 1.3. Location of the test and other areas within the Santa Susana Field Laboratory (Courtesy of Boeing Corporation).

south/southwest, were designed by Daniel, Mann, Johnson & Mendenhall (DMJM) in August 1954 and March 1955. Included are such facilities as the engineering offices, cafeteria, and fire house. CTL II, located immediately west of the Service Area, was designed between March and June 1955 by Kenneth H. Neptune, an architect in Beverly Hills, California. This facility contained a control center office area, a workshop, five test cells, and a storage area for propellants.

The four test sites were designed by DMJM between 1954 and 1956. Alfa came first, in September 1954; Bravo in March 1955; Coca in June 1955; and Delta in April 1956. As completed, each test site had three test stands, a shared recording/control center (blockhouse), a pre-test building, a terminal house, an observation bunker (pill box), and various fuel facilities. The Coca Test Area was subsequently modified and enlarged in the 1960s and 1970s by the Bechtel Corporation. Presently, the Alfa, Bravo, and Coca sites remain relatively intact, with at least two remaining test stands, their blockhouse, a terminal house, a pill box, and fuel facilities. The Delta site retains very little of its original fabric.

1.3 Previous Surveys

In 2006, CH2MHill architectural historians Calvit and Barrier completed a preliminary evaluation of the existing facilities in Area II of the SSFL, inclusive of water tanks, storage sheds, and other temporary buildings. Work included research, field survey, and preparation of a summary technical memorandum which presented preliminary significance evaluations and recommendations. Research methods included a review of drawings, photographs, previous documentation, and available literature. As a result, the initial evaluation indicated that “most or all of the primary structures, sites, and other improvements . . . could be considered potentially eligible for listing on both the National Register of Historic Places and the California Register of Historic Places” (Calvit and Barrier 2006:1). Relevant historic contexts for the SSFL included the U.S. space programs (from Gemini to Space Shuttle) and Cold War defense or missile programs. The study concluded with recommendations for a comprehensive survey of the SSFL.

Also in 2006, ACI and Weitze Research completed a limited survey of NASA-owned facilities located within Area II in the historic context of the U.S. Space Shuttle Program, circa 1969-2010. This survey was part of a NASA-wide survey and evaluation of historic facilities associated with the Space Shuttle Program. Tasks included archival research, context development, field survey, and preparation of draft and final reports. Field survey, conducted on September 20 and 21, included a limited reconnaissance of Area II, and an in-depth survey and evaluation of 29 buildings, structures, and sites located within the Coca Test Area. As a result, the Coca I Test Stand (Building 733) and the Coca Control House (Building 218) were evaluated as NRHP-eligible under Criterion A, for their exceptionally important role in the development and testing of the SSME, and under Criterion C for their specialized engineering and design. The final report was submitted to the California SHPO for review in February 2008 by NASA’s MSFC.

Other previous studies of general relevance to the historic resource assessment survey of NASA-owned facilities within Areas I and II of the SSFL include *Command Lineage, Scientific Achievement, and Major Tenant Missions*, volume I of *Keeping the Edge: Air Force Materiel Command Cold War Context (1945-1991)*, prepared in 2003 by Dr. Karen J. Weitze.

2.0 METHODOLOGY

2.1 Statement of Work

The historic resources survey and assessment of the NASA facility at the SSFL entailed three tasks: research and context development, field survey, and preparation of draft and final reports. In accordance with the scope of work developed by NASA MSFC, research included examination of real property data, historical photographs, master plans, engineering drawings, relevant California site file data and survey reports on file at the California Office of the State Historic Preservation Officer (SHPO), other relevant documents and articles, and informant interviews. The historic context included all relevant periods of significance.

2.2 Research Methods

Archival research and historic context development were accomplished by Dr. Karen Weitze between August and November 2007. Research was conducted at a number of repositories of relevant archival documents and historic photographs, including the MSFC History Office in Huntsville, Alabama; the Air Force Historical Research Agency (AFHRA), Maxwell Air Force Base, Montgomery, Alabama; the Rocketdyne Historic Photograph Collection at SSFL; the Boeing Company office in Canoga Park; and the DMJM office in Los Angeles. In addition, telephone and on-site interviews were conducted with previous and current employees of Rocketdyne (now Pratt & Whitney Rocketdyne) and the Boeing Company.

The historic facilities field survey at the SSFL was performed on August 13-18, 2007 by Patricia Slovinac and Tesa Norman of ACI. All NASA-owned facilities were inspected, described, and photographed. In addition, on-site interviews were conducted with several individuals with decades of work experience at the test facilities. These informants provided invaluable data regarding the historic functions of specific test stands and their ancillary facilities, and clarified changes to individual facilities as well as the overall landscape.

Following the collection of data through research and field survey, all NASA-owned facilities within Area II of the SSFL were evaluated for their significance in terms of the eligibility criteria for listing in the NRHP. Guidance in applying the criteria was provided by reference to a number of U.S. Department of the Interior, National Park Service (NPS) publications, including *Guidelines for Applying the National Register Criteria for Evaluation* (NR Bulletin 15); *Guidelines for Completing National Register of Historic Places Forms: How to Complete the National Register Registration Form* (NR Bulletin 16A); and *Guidelines for Evaluating and Nominating Properties that Have Achieved Significance within the Last Fifty Years* (NR Bulletin 22).

The National Register Criteria for Evaluation, as described in 36 CFR Part 60.4, follow:

The quality of significance in American history, architecture, archeology, engineering and culture is present in districts, sites, buildings, structures and objects that possess integrity of location, design, setting, materials, workmanship, feeling and association and:

A. That are associated with events that have made a significant contribution to the broad patterns of history; or

B. That are associated with the lives of persons significant in our past; or

C. That embody the distinctive characteristics of a type, period, or method of construction, or that represent the work of a master, or that possess high artistic values, or that represent a significant and distinguishable entity whose components may lack individual distinction; or

D. That have yielded, or may be likely to yield information important in prehistory or history.

The significance of historic buildings, structures, objects and districts is usually evaluated under Criterion A (association with historic events); Criterion B (association with important persons); or Criterion C (distinctive design or distinguishing characteristics as a whole). Often, more than one criterion will apply to historic resources. In addition to the identification of facilities which individually meet the criteria of eligibility for listing in the NRHP, all surveyed assets were evaluated for their potential to contribute to a historic district. In accordance with the *Guidelines for Completing National Register of Historic Places Forms: How to Complete the National Register Registration Form* (NR Bulletin 16A), "a district possesses a significant concentration, linkage, or continuity of sites, buildings, structures or objects united historically or aesthetically by plan or physical development." All resources within a district are either contributing or noncontributing. A **contributing** building, structure, or object adds to the historic associations or historic engineering or architectural qualities for which the property is significant because either it was present during the period of significance, relates to the documented significance of the property, and possesses historic integrity or is capable of yielding important information about the period, or it independently meets the NRHP criteria. A **noncontributing** resource does not add to the historic engineering or architectural qualities or historic associations for which a property is significant because it was not present during the period of significance or does not relate to the documented significance of the property; due to alterations, disturbances, additions or other changes, it no longer possesses historic integrity or is capable of yielding important information about the period; or it does not independently meet the NRHP criteria.

Ordinarily, properties that have achieved significance within the past 50 years are not considered eligible for the NRHP. However, a number of facilities at the SSFL do qualify since they meet a special Criteria Consideration G: "*A property achieving significance within the past 50 years if it is of exceptional importance.*"

In addition, to be considered eligible for listing in the NRHP, a property must retain enough integrity to convey its historical significance. The NRHP recognizes seven aspects or qualities that, in various combinations, define integrity: location, setting, materials, design, workmanship, feeling, and association. These are defined as follows (NPS 1995: 44-45):

- *Location is the place where the historic property was constructed or the place where the historic event occurred.*
- *Design is the combination of elements that create the form, plan, space, structure, and style of a property.*
- *Setting is the physical environment of a historic property.*
- *Materials are the physical elements that were combined or deposited during a particular period of time and in a particular pattern or configuration to form a historic property.*
- *Workmanship is the physical evidence of the crafts of a particular culture or people during any given period in history or prehistory.*
- *Feeling is a property's expression of the aesthetic or historic sense of a particular period of time.*
- *Association is the direct link between an important historic event or person and a historic property*.

Many of the test stands at the SSFL have undergone modification. In accordance with the guidance provided by the Advisory Council on Historic Preservation (ACHP), as a general rule, in the case of highly technical and scientific facilities, "there should be continuity in function, and thus, in integrity of design and materials, and there may always be integrity of association" (ACHP 1991:33). These principles were considered in the evaluation of historic facilities at the SSFL.

2.3 Acknowledgements

ACI and Weitze Research gratefully acknowledge the Herculean efforts of Ralph Allen, NASA MSFC's Historic Preservation Officer (HPO), who facilitated all elements of this project. Mr. Allen is especially thanked for serving as the liaison between the project team and the Boeing Company managers at SSFL; for providing direct assistance with research and field survey; and for supplying requested documents and materials, including as-built drawings. We also extend special thanks to Stu Kramer of the Boeing Company, who familiarized our team with the layout and facilities of the SSFL, and who guided us to key sources of information. The cooperation of dozens of individuals contributed to the successive completion of this survey. Thank you to Scottie Barnes, Sharon K. Beamer, Adam Boettner, Steve Dember, Joyce A. Kucinskas, Brian Logan, Laurence Manring, Ivory Matthews, III, Joanne M. Padfield, Thomas Venable, Marty Willis, and the many others who shared their knowledge and experiences at SSFL. Dr.

Weitze would also like to extend a thank you to Joseph D. Caver and Archangelo (Archie) DiFante at AFHRA, and Mike Wright and Roena D. Love at the MSFC History Office.

3.0 HISTORIC CONTEXT: SANTA SUSANA FIELD LABORATORY

Today's Santa Susana Field Laboratory began as a rocket engine test site operated by North American Aviation (NAA) in the late 1940s. Located near Canoga Park northwest of Los Angeles, the Santa Susana enclave evolved as the responsibility of the Rocketdyne Division of NAA (currently, Boeing). During 1954-1956, the United States Air Force worked with NAA to establish two AFPs in an expansion of the original Santa Susana site. These plants, run as Government-Owned Contractor-Operated (GOCO) facilities, occupied a portion of the original acreage (AFP 64, within the current Area I) and all of the west addition (AFP 57, the current Area II). AFP 57 featured four clusters of engine test stands (Alfa, Bravo, Coca, and Delta) as well as a laboratory compound, a service area, and supporting infrastructure. Although functioning as a GOCO from its inception, AFP 57 relinquished a majority of test stand positions and laboratory use through a lease arrangement to NASA in the 1960s to support the Apollo program. The Air Force formally transferred Area II at the Santa Susana site to NASA in 1973.

Transitioning through several early names in addition to AFP 57, the Area II facilities would become best known as the SSFL of NASA's MSFC in Huntsville, Alabama. The Bowl Area in the neighboring Area I (of 1949-1951) was very closely linked in its design to a rocket engine test site in late World War II Germany, and was among the first major such test complexes in the United States. Area II (of 1954-1956) also carried forward aspects of German rocket engine test site layout, although simultaneously incorporated a flurry of American achievements from the early 1950s. The SSFL was a notable scientific research, development, test, and evaluation location. From the middle 1950s into the early 21st century, the SSFL supported rocket engine static testing, providing pivotal data for the development and improvement of many weapons and space vehicles from the Redstone rocket to the Atlas intercontinental ballistic missile (ICBM), to the SSME. A variety of Air Force, Army, and NASA rocket engines underwent testing at Santa Susana during the more than five decades of its active lifespan.

3.1 Origins of the Santa Susana Field Laboratory, 1946-1950

With the stage set for the Cold War between the United States and the Soviet Union, the American guided missile program was seriously underway as soon as World War II ended. In early 1946, the Army Air Forces (AAF) contracted with NAA to develop the Navaho guided missile. NAA immediately began running static (tie-down) tests of captured German V-2 missiles at the White Sands Proving Ground in New Mexico. The firm soon initiated efforts toward a test article for the future missile. By the late 1940s, the Department of Defense (DoD) and Department of Commerce authorized assignment of individual German scientists and engineers from Operation Paperclip, to private companies involved in this type of work. The majority of Paperclippers, best represented by Wernher von Braun, had been sent to Fort Bliss, near the White Sands Proving Ground. Others, however, were allocated to the Air Force and Navy. In 1948, the Air Force's Air Materiel Command had 148 Paperclippers working at Wright-Patterson Air

Force Base in Ohio, with 23 more stationed at its subordinate research and development centers nationwide. The same year, the Army had 177 Paperclippers within its organization (predominantly stationed at Fort Bliss); the Navy, 72. Approximately 50 Paperclippers worked under the jurisdiction of the Department of Commerce. Air Materiel Command assigned temporary duty stations (TDY) for select members of its Paperclip group, including NAA in Los Angeles. As of 1947, the command had placed Paperclipper Walter Riedel at NAA as a liaison between the Air Force and private industry (Photo 3.1) (Weitze August 2003a: 169).

Photo 3.1. North American Aviation Santa Susana executive personnel and visitors, Los Angeles, ca.1947. Back row (left to right): Jim Broadston, Jim Cummings, Bill Cecka, Paul Vogt, visitor, Bob Lodge, Walter Riedel, unidentified NAA employee, and Norm Reuel. Front row: Sam Hoffman, six visitors, and Tom Meyers.
(Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

Engineer Walter Riedel (1902-1968) had a long and illustrious career. First collaborating on a liquid-propellant rocket engine with Dr. Arthur Rudolph (1906-1996) for the Heylandt Company in Germany during the early 1930s, he later became the Chief Designer at the Peenemünde Experimental Rocket Center during World War II. Paul Heylandt (1884-1947) commercially developed and manufactured liquefied gases, including liquid oxygen (LOX) (Stanford University December 2007; Neufeld 1996/1999: 11, 17-19, 32-33). Peenemünde, like the SSFL, had a LOX plant on site. Dr. Rudolph, also subsequently a Paperclipper, would later work at the Redstone Arsenal (and the MSFC). The Heylandt engine powered a rocket 3.5 meters long and 10 centimeters in diameter. The test launch was only modestly successful, but in late 1932 Dr. von Braun and others of the nascent group of space weapons engineers joined the German Army’s Ordnance Office to develop rockets leading to the V-2. The Ordnance Office hired Riedel for the rocket development team in January 1933, a year after Hitler became Chancellor of Germany.

Riedel brought significant practical experience to the small group of rocket scientists and engineers assembled at Kummersdorf (Neufeld 1996/1999: 33). First in design and test was the A-1, a rocket very similar to that designed by Riedel and Rudolph at the outset of the decade (Astronautix December 2007a). The V-2 (alternately known as the A-4) did not undergo its first test launch until mid-1942, and was not in true production until early 1944. A much larger rocket than the other rockets in the A series, the V-2 was the idea of Dr. von Braun and engineer Riedel, and its conception had dated to 1936. The V-2 stood 46 feet high and was 5 feet, 5 inches in diameter, with a lower wing span of 11 feet, 8 inches. Riedel was head of the design unit at Peenemünde (the rocket-test location that followed Kummersdorf), from its opening in 1937 to late summer 1942. Subsequently, he oversaw the V-2's production drawings (Neufeld 1996/1999: 162). Getting these drawings "right" would require 65,000 design modifications. Walter Riedel, sometimes known as "Papa" Riedel, was the granddaddy of the liquid fuel rocket engine. He was also a senior man in the very young group of scientists and engineers, older by a decade, for example, than Dr. Von Braun (Astronautix December 2007c; Neufeld 1996/1999: 33). His expertise and experience made him the perfect man to help set up rocket engine testing at NAA's Santa Susana site.

NAA had expanded its staff to 100,000 employees at the height of its aircraft manufacture for the American military establishment during World War II. Like other aircraft companies, NAA faced the urgent need to find a new business sector by late 1945. The AAF at Wright Field had decided that four types of missiles would be developed in the immediate post-war years: air-to-air, air-to-surface, surface-to-air, and surface-to-surface. By November, the AAF had invited the 17 major aircraft manufacturers, including NAA, to submit proposals for specific weapons designs in these categories. NAA elected to establish a research laboratory in Los Angeles, "staffed with experts in such fields as jet propulsion, rockets, gyros, electronics, and automatic control." The company hired Dr. William Bollay to run the organization, known within NAA as the Technical Research Laboratory. Dr. Bollay, an aeronautical engineer educated at the California Institute of Technology in Pasadena (Cal Tech), had trained among the best and brightest in the field. During World War II, Dr. Bollay had worked as a branch chief at the Navy Bureau of Aeronautics in Washington, D.C., responsible for a turbojet engine program. In consultation with others at NAA, Dr. Bollay decided to focus the efforts of the Technical Research Laboratory on the development of a missile based on the V-2 (Heppenheimer 2002a: Chapter 1).

Dr. Bollay's background had exposed him to German aeronautics through the work of a teacher and colleague, Dr. Theodore von Karman. Cal Tech's Guggenheim Aeronautical Laboratory (GALCIT), the predecessor of the Jet Propulsion Laboratory (JPL), had hired Dr. Theodore von Karman in 1929 from his then-position as Director of the Aachen Aeronautics Institute. Dr. von Karman had fled the rising tide of Nazism, and GALCIT rose to rival the Aachen Aeronautics Institute (Weitze August 2003a: 60). As of 1940, GALCIT built a small group of static test rocket engine test stands in Pasadena's Arroyo Seco Canyon near the Cal Tech campus. In 1942, Dr. von Karman and some of his students formed the Aerojet Engineering Corporation to fabricate liquid- and solid-fueled small rocket engines. In 1944, in receipt of an Army contract to develop tactical ballistic missiles, GALCIT became JPL. And as of 1945, JPL required a more isolated and larger site for its static rocket engine test program, relocating its test stand enclave to Muroc

Army Air Field (today's Edwards Air Force Base) (Weitze August 2003b: 67). Later, a NASA site, the Edwards Field Laboratory (EFL) would also exist at the installation.

On 24 March 1946 (typically cited as "April 1946"), NAA received a letter contract from the AAF to develop a supersonic guided missile with a range of 175 to 500 miles, a weapon assigned the designation MX (missile experiment) 770 and the name Navaho. The mid-range weapon was "fundamentally the same" as the last, winged version of the V-2 (alternately known as the A-4b and the A-9), an unfinished project of the scientists and engineers at Peenemünde. In the next few months, NAA set up a temporary outdoor test site, immediately adjacent to a company parking lot at the Los Angeles Airport. NAA had established its first Los Angeles manufacturing plant at the site in the middle 1930s, a plant that became a GOCO during World War II (Weitze August 2003a: 133). The hastily configured NAA rocket engine test site at the Los Angeles Airport was a makeshift affair.

> A boxlike steel frame held a rocket motor; a wooden shack housed instruments. The steel blade of a bulldozer's scraper was used as a shield to protect test engineers in the event of an explosion. A surplus liquid-fueled engine from Aerojet General, with a [*sic*] 1,000 pounds of thrust, served as the first test motor. The rocket researchers also built and tested home-brewed engines, initially with 50 to 300 pounds of thrust. Some of these engines were so small that they seemed to whistle rather than roar (Heppenheimer 2002a: Chapter 1).

Engine testing at the Los Angeles Airport continued throughout the late 1940s (Photo 3.2). NAA's president in 1948, Leland Atwood, commented that "We had rockets whistling day and night for a couple of years" (Heppenheimer 2002a: Chapter 1). In June1946, Dr. Bollay suggested to the AAF that NAA "refurbish and test a complete V-2 engine system, to be provided by the government." Known as the Mark I, this V-2 engine would lead to NAA's development of a second V-2 engine modified to "American engineering standards and materials." NAA would fabricate and test the follow-on engine, to be designated the Mark II. The AAF shipped NAA two captured V-2 engines before the close of 1946 (Astronautix December 2007b).

Photo 3.2. North American Aviation's makeshift rocket engine test site, neighboring its plant at the Los Angeles Airport, 1947.
(Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

During 1947, NAA hired new staff for its Technical Research Laboratory and initiated construction of test sites in southern California and New Mexico. NAA's soon-to-be President Atwood remembered in a NASA interview of 1988 that the company "scoured the country [in the Los Angeles area]," and located land in the Santa Susana Mountains. The site was austere, and "full of rounded reddish boulders." NAA leased land at the location in March 1947. Work on the design of the Mark II engine, an effort also labeled as Phase II of the V-2 upgrade project, was underway by June 1947. Three months later, in September, NAA undertook the preliminary design of a "new engine," "drawing on V-2 design but incorporating a number of improvements" (Heppenheimer 2002a: Chapter 1). The "new engine" was named the NA-704 Mark III, and was based on the Model 39a engine of the V-2 (A-4b / A-9). By the close of 1947, Dr. Bollay's Technical Research Laboratory had a staff of 43, including 12 professionals with doctorates and 18 mechanical engineers (Astronautix December 2007b). Also a part of the group was Walter Riedel (Weitze August 2003a: 169 and 249). Immediately post-war, in the autumn of 1945, Riedel had been one of three German scientists and engineers assigned to the British Army (rather than to the Americans), responsible for firing three V-2s from a site on the German North Sea coastline for Operation Backfire (Neufeld 1996/1999: 269).

Augmenting the AAF's temporary provision of Riedel to NAA, the Army had additionally provided the company direct access to its rocket research group at Fort Bliss. Participating in the redesign of the V-2 for the Navaho were Dr. von Braun, Hans H. Hueter, Rudi Beichel, and Konrad K. Dannenberg. Another Paperclipper, Dieter Huzel, later became an employee of NAA to "better coordinate work with the German team" (Astronautix December 2007b). The location of NAA's Technical Research Laboratory during the earliest Navaho activities (late 1945-1947) is interpreted to have been in the company's 1930s plant at the Los Angeles Airport, adjacent to its parking-lot rocket engine test site. By July 1948, the Technical Research Laboratory had become NAA's

Electromechanical Division. Subsequently, the research group evolved into the company's Missile Development Division. NAA resituated the Missile Development Division in a newly established manufacturing plant in Downey. The Downey plant was a former Consolidated-Vultee factory, east of Los Angeles, and would be where NAA fabricated its production runs of the Navaho (and later, the Apollo command modules and Space Shuttles) (Astronautix December 2007b). (During this early period, other NAA renamings of the original Technical Research Laboratory include the Aerophysics Laboratory and the Missile and Control Equipment group [Mitchell 1990: 10].)

As the design of the Navaho progressed at the Technical Research Laboratory, NAA moved forward on the development of a test article. Named the Nativ (North American Test Instrumentation Vehicle), the test article was subsumed within the MX-770 designation (Neufeld 1990: 28). Beginning in June 1947, NAA constructed test facilities for the Nativ at Alamogordo Army Air Field (Holloman Air Force Base). The location neighbored the White Sands Proving Ground and was near Dr. von Braun's group of Paperclippers at Fort Bliss. Paralleling these activities, the AAF had amended NAA's contract for the Navaho in May 1947 to include development of the missile's test article. The Army had established the White Sands Proving Ground in 1945 for testing captured V-2 missiles, and for follow-on programs (such as Hermes). The Army (June 1945) and Navy (July 1946) each constructed a large blockhouse, with designs derived from those for German V-2 facilities. The Army's V-2 compound (Launch Area 1 / Launch Complex 33) initially featured only a steel observation tower and concrete launch pad. During 1946, the Army added a gantry crane mounted on rails, to service the V-2, and a flame trench. The finalized configuration paralleled its counterpart at Peenemünde. The Navy's compound (Launch Area 2 / Launch Complex 35) was identical to that of the Army, but was planned to test weapons systems other than refurbished and augmented V-2s. These two compounds accommodated live launches. The Army first fired a captured V-2 in May 1946 (Eidenbach, Wessel, Meyer, and Wimberly September 1996: 24, 29, 70, 72, 136-140).

More importantly, with respect to the nearly simultaneous design and planning for rocket engine test stands at Santa Susana, were the Army's static test stands of 1946 and 1949 at White Sands, and the rocket engine test stands at the Malta Test Station of General Electric (GE) near Schenectady, New York, of 1946-1950. At Malta, GE had initiated testing for small engines as early as 1945. *Aviation Week* described the Malta Test Station in early 1950 as "the first of its type in the U.S. [United States]." The journal further noted that the installation had been in "full-scale operation more than three years." GE, like NAA, had a contract to develop a guided missile based on the V-2. GE's early work focused on the Hermes missile, although the company was also contracted to "assemble components of V-2s captured in Germany, make parts which may be missing or defective and supervise technical aspects of the launchings at White Sands." The Malta Test Station was in its facilities-development stage simultaneously with NAA's Bowl Area at Santa Susana (in Area I). The two vertical test stands at Malta, however, had only a maximum thrust resistance of 50,000 pounds (although the test stands did include deep flame buckets, a deluge system, and a blockhouse) (*Aviation Week* 24 April 1950: 13-14). At White Sands, the Army (and its Paperclippers) conducted captive rocket engine tests on two very large static test stands designed to withstand 100,000 and 500,000 pounds of thrust, respectively, paralleling tests subsequently done by NAA on the Vertical Test Stands (VTSs) in the Bowl Area at Santa Susana (as of early 1950). The Army added a 300-K (300,000-pound) static test stand at the White Sands Proving Ground in 1953. The original static test stands of 1946 and 1949 at White Sands each included a blockhouse. The Army designed and engineered these test stands along the base of, and embedded into, the slopes of the Organ Mountains, with the existing landscape a primary feature of each facility (Eidenbach, Wessel, Meyer, and Wimberly September 1996: 152-159). A similar incorporation of the hard-rock landscape would occur at Santa Susana in 1948.

The NAA test complex at Alamogordo / Holloman, neighboring the White Sands Proving Ground, immediately preceded that at Santa Susana. The 1947 facilities for Nativ at Alamogordo Army Air Field (Holloman Air Force Base) included a blockhouse, static test stand, launch pad and 125-foot steel tower. NAA personnel used the static test stand to run up engines before their installation in the Nativ. As a test article, the Nativ was a smaller missile than the future Navaho. The Nativ more closely resembled the Wasserfall weapons system of Nazi Germany (a missile developed only to the experimental stage). In addition to the static engine testing, the purpose of Nativ testing at Alamogordo / Holloman was to gain early launch experience, focused on the weapon system's aerodynamics and control. The test article's launch tower featured two legs set on adjustable screw jacks, allowing a tilt of 15 degrees off the vertical for differently angled launch windows. Paperclippers von Braun, Riedel, and Huzel participated directly in the NAA Nativ test efforts at Alamogordo / Holloman, and are assumed to have also been active in the Army's testing (static rocket engine tests and live launches) at neighboring White Sands. NAA conducted the first launch trial for Nativ in May 1948 (Photo 3.3) (Astronautix December 2007b). Nativ testing continued at Alamogordo / Holloman throughout most of 1948. The Air Force cancelled the Nativ program in 1949 (Weitze November 1997: 23-24, 29).

Photo 3.3. North American Aviation personnel launching the Nativ at Holloman Air Force Base, neighboring White Sands Proving Ground, New Mexico, in 1948. (Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

In February 1948, the Air Force requested an upgraded design of the Navaho to increase the range of the weapons system from 175-500 miles to 1,000 miles or more. (In 1944-1945, the maximum range of the V-2 was about 200 miles.) The AAF had become an independent military service arm in July 1947 (the United States Air Force), and acquired the responsibility for longer-range missile programs (Heppenheimer 2002a: Chapter 1). NAA increased the size of the Navaho by one-third and redesigned its propulsion system. Construction of a group of static rocket engine test stands was underway at Santa Susana during 1948-1949 on the company's 430 leased acres at the site. Immediately known as the Bowl Area (in Area I), the static test complex would include three numbered VTSs when completed in 1950. The Bowl Area opened in 1949, with VTS I (Photo 3.4), a preparation stand, a blockhouse, two water tanks, and several small supporting facilities well along in construction, and "a handful of employees" (*History of the Air Force Plant Representative Office, North American Rockwell Corporation, Rocketdyne Division, Canoga Park 1 July – 31 December 1968*: 4). The completed Bowl Area at Santa Susana of 1949-1950 also included CTL I, the first of five components laboratories on site. CTL I supported the VTSs, and was operational in 1950 (Photo 3.5).

Photo 3.4. VTS I in the Bowl Area at Santa Susana (Boeing Area I). 14 June 1954. (Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

Photo 3.5. CTL I in the Bowl Area at Santa Susana (Boeing Area I), ca. early 1950s. (Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

NAA's Missile Development Division (from the Downey plant) conducted the very first static tests of a Navaho engine in November 1949 at VTS I. The engine used was incomplete, lacking its turbopumps and necessitating a pressurized feed of the engine's liquid propellant from "heavy-walled tanks." This initial test ran only 11 seconds, at 10 percent of the maximum possible propellant flow. NAA ran slightly longer sustained tests in December 1949. The December tests alerted the NAA engineers to combustion-chamber pressure surges capable of blowing up the engine. To fix this critical problem, Riedel made the needed design modifications. On 2 March 1950, NAA conducted the first full-thrust test of this early Navaho engine (without its turbopumps), achieving the engine's rated level of 75,000 pounds of thrust for 4.5 seconds. In comparison, the rated level of the V-2's engine was 55,000 pounds (Neufeld 1996/1999: 36). More full-thrust run-ups of the Navaho engine took place in the Bowl Area at Santa Susana during May and June 1950, with tests sustained in excess of one minute (Heppenheimer 2002a: Chapter 1; Astronautix December 2007b).

A "deep depression separating a circular arrangement of hills" characterizes the Bowl Area in Area I at Santa Susana (Photo 3.6). Paralleling the cliffside site of the Army's 1946 and 1949 static test stands at the White Sands Proving Ground in New Mexico, the Bowl Area relies on existing land forms to augment the thrust containment designed into the bases and flame trenches at each test stand. In the early 1950s, the incorporation of landscape features was also central to the design and engineering of the static rocket engine test stands on Leuhman Ridge at Edwards Air Force Base. The Leuhman Ridge complex would become the EFL, a laboratory tiered to NAA's Rocketdyne Division during the 1960s. Santa Susana's Bowl Area is sometimes credited as the first liquid-propellant, high-thrust rocket engine test facility constructed in the continental United States with multiple, permanent test stands (Boeing 2006a). Without doubt, the Bowl Area is the first *designed complex* of such test stands, constructed as a triple configuration of high-thrust test stands with an associated single blockhouse. The basic layout of three stands would become the norm for operational intermediate range ballistic missiles (IRBMs) such as Thor, and ICBMs such as Atlas and Titan, of the later 1950s. The single high-thrust, static rocket engine test stand at White Sands Proving Ground, of 1946 (expanded to include a second high-thrust rocket engine test stand in 1949), predated the VTSs of the Bowl Area, but did not offer the refined design of the triple group and its incorporated "bowl" setting as at Santa Susana. Static rocket engine test stands on Leuhman Ridge (Test Stands I-3A and I-5A) followed those at Santa Susana in about 1950-1951 (operational in 1952-1953), with more test stands added on the ridge during 1954-1955 (simultaneous with the design and construction of the Alfa, Bravo, Coca, and Delta static test complexes in Area II at Santa Susana). The Air Force had selected the Leuhman Ridge site simultaneously with NAA's choice of Santa Susana, in 1947 (Weitze August 2006b: 67, 75, and 78).

Photo 3.6. Aerial view of the Bowl Area at Santa Susana (Boeing Area I), as first completed in early 1950. Preparation stand, VTS I, blockhouse (foreground left), and two water tanks (background right of VTS I). (Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

Rocketdyne has described the Bowl Area VTSs of 1948-1949 as directly derived from the Peenemünde test facilities of World War II (Rockwell International 1987). Multiple histories also cite the test stands located at Peenemünde as the models for the V-2 test complexes of 1945-1949 at the White Sands Proving Ground. Without a closer look, the close-knit working relationship of the Army, Air Force, NAA engineers, and a small group of Paperclippers (especially von Braun, Riedel, Huzel, Beichel, Hueter, and Dannenberg) make these hypotheses plausible, indeed likely. However, the Peenemünde test facilities of 1939-1943 primarily were launch stands, not static rocket engine test stands. And while a stand-alone static rocket engine test stand did exist at Peenemünde (Test Stand I), the main test stand (Test Stand VII) could accommodate both engine tests and vehicle launches. The Paperclippers had over-engineered Test Stand VII to withstand 220,000 pounds of thrust, hoping to develop follow-on weapons systems that would have more propulsion power than the 75,000 pounds of thrust that characterized the V-2's engine (Photo 3.7). The actual model for the rocket engine test stands at Santa Susana dates to late in the war, after the German military moved the operations of the rocket scientists to heavily protected, predominantly underground sites following the British Royal Air Force's bombing raid over Peenemünde in August 1943.

Photo 3.7. Launch of a V-2 at Peenemünde, Germany, 1 January 1942. Test Stand VII consisted of a reinforced concrete launch pad with blast containment walls and a moveable gantry. (Source: History Office, Marshall Space Flight Center.)

During 1944-1945, four main locations replaced Peenemünde: Nordhausen (Mittelwerk), a former gypsum mine in Thuringia which had been expanded steadily since 1936 for oil and chemical weapons storage (becoming the primary V-2 production plant); a site in the Austrian Alps east of Salzburg (code-named Zement), physically surveyed and scouted out by Walter Riedel immediately after the raid on Peenemünde (becoming the center for guided missile development and the location of Riedel's late war work); a brewery in central Austria with underground facilities (code-named Schlier), adapted as a LOX plant (and implied to have had engine test stands of some type); and a quarry near Lehesten south of Nordhausen on the Thuringian-Bavarian border (with engine test stands) (Neufeld 1996/1999: 197-207, 269). Photographs of V-2 engine tests from 1945, held by NAA (today, Boeing), suggest that the adapted Lehesten quarry site, not Peenemünde, was the direct model for both the cliffside engine test stands at the White Sands Proving Ground and the Bowl Area in Area I at Santa Susana (Photo 3.8). Personnel at Lehesten conducted a mass production calibration of the V-2's engine on the test stands in the quarry.

Photo 3.8. Acceptance testing of V-2 engines at an adapted quarry near Lehesten, south of Nordhausen (Mittelwerk) on the Thuringian-Bavarian border, 1945. (Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

While the incorporation and adaptation of existing natural landscapes, then, does appear to have occurred first in Thuringia and Austria during 1944-1945 for static-testing rocket engines, the test stands designed and engineered in the immediate post-World War II years at White Sands (1946 and 1949), Santa Susana (1947-1949), and Edwards (1950) represent the first time these types of land forms were selected for this use in their pristine form: cliff (White Sands), rocky outcroppings (Santa Susana), and ridge (Edwards). (At GE's Malta Test Station, small test pits were set "in the forward slope of a hill" [*Aviation Week* 24 April 1950: 13-14].) In the German precursors, the chosen landscapes had been significantly modified by man through mining and quarrying operations, before their conversion to host rocket engine test stands. In all likelihood, too, the higher thrust of the augmented V-2 engine post-war (75,000 pounds versus 55,000 pounds) was initially thought to require an even more protective setting than those hastily adapted during 1944-1945. Did the Paperclippers assigned to continue developing the V-2 toward more powerful weapons systems, working with their American collaborators in the late 1940s, elect to find these landscapes to meet their design and engineering needs? Did they carry immediate memories of the late rocket engine test sites in Thuringia and Austria? The explicit answers are unknown. Adapting large-scale physical land forms would cease to have urgency by the middle 1950s, occurring in some situations (as for the Alfa-Delta test areas at Santa Susana in 1954-1956 and the Sycamore Canyon test site near San Diego in 1956), but not in others (as at the Redstone Arsenal in Huntsville) (*Valley Skywriter* 19 July 1957: 1 and Weitze November 2003: *passim*). During 1946-1948, however, funding, materials, and time were all limited, and finding sites that contributed to the physical design and engineering of the static rocket engine test stands was both expeditious and practical, and allowed rocket science to move forward as quickly as possible.

3.2 The Transition Years, 1950-1953

During the earliest years of rocket engine testing at the Santa Susana site, NAA's efforts concentrated on the development and testing of an engine for the Navaho. NAA also won the Air Force contract to research, develop, test, and manufacture the full weapons system. Navaho was a supersonic, surface-launched guided missile, a weapons system that the Air Force hoped could be improved with the addition of a nuclear ramjet engine to achieve an intercontinental range of 5,000 miles. By spring 1948, inter-service rivalry and funding challenges within the fledging Air Force guided missiles program had mandated that only three developmental missiles were on the boards: Navaho, Rascal, and Falcon. Planning changed successively for the Navaho during 1948-1950, with its range recategorized to 1,700 miles for a final cruise missile and 5,500 miles for a surface-launched version. As of mid-1953, Navaho was one of 28 guided missile programs moving forward among the Air Force, Army, and Navy, including one weapons system that would mature as a much longer-range ICBM (Atlas) (Neufeld 1990: 32, 59-63, 87). During the early 1950s, much of the work done in the field of guided missiles focused on experimental components testing. The Air Force did not fire the cruise version of the Navaho until late 1954, running tests of an air-launched Navaho at Edwards Air Force Base east of Los Angeles. In 1956, the Air Force launched the Navaho from a test stand at Patrick Air Force Base in Florida (Neufeld 1990: 63). Mounted atop an improved liquid propulsion system, the Navaho had a first-stage booster during the initial stages of supersonic flight (Photos 3.9 and 3.10). Following a shift in focus toward the development of a true ICBM in the middle 1950s, the Air Force canceled the Navaho program in 1957. The test stands in the Bowl Area of Area I at Santa Susana had been the main static test site for the Navaho engine during 1950-1956 (Deming, Slovinac, and Weitze November 2007b: 4-3).

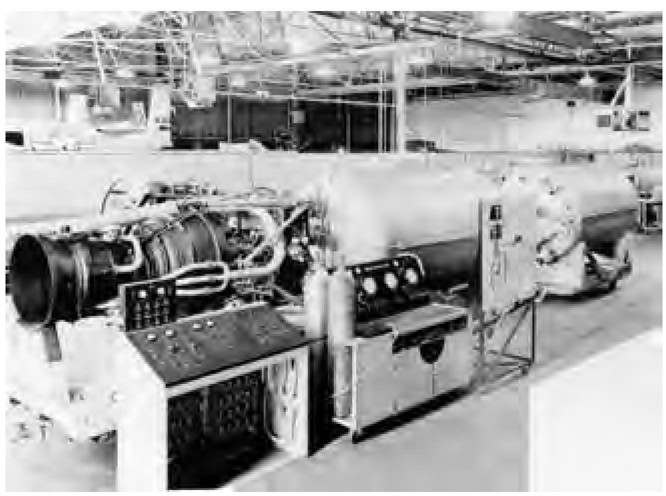

Photo 3.9. MX-770 Navaho Phase 2 engine with propellant tanks, at the North American Aviation plant in Downey, 13 September 1949.
(Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

Photo 3.10. Navaho and booster in launch position at Cape Canaveral, 1956. (Source: *History of the Air Force Missile Test Center July – December 1956*, volume II.)

Primarily due to the outbreak of the Korean War in June 1950, the Air Force, Army, and Navy, as well as their aerospace corporate counterparts such as NAA, constructed very few permanent rocket test facilities during the transitional years of 1950-1953. Nearly simultaneously, Congress directed the DoD to "investigate" its "$100-million-plus" missile program. Senators and Representatives argued that gross duplication of efforts characterized work across the service arms and that funds were being requested to support "projects for which there is no adequate use seen within the next five years" (*Aviation Week* 24 April 1950: 12-13). Construction of new infrastructure for the missiles program was minimal, and moved forward in a start-stop pattern. Augmenting test stands of 1946-1949 in New Mexico (at White Sands Proving Ground and Holloman Air Force Base) and California (at Edwards Air Force Base and Santa Susana) were additional test stands and supporting facilities at Edwards (1949-1952); two Interim Ignition Test Stands and a blockhouse at the Redstone Arsenal in Huntsville, Alabama (1952, with planning during 1949-1951); and a test stand area on the barrier peninsula of Cape Canaveral at Patrick Air Force Base (1950-1952) (Weitze November 2003: 38, 49-50, 53-55, 106-108; Weitze 2003b: 75, 78, 326-329). On Leuhman Ridge at Edwards, the Air Force hired the Aerojet General Corporation to build the static test stand cluster. Aerojet in turn subcontracted the facilities design and engineering task to Ralph M. Parsons, an architectural-engineering firm in Los Angeles. (The Air Force had selected Leuhman Ridge very early, in 1947, as a site for facilities needed to develop the Atlas ICBM.) Initial hot firings on Leuhman Ridge occurred in late 1952 and 1953, using captured German V-2 engines and early Navaho engines (Photo 3.11) (Weitze August 2003b: 78). The Air Force coordinated the tests at Edwards with NAA.

Photo 3.11. V-2 engine on display at Edwards Air Force Base, 18 August 1952. (Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

The Army and Air Force also selected Aerojet-Parsons for the design and engineering of test stands at the Redstone Arsenal in Alabama and Patrick Air Force Base in Florida. At the Redstone Arsenal, 120 German rocket scientists and engineers moved from Fort Bliss to Huntsville in early 1950, with an advance group of the Paperclippers initiating the planning process for rocket-test facilities as of August 1949. The Army hired Aerojet General and Ralph M. Parsons (as the Parsons-Aerojet Company) in early 1952, to design a complex of test stands and supporting infrastructure at Redstone. Simultaneously, the Experimental Missile Firing Branch at Redstone coordinated with the Air Force Missile Test Center at Patrick Air Force Base in Florida for the construction of test stands, blockhouses, and associated ancillary structures there. Parsons-Aerojet received the design-engineering assignment for the first rocket-test facilities at Patrick, with construction initiated in 1950. In Alabama, however, the Parsons-Aerojet rocket-test complex planned for the Redstone Arsenal was on hold by mid-1952, due to a lack of funding. To jump start the situation, the Paperclippers designed, fabricated, and constructed an interim ignition test stand and blockhouse, using materials salvaged at the arsenal. Engineer Fritz A. Vandersee, under the direction of Karl L. Heimburg, both Paperclippers who had worked at Peenemünde, are credited with the design of these facilities (Weitze November 2003: 38, 49-50, 75-76; Weitze August 2003b: 327).

Demonstrating the importance of the Santa Susana site, NAA aggressively expanded its facilities in Area I during the troubled construction period of the early 1950s. NAA added two permanent rocket engine test stands, VTS II and VTS III in the Bowl Area, and initiated the construction of a second cluster of three test stands (Photos 3.12 and 3.13). Known as the Canyon Area, located to the northeast of the Bowl Area, the second site would support the dedicated testing of the H-1 engine as of the late 1950s and early 1960s (see below). NAA also reused items cannibalized from other industrial locations to improve its existing facilities at Santa Susana. The company cut its lead time for testing the propellant pumps integral to large liquid fuel rocket engines by “more than 14 months” through the acquisition of a 42-year old 1000-kilowatt motor generator from Pacific Electric Railway’s North Pomona substation. Refurbishing and installing the generator in CTL I in 1951, the generator supplied power to three 1300-horsepower (hp) motors that NAA had also recycled. The 1300-hp motors had been used "in fleet-type submarines in World War II in the Pacific" (*Valley Skywriter* 22 March 1957: 3). The Bowl and Canyon Areas were the immediate precursors to the Alfa, Bravo, Coca, and Delta Areas that soon followed in Area II. With the Canyon Area completed in 1953, the development of the Santa Susana site can be interpreted to have been relatively seamless. Characteristics of the landscape settings for each of the 1948-1956 test stand clusters at Santa Susana, in particular, link the development of NAA's Area I (the Bowl and Canyon Areas) to the Air Force's Area II (the Alfa, Bravo, Coca, and Delta Areas, see below).

Photo 3.12. Aerial view of the Bowl Area at Santa Susana (Boeing Area I), 3 June 1958. Preparation stand, VTS I, II, and III, flame trenches and spillway, conservation dam (foreground), blockhouse (center), four water tanks (background), and fuel storage infrastructure.
(Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

Photo 3.13. Canyon Area test stand at Santa Susana (Boeing Area I), 15 May 1953. (Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

As of late 1953, the American missiles program again moved forward, with multiple rocket-test complexes designed and built during 1954-1958. These complexes represented an initial maturity for the new Cold War race to field long-distance aerospace weapons systems. Locations for these larger and more sophisticated clusters of test stands, equipment, and associated facilities included sites in southern California (Santa Susana, Leuhman Ridge at Edwards, China Lake northeast of Los Angeles, Camp Elliott, Point Loma, and Sycamore Canyon near San Diego, and Point Mugu near Santa Barbara); northern California (Sacramento area); Colorado (Denver area); New Mexico (White Sands); Missouri (Neosho); Alabama (the Redstone Arsenal); Florida (Cape Canaveral at Patrick and Santa Rosa Island at Eglin Air Force Base); and the Territory of Hawaii (on Kauai). Each of the service arms oversaw rocket test and training facilities, with contractor sites supporting multiple government agencies. White Sands and the Redstone Arsenal were Army installations; Santa Susana (as expanded in the middle 1950s), Leuhman Ridge, Sycamore Canyon, the Denver area, Neosho, Cape Canaveral, and Santa Rosa Island, Air Force installations and AFPs; and China Lake, Camp Elliott, Point Mugu, and Kauai, Navy-Marines installations (Weitze August 2003a: 134-135; Weitze August 2003b: 325-327; Weitze July 2005). Making matters more complicated, selected sites were also in use by more than one service arm (such as a Navy installation at White Sands and at Cape Canaveral). In 1958, three all-service missile ranges existed in the continental United States: at Point Mugu, White Sands, and Cape Canaveral. The Navy's two primary rocket-test complexes, at China Lake and Point Mugu, each had earlier origins. China Lake had been established in 1943 as a proving ground for rockets, augmented by the addition of responsibilities for guided missiles testing in 1946. The Navy had commissioned Point Mugu in late 1946. At both locations, only temporary facilities existed before 1950.

During the early 1950s, NAA began to adapt the Navaho engine for other ballistic missiles, increasing the thrust rating of the basic propulsion system and making numerous other changes. Both the Army and Air Force would contract with the company for future engines based on the Navaho. Not surprisingly, the strong sustained relationships among the Paperclippers created an interwoven professional community that tied together geographic testing locations such as White Sands, Santa Susana / Edwards, Huntsville, and Cape Canaveral, as well as research, development, testing, and evaluation enclaves such as Wright-Patterson Air Force Base and its dispersed centers (at Edwards, Holloman, Eglin, and Patrick, for example). The Army hired NAA to develop a follow-on engine for the Redstone. The Redstone had a range of 200 to 500 miles, and was the seminal major new rocket undertaken by the Guided Missile Development Group at the Redstone Arsenal in Huntsville. The Redstone project, begun under other names, dated to late 1950. NAA's Missile Division conducted the first static firing of a Redstone engine (adapted from a Navaho engine) in the Bowl Area of Area I at Santa Susana in the early 1950s, with the initial test launch at Cape Canaveral in August 1953. NAA would further modify the Redstone engine as the propulsion system for the Army's Jupiter IRBM at mid-decade. The Air Force also turned to NAA, for the development of engines for its Thor IRBM and its Atlas ICBM. Again, both engines derived from the Navaho's propulsion system. (The Thor was a stopgap weapons system linked in its design and engineering to the Atlas, intended to come on line as soon as it could be fielded and to be replaced by the longer-range Atlas within a few years.) To handle its needs for Thor and Atlas engine development and testing, the Air Force established AFPs 57 and 64 at Santa Susana during 1954-1955, concurrently coupled with AFP 56 at Canoga Park (Deming, Slovinac, and Weitze November 2007a: 4-1).

3.3 Expansion of Test Facilities at Santa Susana, 1954-1958: Air Force Plant 57

The Air Force managed its IRBM and ICBM programs through an organizational structure focused in southern California as of 1954, and would work closely with aerospace engineering contractors from the start (Deming, Slovinac, and Weitze November 2007a: 4-4). The hiring of architectural-engineering firms for missiles facilities design and engineering was also concentrated in Los Angeles, although the early 1950s work of Ralph M. Parsons had already set the stage for this pattern. Drawings and site plans for the first Air Force cluster of engine test stands at Santa Susana were completed in late September 1954 (for AFP 57) (DMJM 23 September 1954a). AFP 56 at Canoga Park opened in late 1955 as the manufacturing location for the two engines. NAA had bought 56 acres of the Warner Ranch in Canoga Park the year before, with construction of its rocket engine plant underway in early 1955. NAA established Rocketdyne as a separate company division in November, a division that in turn contracted to run AFPs 56 and 57 as GOCOs for the Air Force (Mitchell 1990: 11). Rocketdyne represented the maturation of the lineage of rocket engine development groups within the company: from the Technical Research Laboratory of 1945, to the Electromechanical, Missile Development, and Missile Divisions of 1948-1954.

Although not formally transferred from NAA to the Air Force until 1958, Area II was designated as AFP 57 by the time DMJM executed its first drawings. Labeled as "U.S.A.F. [United States Air Force] Area #2" on the site plans of September 1954, the initial layout of the plant included only today's Alfa site. A new road, running from "Existing Area #1" (the Bowl Area) to Area II, accessed the Air Force test site, with Areas I and II reached through a main gate at the end of the 1948 entrance road west of Canoga Park (DMJM 23 September 1954a). The designation of Area II as AFP 57 in 1954 implies that the Air Force funded design and construction of the test stands, channeling payment to NAA (Rocketdyne) who in turn hired DMJM and other firms to complete the work. The Air Force became the legal owner of Area II when the last of the four sites, Delta, was completed and fully operational. During the period of 1954-1957, NAA (Rocketdyne) is interpreted as the owner of the facilities at the Alfa, Bravo, Coca, and Delta sites, and of the service enclave, CTL II, and the supporting infrastructure. An agreement is assumed to have been in place between NAA and the Air Force in 1954 for the future transfer of all facilities composing AFP 57 (in Area II). The several-year holding pattern during 1954-1958 also strongly suggests that the Alfa, Bravo, Coca, and Delta sites were not truly sequential in their planning and design, but instead were sequential only in their construction.

DMJM designed the test stand sites within Area II in stages between August 1954 and April 1956. For Phase I of AFP 57, DMJM designed the Alfa complex (interchangeably spelled "Alpha" during the early years), the first of four test-stand clusters that would be constructed in Area II, as well as several basic elements of the support infrastructure necessary for the future expansion of the plant. In 1954, the Alfa site occupied 100 acres, bordering Rocketdyne property on its east (the Bowl and Canyon Areas) and with a 350-foot buffer of Air Force land on its west. In September 1954, the Alfa site defined the near entirety of what would evolve into AFP 57 at Santa Susana. The formal name for AFP 57 was the Hot Test Acceptance Facility, Rocket Engine Field Laboratory, Santa Susana. DMJM handled the design of the Alfa site as supplements "5 and 6" to contract 33(638)-3546 (DMJM 23 September 1954a). The contract is interpreted as augmenting the firm's contract for AFP 56 at Canoga Park. The location of the Alfa site, like that of the Bowl Area, was carefully integrated into the existing natural landscape. Three small engine test stands, each with two platform levels, sat alongside their east-west access road. The test stands stood just under 46 feet high, with a base footprint of 24 by 24 feet. NAA designed and fabricated the flame buckets for the test stands (DMJM 23 September 1954c), with each emptying southwards via short, man-made concrete flame trenches into an east-west rocky ravine that would become the site's common spillway. The lowest elevation in the ravine was 1900 feet, with Alfa's water tanks situated at nearly 2200 feet. Additional outcroppings of boulders and rock to the immediate south and southeast also buffered the discharged rocket engine exhaust and deluge water from the test stands, providing blast and sound protection (Photo 3.14) (DMJM 23 September 1954a).

Photo 3.14. Alfa site at AFP 57 (NASA Area II), 3 June 1958. Pre-test building, Alfa I, II, and III test stands, underground blockhouse facing the spillway ravine (foreground right), pill box (center right), 24-inch aboveground pipeline to water storage tanks (background to upper right corner), and fuel infrastructure.
(Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

The Alfa site was distinct from the Bravo, Coca, and Delta sites that would complete Area II of AFP 57 in 1955-1956. Unlike the final three clusters of rocket engine test stands and their support infrastructure, the Alfa site was stretched out along its access road, with its three test stands and blockhouse configured as a linear group east to west. DMJM designed the control house for the Alfa test site (the blockhouse) as a nearly fully-underground facility to the immediate west of the line of test stands. Other original facilities at the Alfa site were a terminal house, electrical control stations at each test stand, pre-test building, electrical switching house (power substation on the ridge north of the immediate Alfa site), and enclaves of fuel systems support infrastructure (Photo 3.15). The fuel tanks and associated pumping equipment were predominantly clustered at a segregated location at the western edge of the site, with much smaller fuel storage and transfer infrastructure placed at the test stands and pre-test building at the eastern end of the site. The fuel systems infrastructure to the west included liquid nitrogen (LN2) tanks, gaseous nitrogen (GN2) cylinders, a LN2/GN2 vaporizer, a hose house, and jet fuel (JP4) tanks and its paired pumping station. At the eastern terminus of the Alfa site and immediate to Alfa III sat small, horizontal LOX tanks, small GN2 tanks, and a helium cylinder. A pair of vertical tanks stored water for use in the deluge systems at the three Alfa test stands, located distantly to the south of the pre-test building atop an elevated site. A pipeline carried water from the tanks to the flame buckets of each of the test stands. The water kept engine temperatures acceptable during static (tie-down) tests, partially evaporating as steam and combining with engine exhaust as run-off into the ravine spillway (DMJM 23 September 1954b). As initially designed, the Alfa test site did not include observation pill boxes (DMJM 23 September 1954a).

The Alfa test site is highly intact, inclusive of the land forms incorporated into its design of 1954. The primary extant buildings and structures from 1954 at the Alfa test site in 2007 are test stand Alfa I and its electrical control station (Buildings 727 and 727A), test stand Alfa III and its electrical control station (Buildings 729 and 729A), the blockhouse (Building 208), and the terminal house (Building 209). The pre-test facility also remains at the Alfa site (Building 212), but is substantially altered. As designed and constructed, the pre-test building featured an inexpensive and expeditious cladding of plywood panels with wooden battens. Today's water tanks sit atop a different ridge further south within Area II. These tanks are located to the immediate north of the Coca site, configured in mid-1955 near the geographic center of the Alfa, Bravo, Coca, and Delta sites on today's Skyline Drive.

Photo 3.15. Alfa I, II, and III test stands (NASA Area II), with flame trenches emptying into the spillway ravine, 2 May 1959. CTS II (turbopump test facility) and edge of Service Area (both background left) and 24-inch water pipeline (foreground). (Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

Designed and constructed immediately before the cluster of test stands, was Waterwell Ridge, located to the north of the test stands and blockhouse, and a stand-alone prefabricated metal service building, located further north at the entrance to Area II. DMJM prepared drawings for the erection and placement of the service building during late summer 1954 (DMJM 19 August 1954). This building would become the starting point for a more fully developed Service Area, configured as a large group of prefabricated metal buildings adjacent to CTL II, of 1955-1956. DMJM drawings for AFP 57 done in early 1955 indicate the presence of water wells, a power substation, and an incinerator atop the ridge (Photo 3.16). Development on the ridge was minimal in 1954, but was essential to the expansion of the facilities near the Alfa test stands (DMJM 25 March 1955a).

By mid-January 1955, Rocketdyne hired DMJM for a second phase of design and construction in Area II at Santa Susana. Rocketdyne issued a separate contract to DMJM for the remainder of AFP 57, 33(600)-26940. The company had fully distinguished the plant at Santa Susana from AFP 56 by the outset of 1955. The westerly boundary of AFP 57 shifted to the west, approximately 350 feet from the west edge of the former Air Force buffer zone. For the Service Area, DMJM prepared drawings for the placement and erection of more prefabricated metal buildings. Composing the group were a large addition to the service building of August 1954; guard shack; pedestrian gate; protective services facility (on-site security / police); service and operations buildings; cafeteria and photo laboratory; and small paint shop (Photo 3.17) (DMJM 25 March 1955d). The majority of these buildings remain standing today, in greater and lesser states of exterior intactness (Buildings 201-207 and 233).

Photo 3.16. Alfa site at AFP 57 (NASA Area II), 27 January 1964. View toward the spillway ravine, underground blockhouse (center left), test stand cluster (background center), and substation on Waterwell Ridge (background left).
(Source: *History of the Air Force Plant Representative Office North American Aviation Rocketdyne Division Canoga Park 1 July – 31 December 1967*.)

Photo 3.17. Service Area at the entrance to AFP 57 (NASA Area II), under construction, ca. 1955. (Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

With the initiation of Phase II for AFP 57 in January 1955, DMJM mapped Area II at its full 451 acres, in a rectangular layout north to south, at the near west of Rocketdyne's Area I. The first task was the mapping of a new access route south from the easterly turn of Alfa Road (accessing the Alfa site). Named the Flats Road, the corridor continued south until forking easterly as Bravo Road (accessing the Bravo site), and, after an elongated looping, terminated at the Coca site (DMJM 10 January 1955). In March 1955, DMJM undertook an expansion of the Service Area at the entrance to Area II and completed drawings for the second cluster of test stands, the Bravo site. Design of the Bravo site included the addition of a pill box for the Alfa site (to the southeast, up among the rocky outcroppings); a bunkered "Visitors Observation Area" to the west of the Alfa site; and a pill box for the Bravo site (to the south). The pill box for the Alfa site and the visitors' observation area both faced the Alfa II test stand (today extant only through its electrical control center and flame trench foundation works). A DMJM drawing described the bunkering at the visitors' observation area as four to six feet "high." At Bravo, the site's pill box was also oriented toward its middle test stand, Bravo II (DMJM 25 March 1955c).

DMJM engineers approached the layout of the Bravo site differently than they had the Alfa site six months earlier. At Bravo, the cluster of three test stands and their support facilities was more compact, and faced a large, aboveground blockhouse set off to the side near the foot of a common spillway. Each test stand had man-made flame trenches that emptied into the spillway. The existing rocky terrain climbed steeply behind the test stands to provide an elevated location for the observation of engine testing, while the immediate outcroppings also helped to channel existing natural features incorporated into the spillway (Photo 3.18). The layout of both the Alfa and Bravo sites, however, remained within the original 100 acres planned for the development of Area II in late 1954, with the Bravo site situated in the southwestern corner of the plot. The enlargement of Area II from 100 to 451 acres in early 1955 did necessitate the realignment of the westerly boundary of AFP 57, and pushed the Air Force buffer zone west (DMJM 25 March 1955c).

Augmenting the test stands, the original facilities at the Bravo site were a terminal house, electrical control stations at each test stand, pre-test building, fuel systems infrastructure placed immediately adjacent to the other buildings at the site, and a pill box. The fuel systems infrastructure was more sophisticated than that placed at the Alfa site, and as designed in early 1955 included several JP4 tanks and filter pits; a helium bottle rack; both horizontal and vertical LOX tanks (three), with a large concrete pad adjacent to the paired horizontal tanks; a LOX catch tank; and a filled, graded, and compacted pad for future gaseous hydrogen (GH2) tanks (DMJM 25 March 1955b). The test stands designed for the Bravo site were identical to those at the Alfa site (DMJM 3 March 1955a). The Alfa and Bravo test stands could be adapted for the run-up of different rocket engines under evolving requirements, and in this sense would become distinct from one another over time. A 24-inch line extending from the paired Alfa-site tanks to the northeast provided water for Bravo's deluge system, complemented by a second line extending from the western edge of the Alfa site (DMJM 13 April 1956a). By early 1955, a small dam also existed at the Bravo site, located along the access road to the blockhouse (DMJM 25 March 1955a). The dam was a "conservation dam," used for collecting deluge water after static tests. The primary extant buildings and structures from 1955-1956 at the Bravo site in 2007 are test stand Bravo I and its electrical control station (Buildings 730 and 730A), test stand Bravo II and its electrical control station (Buildings 731 and 731A), the blockhouse (Building 213), and the terminal house (Building 214). Only the foundation remains at the location of the pre-test building.

Photo 3.18. Bravo site at AFP 57 (NASA Area II), 17 November 1960. Pre-test building, Bravo I, II, and III test stands, and fuel infrastructure (center), blockhouse (foreground center), and conservation dam (foreground right).
(Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

The land within Area II south of the Bravo site remained vacant until a continuation of Phase II of the design and construction at AFP 57 in June 1955. As of this date, DMJM prepared drawings for the cluster of test stands known as the Coca site. Similar in its layout to the Bravo site, Coca was also compact, but was significantly more elaborate than the Alfa and Bravo sites that preceded it—particularly with regard to the site's water and fuel systems infrastructure. First named the "Coco Area," the Coca site featured three test stands; blockhouse; terminal house; electrical control stations at each test stand; pre-test building; a fuel storage compound with LN2, GN2, and JP4 tanks, pumps, and an operator's shelter (the "fuel farm" at the western edge of the site); two pads for LOX and GH2 tanks; a liquid hydrogen (LH2) bottle bank; and a pill box, located in a centered, elevated position in the rocky terrain behind the test-stand cluster.

To accommodate a much increased need for a deluge water supply, DMJM laid out a row of five large tanks on a ridge to the northeast of the Coca site. Rocketdyne added three additional tanks, each of identical size, in early 1956 (DMJM 13 April 1956a). The row of eight tanks became an impressive landscape feature, initially known as the "Coco Reservoir." Each tank was 24 feet in diameter, and 30 feet high (DMJM 25 March 1955e). These tanks were extant in 2007, complemented by two significantly larger tanks added at the location in 1962 and later (see below). A conservation dam sat along the western side of the common flame trench from the test stands (DMJM 16 June 1955a). A 24-inch line, routed to the north-northeast, connected the Coca site water storage tanks to the two tanks erected for the Alfa site, additionally routed to the southwest from the row of Coca water tanks to the test stands (DMJM 13 April 1956a). The prefabricated buildings added to the Service Area at the entrance to Area II for the Bravo site in early 1955 also sufficed for the Coca site at mid-year, and no additional facilities were erected there.

As originally designed and constructed, the Coca test stands of 1955 were identical in size and type to those erected for the Alfa and Bravo sites during the preceding months (DMJM 16 June 1955b). Like the test stands at the Alfa and Bravo sites, those at the Coca site could be configured to meet the needs of specific test scenarios. Similar to the placement of the blockhouse for the Bravo site, the Coca blockhouse sat in front of the test stands at the foot of a common spillway, off center to the west. Notable at Coca, a single, large rocky outcropping provided the underlying infrastructure for excavated man-made flame trenches (which were cut through the existing rock) (Photo 3.19). The Coca site also included a vehicle shelter adjacent to the LH2 bottle bank (DMJM 16 June 1955a and 1955c). Rocketdyne upgraded the Coca site in the early 1960s, with two much larger test stands both replacing and augmenting the original cluster of 1955 (see below). The primary extant buildings and structures from the middle 1950s at the Coca site in 2007 are test stand Coca II (Building 734), the blockhouse (Building 218), the terminal house (Building 219), the pre-test facility (today's "Lower Pre-Test Building) (Building 222), and the pill box (Building 2A). Today's Coca site maintains a high degree of intactness, although is a mixed landscape of 1950s, 1960s, and 1970s buildings and structures (see below).

Photo 3.19. Coca site at AFP 57 (NASA Area II), 3 June 1958. Showing flame trenches cut through existing rock. Pre-test building, Coca I, II, and III test stands, and fuel infrastructure. Blockhouse not visible.
(Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

The fourth cluster of test stands, with supporting facilities and infrastructure, was the Delta site, laid out to the near southwest of Coca. DMJM completed the design of the Delta site in April 1956. Delta Test Stand Road forked to the southwest off the access road to the Coca site. Similar to both Bravo and Coca, the layout of the Delta site was compact, with its three test stands facing the blockhouse at the foot of its common spillway. As at Coca, a pre-existing, large rocky outcropping functioned as the underlying structure for the individual flame trenches at each test stand (Photo 3.20). The Delta test stands were identical in size and type to those erected at the Alfa, Bravo, and Coca sites (DMJM 13 April 1956c). Fuel systems infrastructure was more modest than at either Bravo or Coca, and included large LOX and GN2 tanks as well as smaller LOX, LN2, and JP4 tanks at the test stands. The Delta site primarily relied on the fuel farm constructed at the western edge of the Coca site. The handling of Delta's water supply paralleled that of its fuel systems. A 24-inch line extended from the Coca site, with Coca's tanks (on today's Skyline Drive) providing Delta's deluge water supply (DMJM 13 April 1956a) (see Photo 3.21). To accommodate the increased staffing for Area II with the addition of the Delta site, DMJM erected a new prefabricated metal operations-service facility in the Service Area (at a location set aside for the building). Supporting work at its test stands, the Delta site included a blockhouse; terminal house; electrical control stations at each test stand; pre-test building; vehicle shelter; and fuel systems tanks and pads. DMJM increased the number of observation pill boxes from one (as constructed at Alfa, Bravo, and Coca in the middle 1950s), to two at the Delta site (DMJM 13 April 1956b). Today, very little remains at the Delta site.

Photo 3.20. Delta site at AFP 57 (NASA Area II), 21 May 1957. Delta I, II, and III test stands, pre-test building, and fuel infrastructure (center), with wooden staircase to pill box (center to background right).
(Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

Photo 3.21. Delta site at AFP 57 (NASA Area II), 3 June 1958. Delta I, II, and III test stands and fuel infrastructure (center left), blockhouse (foreground center left), conservation dam (foreground center), foreshortened view of Coca site (center right), and Coca reservoir (eight tanks on Skyline Ridge) (background center left).
(Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

The final element of AFP 57 was a second components test laboratory, CTL II. Operational in 1956, CTL II (Building 206) neighbored the Service Area at the entrance to Area II (Photo 3.22). CTL II supported AFP 57. Designed in mid-1955 by a Los Angeles-area architect, Kenneth H. Neptune, and two engineers, R.R. Bradshaw and J.S. Hamel, CTL II was an idiosyncratic commission of undetermined history (Neptune 26 June 1955). As built, CTL II was a metal-sided workshop parallel in function to CTL I of 1949-1950. (CTL I supported Rocketdyne's Area II, initially the Bowl Area.) By 1967, CTL II supported NASA's activities in Area II, and included "a control center office area and a workshop comprising 45,000 square feet under one roof with five test cells and a propellant storage area." (*History of the Air Force Plant Representative Office, North American Rockwell Corporation, Rocketdyne Division, Canoga Park 1 July – 31 December 1967*: 32).

Photo 3.22. CTL II, turbopump test facility in NASA Area II, undated. (Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

As completed during 1957, AFP 57 in Santa Susana's Area II included six distinct elements, north to south:

- the Service Area (with a substation and water wells located separately to the south/southwest) (August 1954 and March 1955);
- CTL II (immediately west of the Service Area) (March-June 1955);
- the Alfa (Alpha) site (with a pair of water tanks located separately to the south/southeast) (September 1954);
- the Bravo site (initially connected to the Alfa water supply, but subsequently linked to seven water tanks erected on Skyline Drive for Coca) (March 1955);
- the Coca (Coco) site (linked to the water tanks on Skyline Drive, a grouping first known as the Coco Reservoir) (June 1955); and
- the Delta site (also reliant on the Coco Reservoir for its water supply) (April 1956).

Generally, self-contained geographic sites defined each of the six elements of AFP 57, although the water tanks erected for Alfa and for Coca were discontiguous. In addition, the proximity of the Service Area and CTL II suggest a single physical site with two halves, rather than truly separate elements of the plant. The Alfa, Bravo, Coca, and Delta test stands—12 in all—were identical as designed and constructed during 1954-1957. These were small test stands relative to those of just a few years later at Leuhman Ridge on Edwards Air Force Base. Rocketdyne conducted "hot acceptance" tests of rocket engines at the Alfa, Bravo, Coca, and Delta sites of APF 57, engines designed with an uprated thrust of 150,000 pounds (see below). By late 1958, Rocketdyne was developing rocket engines with 1 million to 1.5 million pounds of thrust. These engines would require larger test stands (see below).

AFP 57, then, is illustrative of a test-stand landscape from the very first years of the development of American IRBMs and ICBMs. And although multi-month phasing between August 1954 and April 1956 staggered the chronology of their designs, the Alfa, Bravo, Coca, and Delta clusters of test stands—and their supporting service area and CTL—each present technology snapshots of the early 1950s, rather than snapshots of the maturing ballistic missile program soon to be seen at other locations. The landscape setting incorporated into the test sites of AFP 57 is a design element reflective of even older rocket engine test facilities, those of late World War II Germany. As late as the autumn of 1967, the Air Force described the test stand clusters and test laboratories as "located in deep, natural bowls," making no distinction between the Bowl Area of 1948-1950 and the Alfa, Bravo, Coca, and Delta sites that followed (*History of the Air Force Plant Representative Office, North American Rockwell Corporation, Rocketdyne Division, Canoga Park 1 July – 31 December 1967*: 31-32). In all likelihood, NAA personnel (influenced directly by German engineer Walter Riedel) had planned that the "bowl areas" within Area I (Rocketdyne's property historically, Boeing's property today) and Area II (Air Force property until 1973, NASA's property today) would host similar test stand clusters, selecting the Santa Susana location in spring 1947 for this reason.

3.4 Ralph M. Parsons and DMJM

The Alfa, Bravo, Coca, and Delta rocket engine sites at AFP 57 (Santa Susana's Area II) were among the very first clusters of permanent buildings and structures designed and constructed for the testing and operations of ballistic missiles in the United States. The test stands, blockhouses, and ancillary facilities predating those at AFP 57, as discussed above, were primarily the work of the Los Angeles architectural-engineering firm Ralph M. Parsons (*Aviation Week* 15 February 1954: 38-46), or, were directly overseen by engineers and rocket scientists from within the German Paperclipper community. Parsons (and also Parsons-Aerojet), with experience in engineering military technical facilities at Los Alamos as of 1948, predated the emergence of DMJM in a parallel role. However, as of 1954, DMJM became a strong competitor of Ralph M. Parsons in the design and engineering of the premier early ballistic test and operational missiles complexes in the United States.

DMJM, a partnership of Phil Daniel, Art Mann, Ken Johnson, and Irv Mendenhall, had originated in 1946 in Santa Maria, California (north of Santa Barbara) as a collaboration of Daniel, Mann, and Johnson. Two of the firm's members had met during World War II in the Pacific, where Art Mann had served in the Army Corps of Engineers on Saipan. Mendenhall was a consulting engineer who joined the firm in 1950. The Army and Air Force hired both Parsons and DMJM for large, complicated bulk underground fuel storage projects, beginning in about 1955. The military service arms turned to Parsons repeatedly for architectural-engineering projects involving biological, chemical, and nuclear weapons throughout the 1950s and 1960s. In counterpoint, during the mid-to-late 1950s, DMJM planned, designed, or rehabilitated upwards of 40 military bases in Great Britain, Europe, and Asia (Weitze August 2003b: 29-30, 96-97).

In about 1954, likely beginning with the work for Rocketdyne at AFPs 56 and 57, DMJM joined Ralph M. Parsons (Parsons-Aerojet) as an architectural-engineering firm of first choice for the Air Force. By 1956, fully three-quarters of DMJM's work was for the Air Force. DMJM executed the design for the 1955-1957 Atlas launch complexes at Cape Canaveral, as a follow-on to the first launch stands handled by Parsons a few years previous. During 1955-1957, DMJM also was responsible for designing and engineering five LOX manufacturing plants for the Air Force, including the plants at Patrick Air Force Base (needed to support the launch complexes at Canaveral), and at Santa Susana (AFP 64, see below). In 1957 also, DMJM handled the design and engineering of the Thor IRBM launch complexes constructed at Vandenberg Air Force Base (north of Santa Barbara, California). During this same period, DMJM designed and engineered the Atlas ICBM test facilities for Convair in Sycamore Canyon near San Diego. DMJM sustained its role of paired dominance for ballistic missiles facilities design with Parsons-Aerojet between 1954 and about 1958 (Weitze August 2003b: 29-30).

Concurrent with the latter stages of DMJM's work at Santa Susana, Parsons-Aerojet handled the design and engineering of the test stand complexes at AFP 70 in the foothills east of Sacramento (at Nimbus / Folsom, 1955-1956). Parsons-Aerojet placed a group of five very large static engine test stands "along the face of a 40 ft. ravine on the eastern edge of the [AFP 70] property." Company engineers designed one of these test stands to withstand 1.5 million pounds of thrust, with its completion in late 1956 or early 1957 (*Aviation Week* 19 March 1956: 37-40). Parsons was also the architectural-engineering firm responsible for the expansion of the large rocket engine test stands on Leuhman Ridge at Edwards from mid-decade forward (McCabe January-February 1959: 9-11), and for the Titan ICBM plant in the Denver area of 1956-1958 (Weitze August 2003a: 134-135). As of the late 1950s, the Air Force turned to Ralph M. Parsons to design and engineer the launch silo complexes for the Titan and Minuteman ICBMs nationwide (Weitze August 2003b: 96-97). While DMJM and Ralph M. Parsons were certainly not the only significant architectural-engineering firms handling the new architectural-engineering problem sets of facilities design for ballistic missiles, they were firms in a very small, elite group.

3.5 Early Personnel at Santa Susana, 1947-1958

In addition to Paperclippper Walter Riedel, employees identified as working at Santa Susana during its first years included L.W. Branum, W.J. Cecka, A.E. Moore, and E.C. Sullivan (see Photo 3.1). One of the first men to undertake an assignment to Santa Susana was Sullivan. NAA brought him on board in 1947. Sullivan immediately became associated with facilities planning at Santa Susana. He rose to the position of supervisor of construction at Santa Susana in 1955. NAA hired Branum in 1951 for its aerophysics group at the Downey plant. In 1952, Branum transferred to Santa Susana, and as of 1954 became the engineering supervisor at CTL I (then the only CTL in operation at the site). Moore also joined NAA in 1951, as part of the equipment development unit at Santa Susana. He soon became the engineer in charge of the unit (*Valley Skywriter* 1 March 1957: 2). Cecka served as the senior representative of management and the chief of Engine Test at Santa Susana as of 1957. NAA had hired Cecka in 1946 for the company's propulsion group. In 1950, Cecka was responsible for NAA testing operations at White Sands, Edwards, and "at a propulsion testing site in Florida" (*Valley Skywriter* 24 May 1957: 1).

Other men working at Santa Susana in 1957 in major roles included Charles Anselmo (administration responsibilities for the Upper Bowl and Canyon Areas); D.M. Carpenter (components engineering testing); J.J. Hary (administration responsibilities for the Alfa and Bravo sites); R.J. Lodge (Assistant Chief of Engine Test); R.D. Lumley (group leader at CTL II); W.R. Johnson (large-engine testing); M.R. Olsen (supervisor of the Upper Bowl Area); and W.L. Warth (supervisor of the Alfa site) (*Valley Skywriter* 7 June 1957: 2). About 30 men and women total were the Rocketdyne pioneers at Santa Susana. The first company test crew working on site (in 1949) included 20 men. Those identified by Rocketdyne in late 1958 as present at "Susy" (Santa Susana) "ten years straight" included Bill Cecka, J.J. Hary, R.J. Lodge, and Bob Lumley. Cecka and Lumley were also members of the inaugural test crew (*Valley Skywriter* 28 November 1958: 1-2).

3.6 The LOX Plant at Santa Susana: AFP 64

Situated in Area I, AFP 64 was a LOX plant supplying liquid fuel to AFP 57 in Area II. The plant was a GOCO run by Air Products, Inc., and was one of a small number of such facilities established during 1955-1957 for the IRBM / ICBM program. Beginning during fiscal year (FY) 1955, the Air Force oversaw the construction of five LOX plants across the continental United States. The Air Force handled the architectural-engineering contracting for these facilities, selecting DMJM for the assignment (Weitze August 2003b: 29, 327ff). The LOX plant at Santa Susana, AFP 64, was the first of the group. In order of their undertaking, the other LOX plants were located at:

- Nimbus in northern California (to support engine testing at AFP 70) (FY 1956);

- Edwards Air Force Base (to support engine testing on Leuhman Ridge) (FY 1956);
- Patrick Air Force Base (to support Air Force missile test launches) (FY 1956); and
- Denver (to support the Glenn L. Martin Titan plant, AFP PJKS) (FY 1957).

A sixth LOX plant was started at Holloman Air Force Base (to support planned testing of the Atlas ICBM at the installation), but was terminated shortly after construction began during FY 1957. Air Force investment in the LOX plant program was most intense for the earliest facilities. Summarized in 1958, costs were $7.1 million for the Santa Susana LOX plant; $5.21 million for the Nimbus plant; $3.37 million for the Edwards plant; $3.58 million for the Patrick plant; and $3.34 million for the Denver plant. AFP 64 at Santa Susana was also the largest LOX plant built, with a capacity of 375 tons per day of generating production. The LOX plant at Nimbus was a close second, with a production output of 300 tons per day. The Air Force established these LOX manufacturing plants for its Thor / Atlas and Titan long-range ballistic missiles (Air Force Ballistic Missile Division May 1958: *passim*). The propulsion systems of the Thor, Atlas, and Titan were all liquid fueled.

AFP 64 was undergoing pre-operations (shakedown) testing as of May 1956. By late in the month, AFP 64 was “able to produce limited amounts of LOX,” with the anticipation that “full capacity operation will be obtained within the next few weeks, if unseasonably hot weather is not encountered.” During the first week in June, AFP 64’s Unit 1 was producing 83 tons of LOX per day. On-stream production of LOX began at AFP 64 on 12 July 1956, although the initial output was far below the engineered capacity of the plant. By late September 1956, the Air Force accelerated construction of the LOX plant at Nimbus and site grading for the plants at Edwards and Patrick was underway. DMJM completed its site plan for the LOX plant in Denver simultaneously. On 1 October 1956, the Air Force accepted Units 1, 2, and 3 of AFP 64 at Santa Susana, and Air Products, Inc., took over full GOCO responsibilities at the plant. The LOX plant at Nimbus was in shakedown testing by this date, while the other three LOX plants at Edwards, Patrick, and Denver were in various stages of design and construction. Initial operations at the LOX plant for Leuhman Ridge were anticipated for February 1957, with a 10-ton temporary LOX plant in place in the interim. In mid-October, the Air Force cancelled the contract for a LOX plant at Holloman (Western Development Division 1956: *passim*). Weekly progress reports, chronicling progress and challenges of initial operations at the five LOX plants, continued throughout 1957 (Air Force Ballistic Missile Division 1957: *passim*).

Air Products, Inc. operated the LOX plants at Santa Susana (AFP 64), Nimbus (AFP 70), Edwards, Patrick, and Denver (AFP PJKS) throughout their industrial lifetimes. The company had originated in Detroit in 1940 as an “on-site” provider of oxygen gas. Air Products, Inc. sold the idea of operating gas generating facilities adjacent to high-volume users, with a piped-in transfer to the end site in lieu of the previous method of packaging and selling highly compressed gas in cylinders. After World War II, Air Products, Inc. relocated its business headquarters to Allentown, Pennsylvania. During the late 1940s, the company established the industrial gas industry’s standard for “over the fence” operations to supply its customers. In the 1950s, Air Products, Inc. received numerous government and military contracts to provide and operate plants producing “tonnage quantities of liquid oxygen and nitrogen” for the missile and space program, later adding LH2 plants to its product line (Air Products 2007). AFP 64 at Santa Susana was Air Products, Inc.’s first LOX plant for the Air Force, and was the inaugural large-scale LOX production facility supporting the testing IRBM and ICBMs (inclusive of static testing of these ballistic missiles’ liquid-fueled rocket engines).

3.7 Complementary Development at Santa Susana, 1954-1958

Rocketdyne expanded its company-owned-and-managed (COCO) rocket engine test facilities at Santa Susana simultaneously with the construction for AFP 57. Rocketdyne added three additional CTLs in the years that followed. The company placed CTLs III and V in Area I, southwest of the Bowl Area. These two components laboratories supported multiple Rocketdyne rocket engine development programs. CTL III, under construction in early 1958, was described as including:

> a control house with two complete control rooms, three modules each containing three test pits, a small test stand, and a valve testing set-up. … A new feature of CTL III is the use of underground tunnels between the control room and test modules for personnel access and to house instrumentation cables (*Valley Skywriter* 3 January 1958: 1-2).

Rocketdyne placed CTL IV in what would later be called Area IV, within the westernmost acres at the Santa Susana location. CTL IV, later known as the Space Test Laboratory (STL) IV, was a complex “specifically [re]designed for the testing of Space Engines and components such as Condor, Lem, Apollo, RS-14 (Minuteman) and the SE-53 (Lockheed Space Engine)” by the late 1960s (*History of the Air Force Plant Representative Office, North American Rockwell Corporation, Rocketdyne Division, Canoga Park 1 July – 31 December 1967*: 32-33). The five CTLs (I-V) at Santa Susana were all operational by November 1958. Rocketdyne had also expanded its original service area.

Rocket engine test activities at the Santa Susana site were often interwoven, utilizing both Rocketdyne and Air Force facilities. By 1957, the neighboring AFP 57 had become known as the Air Force Propulsion Field Laboratory (PFL). Air Materiel Command at Wright-Patterson Air Force Base oversaw the PFL for the Air Force. AFP 57 at Santa Susana was one of 80 Air Force industrial plants managed by Air Materiel Command at the end of 1958, with all but five of the plants in active production. AFPs peaked in number shortly after this date, at about 90 nationwide (Weitze August 2003a: 134). In late November 1958, “more than 17 huge steel-and-concrete test stands, five major components test laboratories, instrumentation centers, and supporting facilities” defined the Rocketdyne and Air Force rocket engine testing complex at Santa Susana (*Valley Skywriter* 28 November 1958: 1-2). The Alfa II test stand was active only into 1957, dismantled by Rocketdyne sometime thereafter (NASA February 2006a). The early discontinuation of tests on Alfa II likely accounts for Rocketdyne's enumeration of 17 active test stands in 1958: three each in the Bowl and Canyon Areas; two at Alfa; and three each at Bravo, Coca, and Delta.

Also established at Santa Susana during 1955-1958 was a complex for Atomics International (AI) located in a 200-acre high valley known as Burro Flats. The acreage bracketed AFP 57 to the west and became known as Area III. NAA had been involved in nuclear reactor research and development since the early 1950s. The first NAA reactor, known as the Water Boiler Neutron Source (WBNS), dated to 1952 and was installed in the Downey plant. Following upon the Atomic Energy Commission's (AEC's) announcement of a reactor-development program in early 1954, NAA began to focus more attention on its experimentation with nuclear reactors. The company's Atomic Energy Research Department won a contract to design, build, and operate a reactor in support of AEC's program. In June 1954, NAA initiated design of the sodium-cooled, graphite-moderated nuclear reactor, known as the Sodium Reactor Experiment (SRE). NAA selected a location for the SRE at Santa Susana in 1954, with construction underway in April 1955 at the western periphery of the overall Santa Susana property (coincident with construction at the Alfa and Bravo sites in Area II). In November 1955, simultaneous with the formation of the Rocketdyne Division, NAA reorganized its nuclear reactor group as AI. In mid-1956, AI dismantled WBNS at its Downey plant and relocated it to Santa Susana (Mitchell 1990: 38ff). As rebuilt at Santa Susana, the reactor was renamed the Kinetic Experiment for Water Boilers (KEWB) (*Valley Skywriter* 31 May 1957: 1). The SRE produced electric power for the first time in July 1957 (*Valley Skywriter* 19 July 1957: 1) Beginning in May 1958, AI initiated a major $1.25-million building program at Santa Susana, expanding its early facilities on Burro Flats (*Valley Skywriter* 2 May 1958: 1 and 3). (AI's SRE was located about a mile from the new enclave.) In the early 1960s, AI would have 10 operating nuclear reactors at Santa Susana (in today's Area III), some operating in support of the joint AEC – Air Force program System for Nuclear Auxiliary Power (SNAP) (Mitchell 1990: 41). A goal of SNAP was to place a nuclear reactor in earth orbit (Rockwell 1987).

3.8 The First Engine Test Programs at AFP 57, 1955-1961

Nearly all rocket engine test and development programs in Areas I (the Bowl and Canyon Areas) and II (AFP 57) during the second half of the 1950s derived from the earliest rocket engines tested at Santa Susana, the Navaho and Redstone engines. (NAA, in turn, had created the Navaho engine from the V-2 engine.) Testing of Navaho and Redstone engines occurred in the Bowl Area. Rocketdyne engineers uprated the Navaho engine from 75,000 pounds thrust to 150,000 pounds thrust for the Thor and Atlas engines (Biggs Winter 2000: 14-15), conducting development, test, and evaluation tasks at Santa Susana's AFP 57 for the Air Force during the second half of the 1950s into the early 1960s (Neufeld 1990: 143-148, 232-238). One uprated engine powered the Thor; two, the Atlas (Biggs Winter 2000: 15). Mirroring their efforts for the Thor IRBM, Rocketdyne engineers also developed and tested the Jupiter IRBM engine for the Army. Test stand allocations for ballistic missile engine testing at AFP 57 during 1955-1961 were:

- Alfa test stands: very early static firings of rocket engines in development for Atlas on Alfa I (1955-1957), static firings of the Atlas flight engine and Navaho engine on Alfa II (1956-1957) (*History of Air Research and Development Command 1 July – 31 December 1955* and Rocketdyne Historic Photographs Collection), and firings of Thor (1955-1958), Atlas (1956-1957), Navaho (1956-1957), and Jupiter (1957) engines on Alfa III;
- Bravo test stands: developmental and acceptance tests of Atlas thrust chambers (1956-1957) on Bravo I and II, with tests of the thrust chambers for the developmental E-1 engine (1956-1959) on Bravo I (NASA February 2006b), and static firing tests of the RS-2, a 50-foot-long, 7-ton sled powered by a liquid fuel engine to 160,000 pounds of thrust on Bravo IIIB, prior to Rocketdyne's shipment of the sled to Holloman Air Force Base for installation on a 7-mile test track (1959) (*Valley Skywriter* 31 July 1959: 3);
- Coca test stands: static firings of development and flight versions of an Atlas engine on Coca I and II (1956-1957), hot-environment tests for the Atlas engine on Coca II (1959), and tests of a late version of the Navaho engine on Coca III (1956-1957); and
- Delta test stands: acceptance testing of Atlas engines in the late 1950s, including tests of a developmental thrust chamber for Atlas on Delta III in 1957 (*Valley Skywriter* 8 August 1958: 3), static firings of the Jupiter engine on Delta I (1960-1963), and research and development tests of experimental Air Force rocket engines, including firings of the E-1 engine (1958-1960), the X-1 engine (1958-1961), and the X-4 engine (1960) on Delta II.

The Air Force was simultaneously conducting tests of the E-1, X-1, and X-4 rocket engines at its Air Force Flight Test Center on Edwards Air Force Base (Deming, Slovinac, and Weitze November 2007b: 4-12).

3.9 Enhanced Infrastructure at the Bravo, Coca, and Delta Sites, 1962-1966

As of the late 1950s, Air Force and Army IRBMs became not only the basis for the more advanced ICBMs to come, but also the building blocks for propulsion systems to carry man into space. In 1958, a Jupiter C rocket, powered by a Redstone engine, carried the first American satellite, Explorer I, into orbit around the Earth. Late the same year, NASA initiated its Saturn I program. In 1961, NASA adapted a Redstone engine as a component of the propulsion system to launch the inaugural manned Mercury capsule (Boeing 2006d). Beginning in 1961, NASA contracted with Rocketdyne for Large Rocket Engine Systems to support its newly established Saturn Apollo program (Weitze November 2003: 89; *History of the Air Force Plant Representative, Rocketdyne Division, North American Aviation, Canoga Park 1 January – 30 June 1961*). Rocketdyne had initiated some preliminary changes at AFP 57 in 1959, at Bravo II (Rocketdyne 3 September 1959). In August 1962, the MSFC and Rocketdyne negotiated a NASA

Industrial Facilities contract to meet "requirements for the J-2, F-1, H-1, and S-II programs at [the] Canoga Park Propulsion Field Laboratory at Santa Susana, Edwards AFB, and Neosho, Missouri" for "[a]ll severable items acquired with NASA funds" (*History of the Air Force Plant Representative, Rocketdyne Division, North American Aviation, Canoga Park 1 July – 31 December 1962*: 11). The Air Force continued to own AFP 57 until its transfer to NASA in November 1973.

The MSFC described its mid-1960s mission at Santa Susana as "the developmental testing of the S-II stage of the Saturn V vehicle, development and testing of the H-1 and J-2 engines, and components testing of the F-1 engine." In 1964, the MSFC further summarized its $36.6-million facilities use as including:

- two S-II stage test positions (on Coca I and IV);
- one F-1 components test stand (Bravo I);
- an F-1 components test laboratory (two modules at CTL V);
- a H-1 components test laboratory (two modules at CTL I);
- three H-1 engine test stands (the Canyon Area);
- a J-2 components test laboratory (three modules at CTL III); and
- five J-2 engine test stands (VTS II and III in the Bowl Area; Delta I, II and III) (NASA November 1965).

By 1966, NASA's MSFC, collocated with the Redstone Arsenal in Huntsville, had field operations in 20 buildings and structures in AFPs 57 and 64 (exclusive of small ancillaries), and in 23 facilities owned by Rocketdyne. At mid-year, the MSFC had supervised the construction of four new buildings and structures in the Coca Area, and had made modifications to the Bravo I and II test stands; the Delta II test stand; and all five CTLs. NASA activities for Saturn (testing for the H-1 engine, and components of the F-1 and J-2 engines) at Santa Susana were most intense during 1964-1968 (see below) (NASA 1966; NASA 1968). In 1968, about 90 percent of the "total contract administration activity…[at AFP 57]…pertain[ed] to support for the National Aeronautics and Space Administration" (*History of the Air Force Plant Representative Office, North American Rockwell Corporation, Rocketdyne Division, Canoga Park 1 July – 31 December 1968*: 2).

The primary firm responsible for the NASA improvements at AFP 57 (Area II) during the early-middle 1960s was the Bechtel Corporation, with the architectural-engineering work subcontracted to Ralph M. Parsons (Parsons 15 March 1963). During these same years, Bechtel oversaw major facilities augmentation at the MSFC (Weitze November 2003: 96). At Santa Susana, the most significant improvements occurred at the Coca site. At Coca, NASA required two much larger test stands, each able to handle the greatly increased physical forces generated by the uprated thrust of the rocket engines in development as space boosters (Photo 3.23). The major added buildings and structures at Coca were:

- Coca I ("completely reconstructed");
- Coca IV (new);

- a blockhouse addition;
- an upper pre-test building;
- two pill boxes;
- a GH2 recovery vessel (the “eight ball”); and
- a LH2 storage vessel.

Photo 3.23. Coca site at AFP 57 (NASA Area II), 27 January 1964. Left to right: Coca IV, I (rebuilt), II (base only), and III. Lower pre-test building (foreground right), wooden staircase to 1950s pill box (center right), 1960s pill box (background center), and GH2 recovery system (“eight ball”) (background center left).
(Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

Simultaneous with the construction of Coca I and IV, Rocketdyne had Coca II “dismantled to provide space” (*History of the Air Force Plant Representative, Rocketdyne Division, North American Aviation, Canoga Park 1 July – 31 December 1962*: 18). Rocketdyne also augmented the row of tanks on Skyline Drive with a ninth tank, simultaneously. The much larger tank held 470,000 gallons of water (Rocketdyne 14 March 1963).

3.10 Additional Improvements at the Coca Site, 1972-1979

In autumn 1969, NASA initiated its formal planning for the SSME. Rocketdyne won one of the four Phase A shuttle developmental contracts, and by late in the year the MSFC was assessing test stands at Santa Susana as infrastructure appropriate for the planned engine (Goodrum and Wade 1969; Mitchell September, October and November 1969). NASA announced in mid-July 1971 that the agency had selected Rocketdyne to develop and manufacture the SSME. North American Rockwell had also received the contract for the shuttle’s orbiter (*Marshall Star* 23 August 1972: 1-2). In early 1972, NASA awarded Rocketdyne a 90-day letter contract to initiate work on the development and production of the SSME. Canoga Park was the designated manufacturing location for the engine. Before the close of the year, NASA provided $15.4 million in additional monies to Rocketdyne to modify Coca I and IV for testing programs supporting the development and manufacture of the SSME. The MSFC reported:

> electrical and low pressure gas distribution systems are being modified, and high pressure gas distributions systems are being added. Changes are also required in the control center and instrumentation systems (*Marshall Star* 25 October 1972: 2).

One major new structure added at the Coca site was a high-pressure gas storage vault, under construction in 1973. The SSME was a very powerful propulsion system that necessitated test stands generally physically larger and more modern than those at Santa Susana. Of Rockwell International's existing test stands, only Coca I and IV were capable of further improvements for the SSME (without fully new construction). As of 1974, the MSFC planned to use facilities at Santa Susana only for components testing of the developmental SSME:

- the three test positions on Coca I;
- one position on Coca IV;
- CTL I (for SSME turbine testing);
- CTL III (for SSME ignition "proof and burst");
- CTL IV (for SSME bearings tests);
- a materials test facility; and
- a valve test facility.

By February 1974, modifications to CTL I were 50 percent completed, with those to CTL IV, 70 percent completed. Modifications to CTL III, the materials test facility, and the valve test facility were finished. The MSFC, working with Rocketdyne, selected Bechtel as the engineering firm to handle the design modifications to the Coca I and IV test stands required for the SSME program. The work extended into 1975, although was prioritized for the Coca IVA test position. In August 1973, Rocketdyne conducted the first preburner test for the SSME on the Coca IVA position, acknowledged within NASA as a shuttle development milestone (Rockwell International February 1974).

Not until the late 1970s did static firings of a complete SSME occur at Santa Susana. Up until then, NASA had chosen to have Rocketdyne run the acceptance tests of completed SSMEs at its Mississippi Test Facility (MTF) near New Orleans, using two massive test stands built in the late 1960s for the Saturn Apollo program. (The MTF was subsequently renamed the National Space Technology Laboratories [NSTL], and today is known as the Stennis Space Center.) Rocketdyne ran components tests for the SSME at Santa Susana (primarily on Coca I and IV), and conducted static firings of the SSME on the (renamed) A-1 and A-2 test stands at the MTF (Photo 3.24). Rocketdyne first fired a complete SSME (engine number 0001) at the NSTL in May 1975. Engine 0001, as initially configured, was a test article alternately known as Integrated Subsystems Test Bed (ISTB). The MSFC soon decided to add a third engine (rather than components) test stand to assist in Rocketdyne's acceptance testing of manufactured SSMEs. NASA contracted to further modify the Coca I test stand at Santa Susana, renaming the facility Test Stand A-3. Following the test program in Mississippi, Rocketdyne rebuilt engine 0001 at its Canoga Park plant, before redesignating the engine as 0201 and placing it on

Test Stand A-3 (Coca I) at Santa Susana. Rocketdyne conducted the first test firing of a complete SSME at Santa Susana on the Coca I test stand, on 7 November 1978. This initial firing was one to check out the test stand, and the rebuilt engine. Engine 0201 had previously completed 67 tests on Test Stand A-1 at the NSTL (as engine 0001), as well as 15 altitude tests on Test Stand A-2 (also at the NSTL) (*Marshall Star* 15 November 1978: 4). In its redesignated role as Test Stand A-3, the Coca I test stand became the primary SSME test facility at Santa Susana (see Photo 3.25). In the late 1970s, Rocketdyne augmented the Coca site with several ancillary facilities to support Test Stand A-3, such as a pump building for a coal hydrogasification system (Rockwell International 22 June 1979).

Photo 3.24. Installation of S-IC booster on test stand at the Mississippi Test Facility (today's Stennis Space Center), 1967. Five F-1 engines powered the S-IC, the first stage of the Saturn V.
(Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

3.11 Engines Tested at Santa Susana during 1962-1980

Beginning during the early 1960s, the Air Force Plant Representative for the Rocketdyne Division of NAA made lengthy summaries of not only company activities supporting the development, test, and manufacture of Air Force rocket engines, but also provided parallel reporting on its work for NASA at AFPs 56 (Canoga Park) and 57 (Santa Susana). Still known as the PFL, AFP 57 (Area II) continued to have four operating clusters of test stands. Engines developed and certified for the Air Force and NASA included several versions of Thor and Atlas propulsion systems (and their components). Designed and engineered not just to power weapons (Thor IRBMs and Atlas ICBMs), but also as first-stage boosters integral to the scientific, communications, and military-intelligence satellite programs, Thor and Atlas engines became the workhorses of space. A Thor engine had first served in this alternate role in October 1958 (for Pioneer I, a deep-space probe that supplied the first measurements of interplanetary magnetic fields) and February 1959 (for Discovery I, a forerunner of military reconnaissance satellites). By early 1967, the Air Force had combined Thor first stages with upper stages as the Thor-Able, Thor-Abelstar, Thor-Delta, Thor-Agena, Thor-Altair, and Thor-Burner II.

As of the 1960s, the Thor engine had been adapted for space boosters in thrust-augmented and long-tank configurations (such as the Thor-Delta), similar to the earlier standard Thor, but enhanced with three solid propellant rocket motors (Thor vernier engines) that increased the thrust at liftoff (*History of the Air Force Plant Representative Office North American Aviation Rocketdyne Division Canoga Park 1 January – 30 June 1967*: 45-46). Rocketdyne manufactured (and tested at Santa Susana) both the "main block" uprated Thor engines and the small, externally mounted Thor vernier engines. The booster's flight system could tilt the vernier engines to adjust the space vehicle's roll, pitch, and yaw attitudes during initial flight (*History of the Air Force Plant Representative Office, North American Rockwell Corporation, Rocketdyne Division, Canoga Park 1 January – 30 June 1968*: 64). NASA adapted Atlas main block and vernier engines in a similar manner as first-stage boosters for the agency's scientific space vehicles. By the middle 1970s, NASA, the Air Force, and the Army all used Atlas engines "for launching a wide variety of ballistic, orbital, and interplanetary payloads." Programs supported by Atlas included the Centaur and Agena (Atlas-Centaur and Atlas-Agena) (*History of the Air Force Plant Representative Office, Rockwell International Corporation, Rocketdyne Division, Canoga Park 1 July – 31 December 1974*: 25).

For NASA, Rocketdyne also initiated testing of the F-1, J-2, and H-1 engines in the early 1960s. The F-1, J-2, and H-1 were configured as very large liquid propulsion systems that required enhanced infrastructure for testing and acceptance run-ups (*History of the Air Force Plant Representative, Rocketdyne Division, North American Aviation, Canoga Park 1 January – 30 June 1962*). The H-1 was a 205,000-pound thrust engine; the J-2, a 230,000-pound thrust engine; the F-1, a 1.5-million-pound thrust engine. Eight H-1 engines provided the propulsion system for the Saturn I. One J-2 engine powered the S-IVB, the second-stage booster of the Saturn IB, while J-2s were also the engines for the second and third stages of the next-era Saturn V (as five- and single-engine configurations). Five F-1 engines powered the S-IC, the first stage of the Saturn V. Rocketdyne production contracts for manufacture of the engines anticipated initial delivery to NASA for these engines beginning in early 1963 (*History of the Air Force Plant Representative, Rocketdyne Division, North American Aviation, Canoga Park 1 July – 31 December 1961*: 6 and *1 July – 31 December 1966*: attached engine profiles). Several locations in the continental United States supported development and testing of the J-2 and F-1 engines, and their associated Saturn booster stages, for the Saturn Apollo program. Large, new test stands were put in place during the early 1960s at the MSFC in Huntsville; on Leuhman Ridge at Edwards; within the Santa Susana complex (at the Coca site); and at a Douglas Aircraft Company test site east of Sacramento near AFP 70 (Weitze November 2003; Weitze July 2005; *Southwest Builder and Contractor* 8 November 1963: 68-70).

NASA's Saturn Apollo program also stimulated the creation of "field laboratories." To support its needs for the F-1, in particular, Rocketdyne expanded its use of two allocated test stands on Leuhman Ridge at Edwards Air Force Base. The transfer process from the Air Force to Rocketdyne (on behalf of NASA), for dedicated use of test stands on Leuhman Ridge, had begun in 1961 (*History of the Air Force Plant Representative, Rocketdyne Division, North American Aviation, Canoga Park 1 July – 31 December*

1961). As of late 1962, three additional single-engine test stands and a new blockhouse were under construction on Leuhman Ridge for NASA's F-1 program. The complex of five very large test stands on Leuhman Ridge from the late 1950s and early 1960s was known as the High Thrust Test Area by late 1963. Each of the three test stands of 1962-1963 stood 175 feet high, with reinforced concrete bases measuring 100 by 150 feet. Rocketdyne was to operate the High Thrust Test Area at Edwards for NASA, and soon the complex became known as the EFL. *Southwest Builder and Contractor* described the test stands of the High Thrust Test Area as "carefully tied into the native rock," echoing a critical design feature previously selected at Santa Susana during 1949-1956 (Photo 3.25). Evocative of the more advanced engineering required for the High Thrust Test Area, "portions of the area are hardened against blast effect as protection against an accidental explosion…[and] includes fuel and water tanks, the control center, and essential plumbing." Ralph M. Parsons handled the design and engineering of the late 1950s-early 1960s test stand complex at Edwards for NASA / Rocketdyne, simultaneously responsible for a small group of discontiguous test-stand locations and an administrative center configured north of Reno (*Southwest Builder and Contractor* 8 November 1963: 68-70). The Rocketdyne Nevada test site, laid out and designed by Parsons in 1958 (Ralph M. Parsons 22 August 1958), was known as the Advanced Research Facility in 1962 and would soon be named the Nevada Field Laboratory (NFL). In northern California, the Douglas test site, an $18-million complex for testing the S-IVB second stage booster of the Saturn IB, became the Sacramento Field Station. The PFL at Santa Susana transitioned to its current name, the SSFL, during this same period.

Photo 3.25. F-1 engine during hot firing at the Edwards Field Laboratory on Leuhman Ridge, Edwards Air Force Base, 11 August 1961.
(Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

During the 1960s, the test stand complexes at the SSFL tended to support particular engine programs (Deming, Slovinac, and Weitze November 2007b, *passim*):

- the Bowl Area: static firings of the J-2 and its thrust chamber on VTSs I, II, and III, including sea-level and altitude testing, and static firings of the Aerospike thrust chamber on VTS I (as of May 1967);

- Alfa test stands: after a period of deactivation during 1964-1968, continued static firings of Atlas booster engines (on Alfa I) and Thor main block engines (on Alfa III, a testing program returned to Santa Susana after its transfer to Rocketdyne-managed AFP 65 at Neosho, Missouri) (NASA February 2006a; *History of the Air Force Plant Representative Office, North American Rockwell Corporation, Rocketdyne Division, Canoga Park 1 July – 31 December 1967*: 33; *History of the Air Force Plant Representative Office, North American Rockwell Corporation, Rocketdyne Division, Canoga Park 1 July – 31 December 1968*: 34), with NASA's Lewis Research Center in Ohio using the Alfa Site for its LOX testing program in 1966 (NASA May 1966: 68-69);
- Bravo test stands: static firings of the Atlas thrust chamber (1963-1964), followed by tests on the F-1 thrust chamber, gas generator, heat exchanger, and components (after mid-decade), on Bravo I, with static run-ups of F-1 turbopumps, on Bravo II (after mid-decade) (NASA February 2006b), and tests of Lunar Module Rocket Engine assemblies as of mid-1967 on Bravo IIIB (*History of the Air Force Plant Representative Office North American Aviation Rocketdyne Division Canoga Park 1 July – 31 December 1967*: 34; *History of the Air Force Plant Representative Office, North American Rockwell Corporation, Rocketdyne Division, Canoga Park 1 January – 30 June 1968*: 28);
- Coca test stands: static firings of the J-2 in its five-engine configuration for the second-stage of the Saturn V (the S-II) on Coca I (the rebuilt test stand) and static qualification trials of the fully configured "battleship" (simulated flight) version of the S-II on Coca IV (see Photo 3.25);
- Delta test stands: continued static firings of Jupiter engines on Delta I (into 1963), testing for the Army's Lance engine on Delta III (beginning in 1962), and run-ups of the J-2 on Delta I, II, and III (throughout the decade) (NASA February 2006d and NASA September 1964); and
- the Canyon Area: dedicated testing of the H-1 engine, until acceptance testing for the engine moved to AFP 65 in Neosho, Missouri, early in the decade.

The Air Force printed statistics on engine testing at individual test-stand positions at the Alfa, Bravo, Coca, and Delta sites only rarely in its reporting for AFP 57. At Delta, for example, Delta II (A position) was the primary test stand for tests of the J-2, with two other test positions at the site "used as standbys." In 103 tests on Delta IIA, Rocketdyne static-fired the J-2 engine a cumulative 20,094 seconds (over five hours) between May 1962 and the close of 1966 (*History of the Air Force Plant Representative Office North American Aviation Rocketdyne Division Canoga Park 1 January – 30 June 1967*: 47). At CTL II, work concentrated on H-1 "test firings and research and development engine testing." Cell 4 of CTL II was "principally a gas generator test facility equipped specifically to test the H-1 engine" (*History of the Air Force Plant Representative Office North American Aviation Rocketdyne Division Canoga Park 1 July – 31 December 1967*: 32).

During 1967-1968, the dynamics of testing at Santa Susana were changing rapidly. Much of the situation derived squarely from operational management and budget shifts within NASA, particularly at the MSFC (Dunar and Waring 1999). Rocketdyne's workload declined progressively during 1965-1967, with its workforce shrinking in proportion. The company interpreted the "future market" for "large, high performance liquid rocket engine design, development, and production" as unpromising, shifting its focus "toward capturing subcontract work in aircraft jet engine components." In late September 1967, NAA merged with the Rockwell-Standard Corporation as the North American Rockwell Corporation (and, subsequently, Rockwell International). The new company was deliberately more diversified (*History of the Air Force Plant Representative Office North American Aviation Rocketdyne Division Canoga Park 1 July – 31 December 1967*: 4).

As of 1968, only 40 percent of the SSFL was "under [NASA] programmed utilization with many of the 18 test stands on inactive status." CTLs II and III were deemed to "have complete redundancy," and were "only about 20% utilized." A parallel situation existed at the EFL, with three of the large F-1 test stands on inactive status and three only 45 percent utilized. The MSFC asked Rocketdyne to analyze its test facilities for "uneconomical operation and determine where cost savings might be possible." Rocketdyne's Development Engineering unit submitted a report to the NASA resident manager at Canoga Park, and to Huntsville, that called for a reconfiguration of test stand use for F-1 components testing, and reminded NASA that the agency had achieved an economy of scale for the F-1, J-2, H-1, Thor, and Atlas programs due to the engines being a "complete package." Rocketdyne also listed ways to remove redundancies created by NASA's monthly delivery schedules for mission requirements and the agency's stipulations about separate test crews to man each test function at Santa Susana (*History of the Air Force Plant Representative Office, North American Rockwell Corporation, Rocketdyne Division, Canoga Park 1 January – 30 June 1968*: 27-30).

Engine explosions at both the Coca and Alfa sites aggravated the unsettled situation of the late 1960s at Santa Susana. An S-II mini-tank exploded on the Coca IV test stand on 20 December 1968, with major damages sustained by the Coca site facilities. Rocketdyne shut down the Coca site at the end of the year, placing it in standby status. A second incident at Santa Susana occurred on 17 June 1969, when a Thor engine exploded on the Alfa III test stand. Both episodes required substantial rebuilding of the host test stands and other facilities. Cleanup and rebuilding at Alfa III occupied eight weeks. During the first six months of 1969, Rocketdyne vacated major square footages in Buildings 201, 202, and 203 in AFP 57's Service Area, as well as in Building 206 (CTL II). By the end of the year, Buildings 201, 206 (CTL II), and 211 were empty (*History of the Air Force Plant Representative Office, North American Rockwell Corporation, Rocketdyne Division, Canoga Park 1 July – 31 December 1968*: 34; *History of the Air Force Plant Representative Office, North American Rockwell Corporation, Rocketdyne Division, Canoga Park 1 January – 30 June 1969*: 24-25, 28-29, 45-46; *History of the Air Force Plant Representative Office, North American Rockwell Corporation, Rocketdyne Division, Canoga Park 1 July – 31 December 1969*: 23).

By the close of the 1960s, the SSFL had become "one of the largest and most diversified liquid test facilities in the world, offering "a capability and flexibility for research and development testing as well as production acceptance testing on liquid rocket engines ranging from relatively small thrust to a quarter million pounds of thrust." Yet simultaneously, declining use and possible sustained inactivity seriously jeopardized the future of Santa Susana. Rocketdyne employees at Canoga Park, Santa Susana, Reno (Nevada), and Neosho (Missouri) dropped from a high of 17,000 in 1964 (variously cited as a peak of 19,000 in 1965), to a 1969 figure of 7,800 (*History of the Air Force Plant Representative Office, North American Rockwell Corporation, Rocketdyne Division, Canoga Park 1 July – 31 December 1968*: 2-4). Rocketdyne dipped to only 3,000 employees in 1972 (*History of the Air Force Plant Representative Office Rockwell International Corporation, Rocketdyne Divisio*n *1 January – 31 December 1976*: 3).

Rocketdyne's winning of Phase A and B contracts for tests of a space shuttle engine revitalized the SSFL. The company first ran developmental ignition tests for a space shuttle engine at the NFL during late 1970 and early 1971. The NFL would close in March 1971 after nine years of operation, following completion of space shuttle engine tests in Area D (*History of the Air Force Plant Representative Office North American Rockwell Corporation, Rocketdyne Division* 1 *January – 30 June 1969*: map; *History of the Air Force Plant Representative Office North American Rockwell Corporation, Rocketdyne Division 1 January – 30 June 1971*: 28). A prototype SSME thrust chamber (partial engine) fired successfully in early 1971 at the NFL, giving Rocketdyne the critical edge toward award of the later manufacturing contract for the engine. (Heppenheimer 2002b: 102, 132). Rocketdyne submitted its proposal for Phase C/D shuttle studies in April 1971 (*History of the Air Force Plant Representative Office North American Rockwell Corporation, Rocketdyne Divisio*n *1 January – 30 June 1971*: 46).

After major facilities modifications during the middle and late 1970s, primarily at the Coca site and three CTLs, Rocketdyne initiated development and testing of the SSME. The Coca site had been inactive from the close of 1968 until Rocketdyne initiated early SSME-related testing on Coca IVA in August 1973. In June 1973, the Air Force commander for AFP 57 commented that 1973 was "the year Rocketdyne business reversed itself" (*History of the Air Force Plant Representative Office Rockwell International Corporation, Rocketdyne Divisio*n *1 January – 30 June 1973*: 4). The statement, with associated financial projections, was repeated in all semi-annual reports for the next two years (*History of the Air Force Plant Representative Office Rockwell International Corporation, Rocketdyne Divisio*n *1 January – 30 June 1975*: 4). NASA launched the first shuttle, the *Columbia*, into space on 12 April 1981 at the Kennedy Space Center.

During the 1970s, activities at the Alfa, Bravo, Coca, and Delta sites were varied, and included:

- <u>Alfa test stands</u>: static firings of improved Atlas and Thor engines (used as Air Force and NASA space boosters), with Atlas booster and sustainer engines tested on Alfa I and Thor main block and Delta RS-27 engines tested on Alfa III, and with Alfa I deactivated for an undetermined period in mid-1973 (*History of the Air Force Plant Representative Office North American Rockwell Corporation Rocketdyne Division Canoga Park, California 1 January – 30 June 1969*: 45, and, *1 January – 30 June 1973*: 37; NASA February 2006a);

- <u>Bravo test stands</u>: acceptance testing for Atlas and Delta RS-27 vernier engines on Bravo ID, with tests of Atlas sustainer turbopumps, Atlas booster engines, and Delta RS-27 turbopumps on Bravo II (NASA February 2006b);
- <u>Coca test stands</u>: development and testing support for the SSME on Coca I and IV (Photo 3.26); and
- <u>Delta test stands</u>: static firings of the Linear Aerospike engine on Delta IIA (1970) (NASA February 2006d) and the Linear Engine Test Bed No. 2 on Delta IIB (in 1973) (*History of the Air Force Plant Representative Office North American Rockwell Corporation Rocketdyne Division Canoga Park, California 1 January – 30 June 1973*), with possible continued testing of the Lance engine on Delta III (NASA February 2006d).

Photo 3.26. Preparations for SSME components test on Coca I (Test Stand A-3) at Santa Susana (NASA Area II), 20 December 1974.
(Source: Boeing, Rocketdyne Historic Photograph Collection, SSFL.)

Rocketdyne had won a contract to manufacture RS-27 engines in early 1972. The RS-27 was an uprated version of the company's original Thor engine. The more powerful Thor engine was needed to boost the "extended long tank" Delta launch vehicle (*History of the Air Force Plant Representative Office North American Rockwell Corporation Rocketdyne Division Canoga Park, California 1 January – 30 June 1973*: 42).

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3.12 Post-1980 Activities at Santa Susana

To greater and lesser degrees, the Alfa, Bravo, and Coca sites continued to host static firings for Rocketdyne during the 1980s and 1990s, with several locations active into the early 21st century. Test usage is summarized as:

- Alfa test stands: ongoing reliability, verification, and acceptance testing of Atlas MA-5 engines on Alfa I (1982-2000) and Delta RS-27 and RS-27A engines on Alfa III (1980-2006, with a period of hiatus during the mid-1980s) (Rockwell International 1987 and NASA February 2006a);
- Bravo test stands: "modified extensively [ca.1985] for the Delta RS-27 and Atlas programs to handle the acceptance testing of all turbopumps" (Rockwell International 1987), with continued tests run on Bravo I and II as in the 1970s (into 2005) (NASA February 2006b); and
- Coca test stands: continued developmental testing for the SSME and acceptance testing of the SSME turbopump on Coca I (Test Stand A-3) (into 1988) (NASA February 2006c)

The Atlas MA-5 engine, like the later Thor engines, was a follow-on to the original Atlas engine of the late 1950s. Individual component engines of the Atlas MA-5 included a sustainer engine (with 60,000 pounds of thrust), a booster engine (with 370,000 pounds of thrust), and two vernier engines (each with 2,000 pounds of thrust) (*History of the Air Force Plant Representative Office Rockwell International Corporation, Rocketdyne Divisio*n *1 January – 30 June 1975*: 29).

Each cluster of test stands, as well as individual test stands, had periods of inactivity between 1955-1956 and 2006—sometimes very short, sometimes sustained. Permanent deactivation of test stands was underway at the four sites as of the 1970s. Delta was only minimally active after 1970, and was completely inactive at some point in the decade (NASA February 2006d; NASA February 2006d; *History of the Air Force Plant Representative Office North American Rockwell Corporation Rocketdyne Division Canoga Park, California 1 January – 30 June 1973*). Coca concluded its support of the SSME program in 1988, with subsequent activities at the location minimal. Bravo continued its missions for the Air Force Atlas and Thor (Delta RS-27) space booster engines into 2005 (NASA February 2006b). Alfa was both the oldest (first) test area at AFP 57 (Area II) and the longest lived. Late missions at Alfa paralleled those at Bravo. Alfa I was not deactivated permanently until 2000, while Alfa III was still in use in early 2006 (NASA February 2006a).

4.0 SURVEY RESULTS AND FACILITY EVALUATIONS

4.1 Overview

The evaluation of the SSFL included an initial review of a list of 135 NASA-owned buildings, structures, and sites located within Areas I and II of the SSFL, provided to ACI by MSFC HPO, Ralph Allen. With the exception of a single well in Area I, all of the facilities are located within Area II. This initial review revealed that 60 of the facilities within Areas I and II are temporary structures, small storage sheds, roadways, pipelines, or other small objects, such as light fixture poles, which are used for generic purposes, with no specific historic function. The remaining 75 facilities are all buildings and structures located within the Alfa, Bravo, Coca, Delta, Storable Propellant Area (SPA), and Service Area complexes of Area II; field survey focused on these 75 facilities (Table 4.1). Although many of these resources were previously assessed by various contractors (Calvit and Barrier 2006; Deming, Slovinac and Weitze 2007b) as meeting the criteria of eligibility for inclusion in the NRHP, none of the surveyed facilities is currently listed in the NRHP or has been formally determined eligible. As a result of research and field survey, three new NRHP-eligible historic districts were identified, as well as nine resources which are considered individually eligible for listing in the NRHP. These 12 historic properties are as follows:

- Alfa Test Area Historic District
- Alfa I Test Stand
- Alfa III Test Stand
- Alfa Control House
- Bravo Test Area Historic District
- Bravo I Test Stand
- Bravo II Test Stand
- Bravo Control House
- Coca Test Area Historic District
- Coca I Test Stand
- Coca IV Test Stand
- Coca Control House

Summary descriptions and evaluations of the nine individually NRHP-eligible historic properties, as well as the three proposed historic districts, are contained in Section 4.2. The assets which do not meet the criteria of eligibility for listing in the NRHP are briefly discussed in Section 4.3.

Table 4.1. List of Surveyed Assets at the SSFL (names reflect those on the real property records or architectural drawings, as appropriate).

FACILITY NO.	NAME	DATE	NRHP STATUS
	Alfa Test Area		
2727	Alfa I Test Stand	1954	Individually eligible and contributing to Alfa Test Area H.D.
2729	Alfa III Test Stand	1954	Individually eligible and contributing to Alfa Test Area H.D.
2208	Alfa Control House	1954	Individually eligible and contributing to Alfa Test Area H.D.
2208A	Alfa CC Engineering Trailer	1987	Not eligible and noncontributing to Alfa Test Area H.D.
2209	Alfa Terminal House	1954	Not individually eligible; contributes to Alfa Test Area H.D.
2209A	Alfa II Electrical Control Station (now storage)	1954	Not eligible and noncontributing to Alfa Test Area H.D.
2212	Alfa Pre-Test Building	1954	Not eligible and noncontributing to Alfa Test Area H.D.
2212B	Alfa Old Guard Shack	1997	Not eligible and noncontributing to Alfa Test Area H.D.
2212S	Alfa Pretest Extension	1991	Not eligible and noncontributing to Alfa Test Area H.D.
2727A	Alfa I Electrical Control Station	1954	Not individually eligible; contributes to Alfa Test Area H.D.
2729A	Alfa III Electrical Control Station	1954	Not individually eligible; contributes to Alfa Test Area H.D.
2739	Standtalker Shack	Mid-1960s	Not individually eligible; contributes to Alfa Test Area H.D.
2X	Alfa Pill Box	1955	Not individually eligible; contributes to Alfa Test Area H.D.
2Y	Alfa Pill Box	1955	Not individually eligible; contributes to Alfa Test Area H.D.
	Landscape/Spillway		Not individually eligible; contributes to Alfa Test Area H.D.
	Bravo Test Area		
2730	Bravo I Test Stand	1955	Individually eligible and contributing to Bravo Test Area H.D.
2731	Bravo II Test Stand	1955	Individually eligible and contributing to Bravo Test Area H.D.
2213	Bravo Control House	1955	Individually eligible and contributing to Bravo Test Area H.D.
2214	Bravo Terminal House	1955	Not individually eligible; contributes to Bravo Test Area H.D.
2730A	Bravo I Electrical Control Station	1955	Not individually eligible; contributes to Bravo Test Area H.D.
2731A	Bravo II Electrical Control Station	1955	Not individually eligible; contributes to Bravo Test Area H.D.
2732A (now 2732)	Bravo III Electrical Control Station (now "Bravo Storage")	1955	Not eligible and noncontributing to Bravo Test Area H.D.
2Z	Bravo Pill Box	1955	Not individually eligible; contributes to Bravo Test Area H.D.
	Landscape/Spillway		Not individually eligible; contributes to Bravo Test Area H.D.

FACILITY NO.	NAME	DATE	NRHP STATUS
	Coca Test Area		
2733	Coca I Test Stand	1962-3	Individually eligible and contributing to Coca Test Area H.D.
2787	Coca IV Test Stand	1962-3	Individually eligible and contributing to Coca Test Area H.D.
2218	Coca Control House (now Coca Control Center)	1955	Individually eligible and contributing to Coca Test Area H.D.
2219	Coca Terminal House	1955	Not eligible and noncontributing to Coca Test Area H.D.
2222	Pre-Test Building	1955	Not individually eligible; contributes to Coca Test Area H.D.
2235	Electrical Control Station (LOX)	1964	Not individually eligible; contributes to Coca Test Area H.D.
2236	Electrical Control Station (LH2)	1964	Not individually eligible; contributes to Coca Test Area H.D.
2237	GH2 Compressor Building – Control Center	1964	Not individually eligible; contributes to Coca Test Area H.D.
2239	GH2 Compressor Building (now Compressor Station – Main Building)	1966	Not individually eligible; contributes to Coca Test Area H.D.
2240	Hydraulic Supply Building	1972	Not eligible and noncontributing to Coca Test Area H.D.
2241	Pump House	1973	Not individually eligible; contributes to Coca Test Area H.D.
2451	Roof Shelter	1967	Not eligible and noncontributing to Coca Test Area H.D.
2520	High Pressure GH2 and GN2 Vault	1972	Not individually eligible; contributes to Coca Test Area H.D.
2614	Observation Bunker (now Coca IV Pillbox)	1962	Not individually eligible; contributes to Coca Test Area H.D.
2734	Coca II Test Stand	1955	Not eligible and noncontributing to Coca Test Area H.D.
2A	North Observation Bunker	1964	Not individually eligible; contributes to Coca Test Area H.D.
2B	Pill Box (now Observation Bunker)	1955	Not individually eligible; contributes to Coca Test Area H.D.
V100	LH2 Vessel #1	1964	Not individually eligible; contributes to Coca Test Area H.D.
V180	LOX Vessel #1	1963	Not individually eligible; contributes to Coca Test Area H.D.
V99	GH2 Vessel	1964	Not individually eligible; contributes to Coca Test Area H.D.
	Cable Tunnel	1963	Not individually eligible; contributes to Coca Test Area H.D.
	Landscape/Spillway	1964	Not individually eligible; contributes to Coca Test Area H.D.
	Delta Test Area		
2223	Delta Pre-Test Building	1956	Not eligible
2225	Delta Terminal House	1956	Not eligible

FACILITY NO.	NAME	DATE	NRHP STATUS
2601	Delta – Pillbox #3	1964	Not eligible
2H	Delta – Pillbox #1	Unk	Not eligible
2J	Delta – Pillbox #2	Unk	Not eligible
	Service Area/CTL II		
2201	Engineering Building	1956	Not eligible
2202	Maintenance Stock Building	1956	Not eligible
2203	Laser Labs Facility	1954	Not eligible
2204	Maintenance Building	1956	Not eligible
2205	Maintenance Paint Building	1956	Not eligible
2206	ELV Final Assembly Building (formerly CTL II)	1956	Not eligible
2207	Security Control Center	1956	Not eligible
2211	Engineering Offices (now storage)	1958	Not eligible
	Storable Propellant Area		
2761	SPA – Scale Shelter	1952	Not eligible
2769	SPA – Awning Shelter	1961	Not eligible
2770	SPA – Storage Propellant Office	Unk	Not eligible
2777	SPA – Oxidizer Storage Shelter	1960	Not eligible
2925	SPA – Fuel Mix Shed Awning	1961	Not eligible
2926	SPA – Equipment Storage	Unk	Not eligible
2927	SPA – Storage Shelter for Fuels	1959	Not eligible
2928	SPA – Oxidizer Storage	1960	Not eligible
	Skyline Drive		
2818	Water Tank	1956	Not eligible
2819	Water Tank	1956	Not eligible
2820	Water Tank	1956	Not eligible
2821	Water Tank	1956	Not eligible
2822	Water Tank	1956	Not eligible
2823	Water Tank	1956	Not eligible

FACILITY NO.	NAME	DATE	NRHP STATUS
2824	Water Tank	1956	Not eligible
2825	Water Tank	1957	Not eligible
2826	Water Tank	1957	Not eligible
2827	Water Tank	1957	Not eligible
2828	Water Tank	1957	Not eligible
2829	Water Tank	1957	Not eligible

4.2 Description of NRHP-Eligible Properties

4.2.1 Alfa Test Area Historic District

Photo 4.1. Alfa Area showing Test Stand No. I (Building 2727) in the foreground, Test Stand III (Building 2729), and the Alfa Pretest Shop (Building 2212) (Source: Boeing, Rockdtdyne Historic Photograph Collection, SSFL)

Designed in 1954 and constructed during 1954-1955, the Alfa engine test site (Photo 4.1) featured the first cluster of static test stands (Alfa I, II, and III) operational for AFP 57 at Santa Susana. The design and construction of the test site followed the design and construction of two similar test sites at the SSFL: the Bowl Area of 1948-1950 and the Canyon Area of 1953, both for NAA. Constructed along what became known as Alfa Road, the ATA was distinct from the other three test areas as a linear complex, rather than a cluster of facilities. The complex consisted of three test stands, Alfa I, Alfa II, and Alfa III (Photo 4.2), each with its own electrical control station to the northeast of its respective stand. Each stand also had a gunite run-off channel that emptied into a collection area, carved within the terrain. Between Alfa I and Alfa II sat the Terminal House, and across the road were two LOX storage tanks. To the east of these tanks were GN2 and GHe bottle banks. North of Alfa III sat the Pre-Test Building; to its northwest was a second GN2 bottle bank; to the southeast was another LOX tank. The Control House for the complex sat to the west of the test stands, and had a leaching pond to its southwest. Further along to the west was a JP-4 fuel storage facility; water tanks and wells were located to the northeast and southeast of Alfa III. As initially designed, there were no observation bunkers within the Alfa test area. In 1955-56, during the design of the Bravo site, DMJM provided plans for the addition of a pill box for the Alfa site, located to the southeast of Alfa III. Later, a second observation bunker was built to the southwest of Alfa I.

Photo 4.2. Alfa Area Test Stands, May 1959, camera facing northwest.
(Source: Boeing Company/Santa Susana Field Laboratory; Photo #131.)

The Alfa Test Area (ATA) Historic District (Figures 4.1 and 4.2) contains 10 contributing and four noncontributing resources. Most of the contributing resources date to 1954-1955, with operations beginning at the Alfa site in late 1955; one resource dates to the 1960s, as noted below. Contributing to the district are the Control House (Building 2208, a mostly underground facility), the Terminal House (Building 2209), the Alfa I Test Stand (Building 2727), the Alfa I Electrical Control Station (Building 2727A), the Alfa III Test Stand (Building 2729), the Alfa III Electrical Control Station (Building 2729A), the Standtalker Shack from the mid-1960s (Building 2739), two observation pill boxes (Buildings 2X and 2Y), and the surrounding rocky landscape, inclusive of the integrated man-made flame trenches and the spillway running the length of the ravine. Buildings 2208, 2727, and 2729 are also considered to be individually eligible for listing in the NRHP. The noncontributing resources are also predominantly from the period of original design and construction, and include the Alfa CC Engineering Trailer (Building 2208A), the Alfa II Electrical Control Station (Building 2209A, now used for storage), the Pre-Test Building (Building 2212) and its extension (Building 2212S). These resources are highly altered (Building 2212), without an intact primary structure (the Alfa II Electrical Control Station and the pre-test extension), or were constructed after the period of significance (Building 2212B). Tanks and pipelines for fuels and deluge water systems have been excluded from the district as either moveable equipment (typically updated or changed out) or underlying infrastructure.

Of the 10 contributing resources, two are structures, seven are buildings, and one is a site. The two contributing structures are the two remaining test stands, Alfa I and Alfa III., described in detail in Sections 4.2.2 and 4.2.3. The seven contributing buildings consist of the Alfa Control House (described in detail in Section 4.2.4), two pill boxes, a terminal facility, two electrical control stations, and a standtalker shack. The ATA retains two Pill Boxes, Buildings 2X and 2Y, also known as observation bunkers, both designed in 1955. Each bunker measures approximately 15 ft in length, 5 ft in width, and 8 ft in height, and

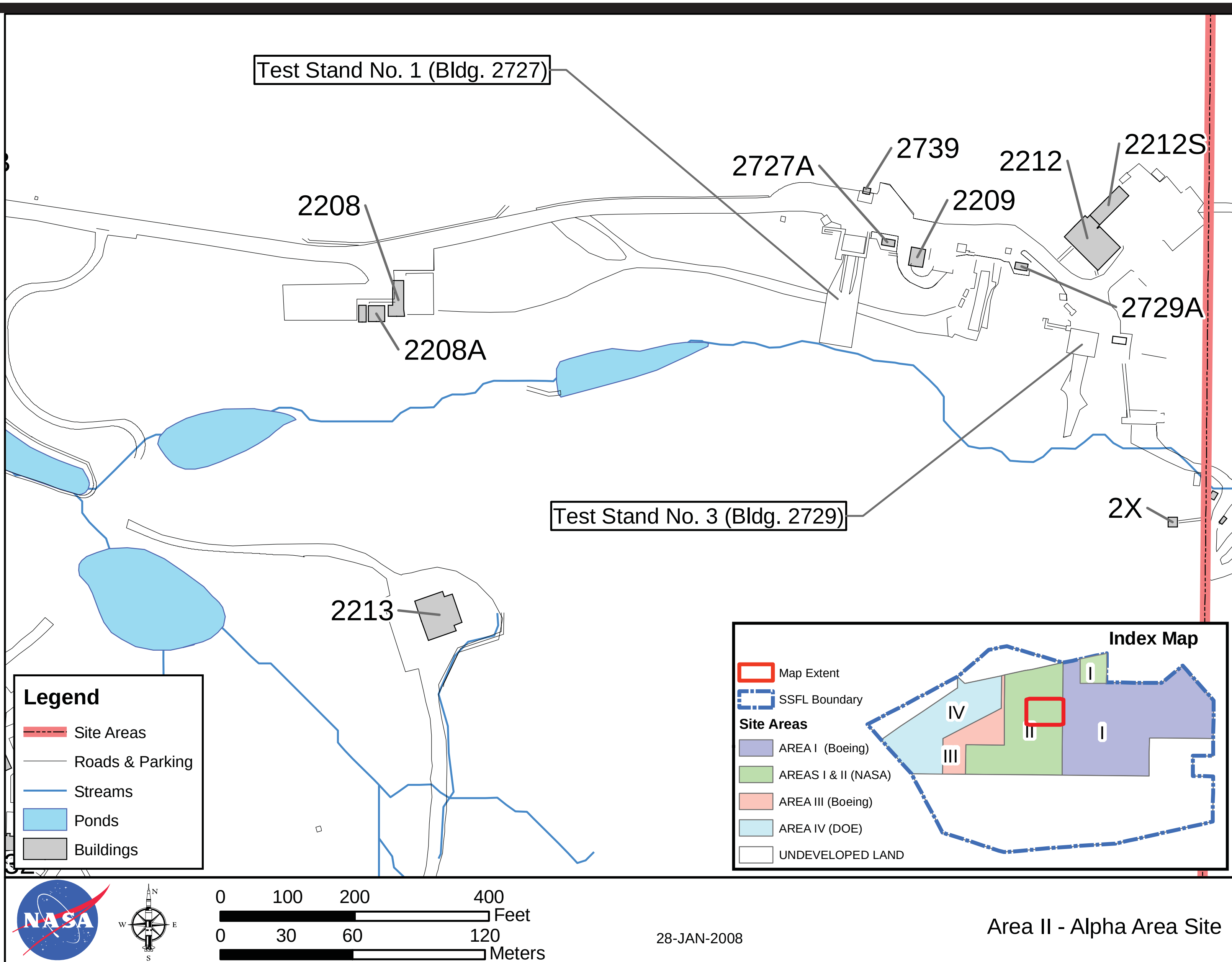

Figure 4.1. Plan of Alfa Test Area. The locations of the Alfa II ECS (2209A) and Alfa Pill Box (2Y) are not indicated (Courtesy of Ralph Allen, MSFC).

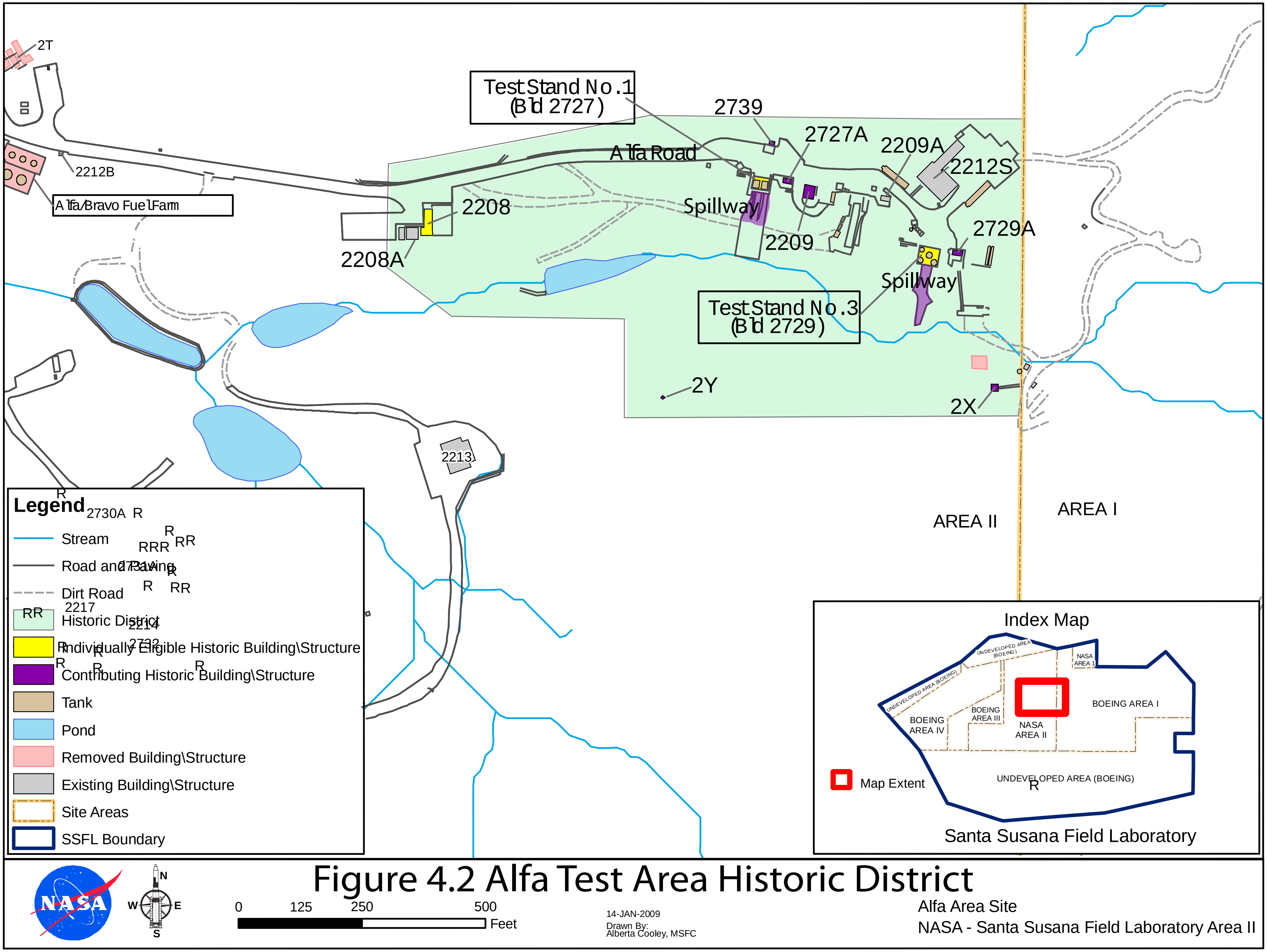

Figure 4.2 Alfa Test Area Historic District

Map Document: (O:\NASA\SSFL\maps\GSA_Alfa_HistoricDistrict.mxd) is composed entirely of reinforced concrete, and has a slight gable to the roof. The east and west elevations of each bunker are void of openings. The south elevation contains a set of concrete steps down to the metal swing door. There are two observation windows on the north elevation, facing the test stand. They are framed with metal and have a small metal awning that extends across both windows. Internally, each bunker is a single room meant for two individuals to occupy during testing procedures. One of these individuals is the supervising engineer of the test, who has control over the Firex (a fire suppression system) switch and a cut-off button, in case an emergency requires the test to be terminated. The other individual in the pillbox during testing is the Standtalker, who has a headset and is audibly connected to the engineers within the Control House.

Photo 4.3. Alfa Terminal House, camera facing northwest.
(Source: Archaeological Consultants, Inc., 2007.)

The Terminal House (2209; Photo 4.3), designed in 1954, is located to the east of Alfa I, roughly in line with its flame deflector. It is partially underground, and has approximate dimensions of 34 ft in length, 21 ft in width, and 11 ft in height, after a 7-ft southern extension in 1958. It is constructed entirely of reinforced concrete, including its flat roof. The door to the facility is on the south elevation, and there is a short retaining wall to its west. Along the east wall are concrete steps from the road level down to the entrance level. To the east of the building is a concrete pad which contains electrical equipment. Within the Terminal Building are various electrical and data panels, which connect each test stand to the control house. The two contributing Electrical Control Stations (ECS) within the ATA Historic District were both designed in 1954. One serves the Alfa I Test Stand (2727A), and the other serves the Alfa III Test Stand (2729A). Each is located to the northeast of their respective test stand, and measures approximately 18 ft in length, 9 ft in width, and 8 ft in height. The walls are corrugated metal supported by a steel skeleton. The floor is a poured concrete slab, and the roof is gabled and covered with corrugated metal. Each ECS has sliding doors on both the east and west elevations, and electrical panels on the south elevation. The Standtalker Shack (2739; Photo 4.4) was built on site in the mid-1960s (Manring 2008) and lies to the north of the Alfa I Test Stand. It is a wood frame building that measures roughly 6 ft in length and width, and 8 ft in height. The walls are faced in plywood, as is its flat roof. The wood swing door is on the east elevation, and there are windows on the north, west and south elevations. This is the Standtalker's position during test preparation; during testing, the standtalker is in the pill box, as noted above.

Photo 4.4. Alfa Standtalker Shack, camera facing northwest.
(Source: Archaeological Consultants, Inc., 2007.)

The contributing site to the Alfa Test Area Historic District is the natural and man-made landscape within the test complex boundaries. The natural terrain of cliffs, slopes, and rocky out-croppings provided an ideal setting for a test stand complex. The landscape created a natural buffer zone for rocket engine fuel and deluge water, as well as blast and sound protection. The varying elevations allowed the observation bunkers to be placed at safe distances from the test stands, while providing an excellent visual advantage. In addition, water tanks and wells which fed the ATA were placed at higher altitudes than the test stands, allowing gravity to aid the water flow. The natural terrain also dictated the design of the man-made elements within the test complex site. The main road through the ATA Historic District provides direct access to the First Deck of each test stand, as well as all contributing and noncontributing buildings and structures except for the terminal house and the two observation bunkers. A small branch off of the main road slopes down to the terminal house; the observation bunkers had wooden access stairs, which are no longer extant. Below this road level, roughly in line with the terminal house, are the stands' flame deflectors. Each test stand had a gunite channel, which directed run-off from the deflector to the earthen spillway; all three gunite channels remain. Each gunite channel is 4-ft-deep, and 18 ft in width at the deflector, narrowing to a width of 10 ft where it meets the terrain. The Alfa I channel measures 75 ft in length; the Alfa II channel is 67 ft in length; and the Alfa III channel measures 52 ft in length. Near, and roughly parallel to, the spillway is an unpaved access road.

All four of the noncontributing resources, which include the Alfa CC Engineering Trailer (2208A), the Alfa II Electrical Control Station (2209A), the Pre-Test Building (2212), and the Pretest Extension (2212A), are buildings. The Alfa CC Engineering Trailer was designed in 1987 and built to the west of the ACH. It is a prefabricated building constructed after the period of significance for the ATA Historic District and has no significant historical associations or functions. The Alfa II Electrical Control Station was designed in 1955 to support the Alfa II Test Stand. In 1957, the Alfa II Test Stand was deactivated and dismantled, rendering the ECS useless. Some time after that, the ECS was enlarged and became a storage shed. Therefore, it lacks integrity of design and no longer reflects its original function due to the absence of its associated test stand. The Pre-Test Building (Photo 4.5) was designed in 1954. In 1990, its original plywood siding was replaced with aluminum siding. The metal sliding door was replaced with a rolling door, and a second rolling door was added to its north; a swing door was added to the east elevation. Therefore, its integrity of design, materials, workmanship, and feeling has been compromised. The Pre-Test Extension was completed in 1991 to the northeast of the Pre-Test Building. It is a prefabricated building that has no significant historical associations or functions, and was built after the period of significance. The Alfa Old Guard Shack (2212B) was constructed ca. 1997 (Manring 2008). It is a simple, wood frame structure faced with plywood, with a gate to the east. Although the Alfa complex has historically contained a guard station at the entrance, the construction date of the present facility falls out of the period of significance.

Photo 4.5. Alfa Pre-Test Building, camera facing north.
(Source: Archaeological Consultants, Inc., 2007.)

Presently, there are three LOX vessels, one GHe bottle bank, and two GN2 bottle banks within the Alfa Test Area complex. Although fuel facilities have been present within the test area throughout its history, it is unclear if these tanks are original or replacement tanks. Therefore, they can not be evaluated as contributing or noncontributing.

The ATA Historic District is considered eligible for listing in the NRHP in the contexts of the Cold War (Military) and Space Exploration, under Criteria A and C. The period of significance is defined as 1954, the date of design, through 1991, which reflects the formal conclusion of the sustained conflict between the United States and the former Union of Soviet Socialist Republics (USSR). Because the district has achieved significance within the past 50 years, Criteria Consideration G applies. Under Criterion A, the ATA Historic District is considered eligible for its underlying associations with multiple static engine tests run between 1955 and 1991, including tests for developmental Atlas ICBM engines (1950s), Navaho cruise missile engines (1950s), Thor and Jupiter IRBM engines (1950s), Thor engines for space vehicle boosters (1960s and 1970s), Atlas engines for space vehicle boosters (late 1960s forward), and RS-27 (uprated Thor) engines for the Delta space vehicle (early 1970s forward). Under Criterion C, the ATA Historic District is considered eligible for the design and engineering of the test site, inclusive of the test stands and blockhouse, the associated ancillary buildings and structures (both contributing and noncontributing to the district), and that portion of the natural landscape integrated into the man-made complex. The complex was designed by the Los Angeles architectural-engineering firm of DMJM, who designed major early test and operational missile complexes and missile-components complexes, across the United States, between 1954 and 1957. Assisting with the design was German engineer Walter Riedel, a rocket engine expert who had worked with Dr. Werhner von Braun’s team in Nazi Germany and had been assigned to NAA in Los Angeles by 1947 under Project Paperclip. The design and engineering of the Alfa site is representative of a static rocket engine test site of the late 1940s and early 1950s, and reflects site planning and design tenets adapted from late World War II Germany.

The ATA Historic District maintains its integrity of location, design, setting, materials, workmanship, feeling, and association, with 67% of the extant resources contributing to the district.

4.2.2 Alfa I Test Stand (Building 2727)

Photo 4.6. Alfa I Test Stand, north elevation.
(Source: Archaeological Consultants, Inc., 2007.)

Designed in 1954, the Alfa I Test Stand (Alfa I) (Photo 4.6) has overall dimensions of approximately 40 ft in length, 40 ft in width, and 90 ft in height. The entire test stand is built of structural steel, supported by concrete pile foundations at the four corners. Alfa I is generally comprised of two distinct portions: the below grade flame deflector and the above grade work decks. The flame deflector (Photo 4.7) measures approximately 16 ft in width, 13 ft in depth, and 19 ft in height, overall, and has a separate foundation of steel trusses. Like the test stand, it is composed of steel, and has holes, which are connected to pipes to allow water to flow over the surface during testing to prevent the steel from melting. The deflector directs the water towards the south, where a 75 ft long gunite channel further directs the run-off to a collecting area carved within the terrain. This 4-ft-deep channel is 18 ft in width at the deflector, and narrows to a width of 10 ft where it meets the terrain. Behind the flame deflector, to the north, is a concrete retaining wall.

Photo 4.7. Alfa I Test Stand, flame deflector, camera facing northeast. (Source: Archaeological Consultants, Inc., 2007.)

Beginning at ground level is a series of platform decks that constitute the test stand portion. At ground level is the First Deck, commonly referred to as the “dance floor” (Photo 4.8). This deck measures about 40 ft by 40 ft, and has a 28-ft square opening in the center, directly over the flame deflector. This area is fitted with sliding metal grate panels that can be placed over the opening while the engine is being prepared for testing. Six-ft-wide stationary platforms wrap around the perimeter. The next platform, known also as the “engine deck”, sits approximately 8 ft above grade, and measures 28 ft by 28 ft., with a 14-ft by 14-ft opening in the center. Like the lower platform, sliding panels fit over the opening for the preparation operations, and stationary panels are located around the perimeter. As the name suggests, this level is where the engine is placed for testing procedures. The Second Deck sits at 19’-6” above grade, and measures 33 ft in length and 30 ft in width, and has a 14-ft by 14-ft opening, to allow for the connection pipes from the fuel tanks to the engine. This level also contains the various pneumatic panels and valves, which verify that the stand is functioning properly. Access stairs for these three levels are the east side of the stand.

Photo 4.8. Alfa I Test Stand, First Deck, or “dance floor”, camera facing southwest. (Source: Archaeological Consultants, Inc., 2007.)

The fourth platform, commonly referred to as the Fuel Vessel Service Deck, sits roughly 31 ft above grade, and measures approximately 25 ft by 25 ft. In the center of this deck sits a vertical LOX tank. The tank is supported by a light steel truss system that wraps around its circumference. There are two additional service platforms supported by the truss. One, the LOX Vessel Service Deck (LVSD), sits 44 ft above grade and measures roughly 20 ft by 20 ft, with an opening for the tank. The second platform, called the LOX Vessel Upper Service Deck, measures about 16.5 ft by 16.5 ft and sits 64 ft above grade. These three decks are accessed by caged ladders on the east side. All six platform levels have guard rails around their perimeters. In the early 1960s, a 5-ton crane was added to the north side of the test stand for engine positioning.

Minor additions to Alfa I were completed in 1990 for extended duration testing. The first of these was the relocated Vernier engine test stand from the Bravo area. It measures approximately 5 ft by 5 ft, and extends from the west side of the First Deck at the south end. A metal platform provides access from the pavement to the stand. A 9-ft extension was also built on the west side of the engine deck, and was given a canopy that sits just below the level of the Second Deck. A set of metal steps provides access to this extension. Supported by the LVSD was a new 5-ft by 5-ft flange service deck. Finally, a RP-1 tank was added to the Second Deck.

To the northeast of the stand is the gauge panel (Photo 4.9), and to the east is the Electrical Control Shack.

Photo 4.9. Alfa I Test Stand, Pneumatic Gauge Panel, camera facing south. (Source: Archaeological Consultants, Inc., 2007.)

Alfa I is considered individually eligible for listing in the NRHP in the contexts of the Cold War (Military) and Space Exploration, under Criteria A, B, and C. The period of significance is defined as 1954, the date of design, through 1991, which reflects the formal conclusion of the sustained conflict between the United States and the former USSR. Because the stand has achieved significance within the past 50 years, Criteria Consideration G applies. Under Criterion A, Alfa I is considered eligible for its underlying associations with multiple static engine tests (Photo 4.10) run between 1955 and 1991, including tests for developmental Atlas ICBM engines (1950s), Navaho cruise missile engines (1950s), Thor and Jupiter IRBM engines (1950s), Thor engines for space vehicle boosters (1960s and 1970s), Atlas engines for space vehicle boosters (late 1960s forward), and RS-27 (uprated Thor) engines for the Delta space vehicle (early 1970s forward). Under Criterion C, Alfa I is considered eligible for its design and engineering as a small test stand reflective of the relatively small parameters of thrust ("pounds of thrust") characterizing rocket engines of 1945-1955. The stand was designed by the Los Angeles architectural-engineering firm of DMJM, with assistance from German engineer Walter Riedel. The base foundations of Alfa I are tied into the existing natural rock, and integrated with the landscape to a much greater extent than typically found after the early 1950s. This is interpreted as reflective of the design and engineering of similar test stands of 1945 in Nazi Germany; as a precaution against explosions on the test stands; and as over-engineering to accommodate the uprated rocket engines of the future.

Photo 4.10. Alfa I Engine Hot Fire Test, date unknown, camera facing northeast. (Source: Boeing Company/Santa Susana Field Laboratory; Photo #133.)

Although Alfa I has undergone minor alterations over its lifetime, these changes have reflected new technologies and the requirements for testing different engines. Therefore, Alfa I maintains its integrity of location, design, setting, materials, workmanship, feeling, and association.

4.2.3 Alfa III Test Stand (Building 2729)

Photo 4.11. Alfa III Test Stand, east elevation.
(Source: Archaeological Consultants, Inc., 2007.)

Designed in 1954, the Alfa III Test Stand (Alfa III) (Photo 4.11) is structurally similar to Alfa I with overall dimensions of approximately 40 ft in length, 40 ft in width, and 90 ft in height. The entire test stand is built of structural steel, supported by concrete pile foundations at the four corners. Alfa III is generally comprised of two distinct portions: the below grade flame deflector and the above grade work decks. The flame deflector measures approximately 18 ft in width, 16 ft in depth, and 19 ft in height, overall, and has a separate foundation of steel trusses. Like the test stand, it is composed of steel, and has holes, which are connected to pipes to allow water to flow over the surface during testing to prevent the steel from melting. The deflector directs the water towards the south, where a 52-ft-long gunite channel (Photo 4.12) further directs the run-off to a collecting area carved within the terrain. This 4-ft-deep channel is 18 ft in width at the deflector, and narrows to a width of 10 ft where it meets the terrain. Behind the flame deflector, to the north, is a concrete retaining wall.

Photo 4.12. Alfa III Test Stand, gunite channel, camera facing south.
(Source: Archaeological Consultants, Inc., 2007.)

Beginning at ground level is a series of platform decks that constitute the test stand portion. At ground level is the First Deck, commonly referred to as the “dance floor” (Photo 4.13). This deck measures about 40 ft by 40 ft, and has a 28-ft square opening in the center, directly over the flame deflector. This area is fitted with sliding metal grate panels that can be placed over the opening while the engine is being prepared for testing. Six-ft-wide stationary platforms wrap around the perimeter. The next platform, known also as the “engine deck,” sits approximately 8 ft above grade, and measures 28 ft by 28 ft, with a 14-ft by 14-ft opening in the center. Like the lower platform, sliding panels fit over the opening for the preparation operations, and stationary panels are located around the perimeter. As the name suggests, this level is where the engine is placed for testing procedures. The Second Deck sits at 19.5 ft above grade, and measures 33 ft in length and 30 ft in width, and has a 14-ft by 14-ft opening, to allow for the connection pipes from the fuel tanks to the engine. This level also contains the various pneumatic panels and valves, which verify that the stand is functioning properly. Access stairs for these three levels are the east side of the stand.

Photo 4.13. Alfa III Test Stand, First Deck, or "dance floor," camera facing west. (Source: Archaeological Consultants, Inc., 2007.)

The fourth platform, commonly referred to as the Fuel Vessel Service Deck, sits roughly 31 ft above grade, and measures approximately 25 ft by 25 ft. In the center of this deck sits a vertical LOX tank. The tank is supported by a light steel truss system that wraps around its circumference. There are two additional service platforms supported by the truss. One, the LVSD, sits 44 ft above grade and measures roughly 20 ft by 20 ft, with an opening for the tank. The second platform, called the LOX Vessel Upper Service Deck, measures about 16.5 ft by 16.5 ft and sits 64 ft above grade. These three decks are accessed by caged ladders on the east side. All six platform levels have guard rails around their perimeters. In the early 1960s, a 5-ton crane was added to the north side of the test stand for engine positioning.

In 1993, a 10-ft wide by 30-ft long platform was constructed to the west of the "engine deck" to accommodate the trichloroethylene system. To the northeast of the stand is the gauge panel, and to the east is the Electrical Control Shack (Photo 4.14).

Photo 4.14. Alfa III ECS, interior, camera facing east.
(Source: Archaeological Consultants, Inc., 2007.)

Alfa III is considered individually eligible for listing in the NRHP in the contexts of the Cold War (Military) and Space Exploration, under Criteria A and C. The period of significance is defined as 1954, the date of design, through 1991, which reflects the formal conclusion of the sustained conflict between the United States and the former USSR. Because the stand has achieved significance within the past 50 years, Criteria Consideration G applies. Under Criterion A, Alfa III is considered eligible for its underlying associations with multiple static engine tests (Photo 4.15) run between 1955 and 1991, including tests for developmental Atlas ICBM engines (1950s), Navaho cruise missile engines (1950s), Thor and Jupiter IRBM engines (1950s), Thor engines for space vehicle boosters (1960s and 1970s), Atlas engines for space vehicle boosters (late 1960s forward), and RS-27 (uprated Thor) engines for the Delta space vehicle (early 1970s forward). Under Criterion C, Alfa III is considered eligible for its design and engineering as a small test stand reflective of the relatively small parameters of thrust ("pounds of thrust") characterizing rocket engines of 1945-1955. The test stand was designed by the Los Angeles architectural-engineering firm of DMJM, with assistance by German engineer Walter Riedel. The base foundations of Alfa III are tied into the existing natural rock, and integrated with the landscape to a much greater extent than typically found after the early 1950s. This is interpreted as reflective of the design and engineering of similar test stands of 1945 in Nazi Germany; as a precaution against explosions on the test stands; and as over-engineering to accommodate the uprated rocket engines of the future.

Photo 4.15. Alfa Test Stands II and III
(Source: MSFC Historic Preservation Archives)

Although Alfa III has undergone minor alterations over its lifetime, these changes have reflected new technologies and the requirements for testing different engines. Therefore, Alfa III maintains its integrity of location, design, setting, materials, workmanship, feeling, and association.

4.2.4 Alfa Control House (Building 2208)

Photo 4.16. Alfa Control House, east elevation, which faces test stands. (Source: Archaeological Consultants, Inc., 2007.)

Designed in 1954, the Alfa Control House (ACH) (Photo 4.16), or blockhouse, measures approximately 62 ft in length, 60 ft in width, and 24 ft in height, overall. It contains two distinct sections: the underground control center and the above ground support areas. The control center has rough dimensions of 60 ft in length and 42 ft in width, excluding the window wells (Photos 4.17 and 4.18). It is constructed of 12-inch-thick reinforced concrete walls, and has a reinforced concrete floor and foundation. Two sets of L-shaped concrete steps provide access to the control area, one at the northwest corner and one at the southwest corner. There is also an escape hatch in the roof at the southwest corner, used in emergency situations. Access to the hatch is provided by a series of metal rungs built into the wall surface. The floor of the control area is composed of 2-ft by 2-ft floor tiles, raised off of the concrete slab, allowing the cables to be run underneath. The east wall contains seven observation ports; three of which are grouped at the center with a pair to either side. The windows sit below grade, and each has a viewing shaft with mirrors to direct the images of the test stand through the windows. Above grade, there is a corrugated metal shade, which provides a mounting point for the upper mirror, as well as protection from the elements.

Photo 4.17. ACH, interior, conference and data areas to left, camera facing east. (Source: Archaeological Consultants, Inc., 2007.)

Photo 4.18. ACH, interior, console detail, camera facing west. (Source: Archaeological Consultants, Inc., 2007.)

Above ground, to the west of the control area is a 45-ft by 13-ft support area (Photo 4.19). The east wall is a continuation of the 12-inch-thick reinforced concrete, up to a height of 8 ft. The remaining 4 ft, as well as the north, west, and south walls, are of wood frame construction. At the north end is the 12-ft by 8-ft restroom; in the middle is the 17-ft by 12-ft electrical equipment room; and to the south is the 20-ft by 12-ft mechanical equipment room. Each of the three rooms has its own doorway on the west elevation, and there is a metal ladder for roof access on the east elevation. The north elevation has one four-light fixed window, and the south elevation has a louvered vent. In the 1980's, a canopy cover was built over the southwest stairwell into the control area.

Photo 4.19. ACH, support area, camera facing southeast.
(Source: Archaeological Consultants, Inc., 2007.)

In 1987, the interior of the control area was renovated to its present condition. During this work, no structural changes were made, nor was the raised floor altered. The exposed ceiling was covered with 2-ft by 4-ft acoustical ceiling tile, and the surface mounted light fixtures were replaced with recessed light fixtures. Two partitioned rooms were placed along the north wall, a Data Process Room to the west and a Conference Room to the east, both measuring 15 ft by 9 ft (Photo 4.17). Centered along the west wall, a partitioned 28-ft by 20-ft workshop was constructed, and all control consoles were moved into the eastern portion of the control area.

The ACH is considered individually eligible for listing in the NRHP in the contexts of the Cold War (Military) and Space Exploration, under Criteria A and C. The period of significance is defined as 1954, the date of design, through 1991, which reflects the formal conclusion of the sustained conflict between the United States and the former USSR. Because the control house has achieved significance within the past 50 years, Criteria Consideration G applies. Under Criterion A, the ACH is considered eligible for its underlying associations with multiple static engine tests run between 1955 and 1991, including tests for developmental Atlas ICBM engines (1950s), Navaho cruise missile engines (1950s), Thor and Jupiter IRBM engines (1950s), Thor engines for space vehicle boosters (1960s and 1970s), Atlas engines for space vehicle boosters (late 1960s forward), and RS-27 (uprated Thor) engines for the Delta space vehicle (early 1970s forward). Under Criterion C, the ACH is considered eligible for its design and engineering as a predominantly underground facility, integrated into existing natural rock. The control house was designed by the Los Angeles architectural-engineering firm of DMJM, with the assistance of German engineer Walter Riedel. The blockhouse faces up the ravine toward the flame buckets of the three test stands and is unusual in its offset positioning. An aboveground line of protected angled mirrors projects downwards into viewing portals that extend below ground. This linear component of the blockhouse is its primary exterior character-defining feature, and is both rare and possibly unique among identified blockhouses of the late 1940s and early 1950s, the majority of which were aboveground facilities.

Although the ACH has undergone minor alterations over its lifetime, these changes have reflected new technologies and the requirements for testing different engines. Therefore, the ACH maintains its integrity of location, design, setting, materials, workmanship, feeling, and association.

4.2.5 Bravo Test Area Historic District

Photo 4.20. Bravo Test Area, camera facing west.
(Source: Archaeological Consultants, Inc., 2007.)

Designed in early 1955 and constructed during 1955-1956, the Bravo engine test site (Photos 4.20 - 4.22) featured the second cluster of static test stands (Bravo I, II, and III) operational for AFP 57 at Santa Susana. The design and construction of the test site followed the design and construction of three similar test sites at the SSFL: the Bowl Area of 1948-1950 and the Canyon Area of 1953, for NAA; and the Alfa site of 1954-1955, the first of four test sites for the Air Force. Constructed along what became known as Bravo Road, the Bravo Test Area consisted of three test stands, Bravo I, Bravo II, and Bravo III, each with its own electrical control station to the northwest of its respective stand. Each stand also had a gunite run-off channel that emptied into a collection area, carved within the terrain. Unlike the other three complexes, at the outset of construction, Bravo I was designed differently from Bravo II and Bravo III, both of which resembled the stands in the other areas. Between Bravo II and Bravo III sat the Terminal House; to the southwest, across the road, were two LOX storage tanks. Between Bravo I and Bravo II sat a GN2 bottle bank. To the west of Bravo II sat the Pre-Test Building; to its south was a GHe bottle bank. The Control House for the complex sat to the east of the test stands, and there was a run-off gathering pond in between. A pill box was placed to the southwest of the test stands. In the 1960s, a third LOX tank was added near the original two, and at an unknown date, a fourth LOX tank joined the other three. Also in the 1960s, two kerosene tanks were placed to the east of Bravo II, where the flame deflector had been. In the 1990s, an office trailer was built to the west of the Pre-Test Building.

Photo 4.21. Bravo Test Stand construction, June 1956, camera facing northwest. (Source: Boeing Company/Santa Susana Field Laboratory; Photo #694.)

Photo 4.22. Bravo Test Stands, January 1964, camera facing northwest. (Source: Boeing Company/Santa Susana Field Laboratory; Photo #10.)

The Bravo Test Area (BTA) Historic District (Figures 4.3 and 4.4) contains eight contributing resources and one noncontributing resource. Each of the contributing resources dates to 1955-1956, with operations beginning at the Bravo site in 1956. Contributing to the district are the Control House (Building 213), the Terminal House (Building 2214), the Bravo I Test Stand (Building 730), the Bravo I Electrical Control Station (Building 2730A), the Bravo II Test Stand (Building 2731), the Bravo II Electrical Control Station (Building 2731A), an observation pill box (Building 2Z), and the surrounding rocky landscape, inclusive of the integrated man-made flame trenches

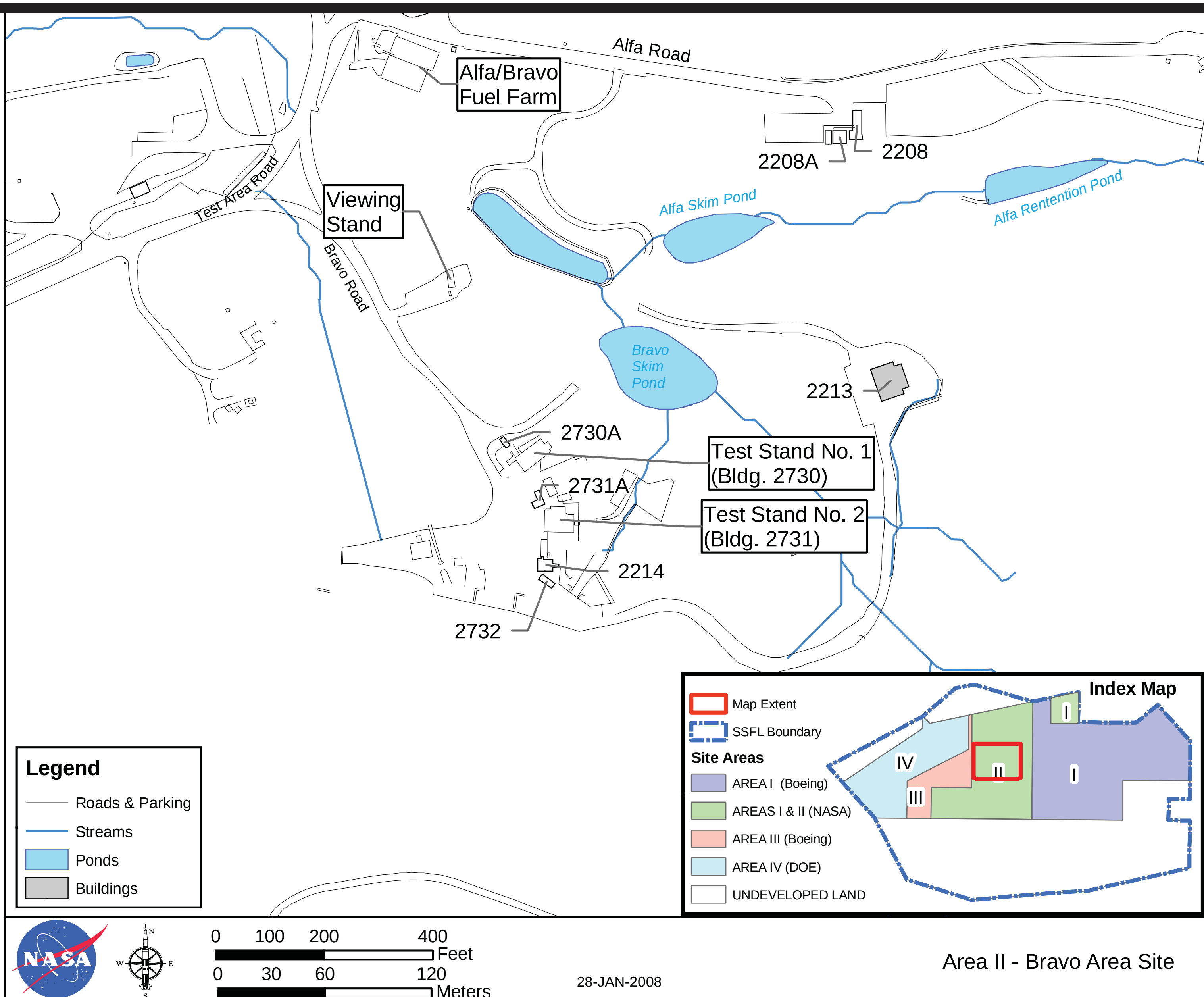

Figure 4.3. Plan of Bravo Test Area. The location of the Bravo Pill Box (2Z) is not indicated (Courtesy of Ralph Allen, MSFC).

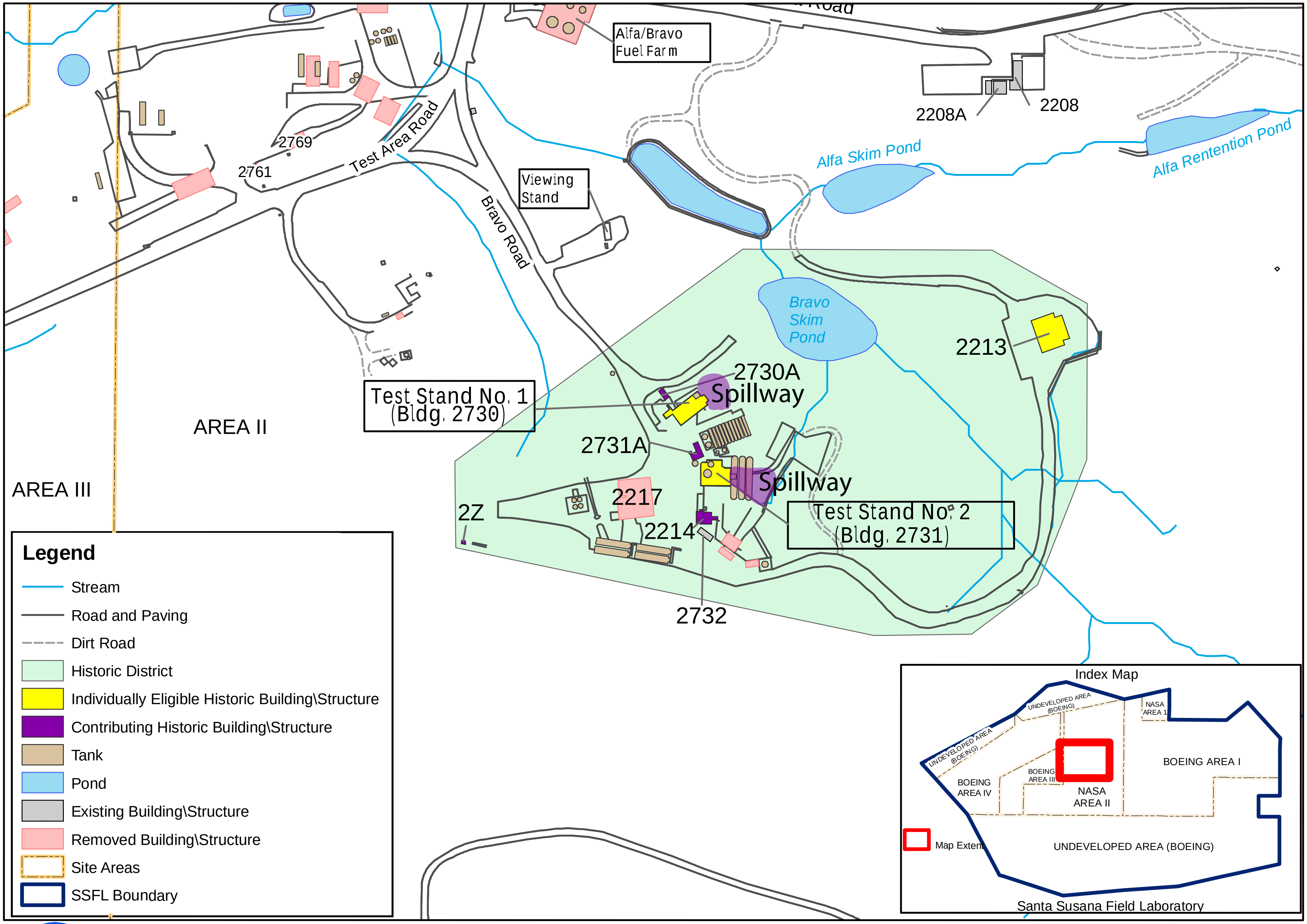

Figure 4.4 Bravo Test Area Historic District

0 100 200 400 Feet

14-JAN-2009
Drawn By:
Alberta Cooley, MSFC

Bravo Area Site
NASA - Santa Susana Field Laboratory Area II

Map Document:(O:\NASA_GIS_Data\SSFL\maps\GSA_Bravo_HistoricDistrict.mxd) and the spillway. Buildings 2213, 2730, and 2731 are also considered to be individually eligible for listing in the NRHP. The noncontributing resource, also from the period of original design and construction, is the Bravo III Electrical Control Station (now referred to as Building 2732, Bravo Storage), which has been altered from its original design and lacks the test stand to which it was associated. Tanks and pipelines for fuels and deluge water systems have been excluded from the district as either moveable equipment (typically updated or changed out) or underlying infrastructure.

Of the eight contributing resources, two are structures, five are buildings, and one is a site. Both of the contributing structures are the remaining test stands, Bravo I and Bravo II, described in detail in Sections 4.2.6 and 4.2.7, respectively. The five contributing buildings are the Bravo Control House (described in detail in Section 4.2.8), one pill box, a terminal facility, and two electrical control stations.

Photo 4.23. Bravo Pill Box, camera facing south.
(Source: Archaeological Consultants, Inc., 2007.)

Designed in 1955, the Bravo Pill Box, Building 2Z, measures approximately 15 ft in length, 5 ft in width, and 8 ft in height (Photo 4.23). It is composed entirely of reinforced concrete, and has a slight gable to the roof. The east and west elevations of the bunker are void of openings. The south elevation contains a set of concrete steps down to the metal swing door. There are two observation windows on the north elevation, facing the test stand. They are framed with metal and have a small metal awning that extends across both windows. Internally, the bunker is a single room meant for two individuals to occupy during testing procedures. One of these individuals is the supervising engineer of the test, who has control over the Firex (a fire suppression system) switch and a cut-off button, in case an emergency requires the test to be terminated. The other individual in the pillbox during testing is the Standtalker, who has a headset and is audibly connected to the engineers within the Control Center.

Photo 4.24. Bravo Terminal House, interior, camera facing east.
(Source: Archaeological Consultants, Inc., 2007.)

The Terminal House was designed in 1955 (Photo 4.24). It lies to the south of Bravo II, roughly in line with its flame deflector. It is partially underground, and has approximate dimensions of 34 ft in length, 21 ft in width, and 11 ft in height, after a 7-ft southern extension in 1958. It is constructed entirely of reinforced concrete, including its flat roof. The door to the facility is on the west end of the north elevation, and there is concrete ramp that leads from the road level to the entrance level. To the east of the building is a concrete pad which contains electrical equipment. Within the Terminal House are various electrical and data panels, which connect each test stand to the recording center.

There are two contributing Electrical Control Stations (ECS) within the BTA Historic District, both of which were designed in 1955. One serves the Bravo I Test Stand, and the other, the Bravo II Test Stand (Photo 4.25). Each is located to the northwest of their respective test stand, and measures approximately 18 ft in length, 9 ft in width, and 8 ft in height. The walls are corrugated metal supported by a steel skeleton. The floor is a poured concrete slab, and the roof is gabled and covered with corrugated metal. The Bravo I ECS has a door on the south elevation; the Bravo II ECS has a door on both the north and west elevations. The long walls contain the electrical panels.

Photo 4.25. Bravo II ECS, camera facing northeast.
(Source: Archaeological Consultants, Inc., 2007.)

The contributing site to the Bravo Test Area Historic District is the natural and man-made landscape within the test complex boundaries. The natural terrain of cliffs, slopes, and rocky out-croppings provided an ideal setting for a test stand complex. The landscape created a natural buffer zone for rocket engine fuel and deluge water, as well as blast and sound protection. The varying elevations allowed the observation bunkers to be placed at safe distances from the test stands, while providing an excellent visual advantage. In addition, water tanks and wells which fed the BTA were placed at higher altitudes than the test stands, allowing gravity to aid the water flow. The natural terrain also dictated the design of the man-made elements within the test complex site.

The main road through the BTA Historic District provides direct access to the First Deck of each test stand, as well as all contributing and noncontributing buildings and structures except for the terminal house and the observation bunker. A small branch off of the main road slopes down to the terminal house; the observation bunkers had wooden access stairs, which are no longer extant. Below this road level, roughly in line with the terminal house, are the stands' flame deflectors. Each test stand had a gunite channel, which directed run-off from the deflector to the earthen spillway; all three gunite channels remain. Each channel measures 50 ft in length, and 18 ft in width at the deflector, narrowing to a width of 10 ft where it meets the terrain. The channels are 4 ft in depth, and have banked sides. The main road curves around the spillway area, and ends at the recording center.

The noncontributing resource within the district is a building, the original Bravo III ECS, now the Bravo Storage facility. The Bravo III ECS was designed in 1955 to support the Bravo III Test Stand. By the 1970s, the Bravo III Test Stand was deactivated and dismantled, rendering the ECS useless. Some time after that, the ECS became a storage shed. Therefore, it lacks integrity of design and no longer reflects its original function due to the absence of its associated test stand.

Presently, there are four LOX vessels, and two kerosene tanks within the Bravo Test Area complex. Although fuel facilities have been present within the test area throughout its history, it is unclear if these tanks are original or replacement tanks. Therefore, they can not be evaluated as contributing or noncontributing.

The BTA Historic District is considered eligible for listing in the NRHP in the contexts of the Cold War (Military) and Space Exploration, under Criteria A and C. The period of significance is defined as 1955, the date of design, through 1991, which reflects the formal conclusion of the sustained conflict between the United States and the former USSR. Because the district has achieved significance within the past 50 years, Criteria Consideration G applies. Under Criterion A, the BTA Historic District is considered eligible for its underlying associations with multiple static engine tests run between 1956 and 1991, including tests for Atlas ICBM thrust chambers (1950s and early 1960s), E-1 developmental thrust chambers (1950s), the RS-2 rocket sled pre-shipment to Holloman Air Force Base (1950s), F-1 thrust chambers, gas generators, heat exchangers, turbopumps, and components (after 1965), Lunar Module Rocket Engine assemblies (late 1960s), Atlas and Delta RS-27 vernier engines (1960s forward), Atlas sustainer turbopumps and booster engines (1970s forward), and Delta RS-27 turbopumps (1970s forward). Under Criterion C, the BTA Historic District is considered eligible for the design and engineering of the test site, inclusive of the test stands and blockhouse, the associated ancillary buildings and structures (both contributing and noncontributing to the district), and that portion of the natural landscape integrated into the man-made complex. The test complex was designed by the Los Angeles architectural-engineering firm of DMJM, with the aid of German engineer Walter Riedel, a rocket engine expert who had worked with Dr. von Braun’s team in Nazi Germany and had been assigned to NAA in Los Angeles by 1947 under Project Paperclip. The design and engineering of the Bravo site is representative of a static rocket engine test site of the late 1940s and early 1950s, and reflects site planning and design tenets adapted from late World War II Germany.

The BTA Historic District maintains its integrity of location, design, setting, materials, workmanship, feeling, and association, with 89% of the extant resources contributing to the district.

4.2.6 Bravo I Test Stand (Building 2730)

Photo 4.26. Bravo I Test Stand, west and south elevations.
(Source: Archaeological Consultants, Inc., 2007.)

Designed in 1955, the Bravo I Test Stand (Bravo I) (Photo 4.26) has overall dimensions of approximately 36 ft in length, 36 ft in width, and 46 ft in height, excluding the upper truss work. The entire test stand is formed of structural steel, supported by concrete pile foundations at the four corners. The First Deck, considered to be ground level, measures 36 ft by 36 ft, and has a 24-ft by 24-ft opening in the center (Photo 4.27). The opening is covered with removable metal grating, while around the circumference are stationary platforms. Approximately 9.5 ft above the First Deck is the Second Deck. This level is slightly smaller, measuring roughly 30 ft by 30 ft, with a 14-ft by 14-ft opening in the center. Like the lower deck, permanent platforms surround the opening, which has removable platforms. Historically, the fuel tanks have sat on this level. Around both decks is a metal railing. Above the second deck is a light metal truss system, which supports the cranes and light fixtures. The north and south elevations take the form of upside-down trapezoids, while the east and west elevations are rectangular. On the north and south of the test stands are metal steps for access to the First and Second Deck. Additionally, there are steps to reach the intermediate platform level, which sits about 6-ft off of the First Deck and projects over the east. This level is used for test firing in the horizontal position.

Photo 4.27. Bravo I Test Stand, First Deck or “dance floor,” camera facing east. (Source: Archaeological Consultants, Inc., 2007.)

Below the First Deck is the flame deflector (Photo 4.28). The flame deflector measures approximately 16 ft in width, 30 ft in depth, and 23 ft in height, overall, and has a separate foundation from the test stand. Across the extent of the deflector are numerous holes for water to run over the surface during testing, which helps prevent the steel from melting due to the heat produced by the engines. At the base of the deflector is a 50-ft-long gunite run-off channel. The channel measures 18 ft in width at the deflector, and narrows to a width of 10 ft where it meets the terrain. It is 4 ft in depth, and has banked sides.

Photo 4.28. Bravo I Test Stand, flame deflector, camera facing east. (Source: Archaeological Consultants, Inc., 2007.)

To the northwest of the stand is a two-level instrumentation panel (Photo 4.29). The upper level contains the valves for the systems, while the lower level has the gauges which monitor the systems. To the north of this panel is the Electrical Control Shack.

Photo 4.29. Bravo I Test Stand, instrumentation panel, camera facing north. (Source: Archaeological Consultants, Inc., 2007.)

Bravo I is considered individually eligible for listing in the NRHP in the contexts of the Cold War (Military) and Space Exploration, under Criteria A and C. The period of significance is defined as 1955, the date of design, through 1991, which reflects the formal conclusion of the sustained conflict between the United States and the former USSR. Because the stand has achieved significance within the past 50 years, Criteria Consideration G applies. Under Criterion A, Bravo I is considered eligible for its underlying associations with multiple static engine tests (Photo 4.30) run between 1956 and 1991, including tests for Atlas ICBM thrust chambers (1950s and early 1960s), E-1 developmental thrust chambers (1950s), the RS-2 rocket sled pre-shipment to Holloman Air Force Base (1950s), F-1 thrust chambers, gas generators, heat exchangers, turbopumps, and components (after 1965), Lunar Module Rocket Engine assemblies (late 1960s), Atlas and Delta RS-27 vernier engines (1960s forward), Atlas sustainer turbopumps and booster engines (1970s forward), and Delta RS-27 turbopumps (1970s forward). Under Criterion C, Bravo I is considered eligible for its design and engineering as a small test stand reflective of the relatively small parameters of thrust ("pounds of thrust") characterizing rocket engines of 1945-1955. The test stand was designed by the Los Angeles architectural-engineering firm of DMJM, with the assistance of German engineer Walter Riedel. The base foundations of Bravo I are tied into the existing natural rock, and integrated with the landscape to a much greater extent than typically found after the early 1950s. This is interpreted as reflective of the design and engineering of similar test stands of 1945 in Nazi Germany; as a precaution against explosions on the test stands; and as over-engineering to accommodate the uprated rocket engines of the future.

Photo 4.30. Bravo I Test Stand, engine test, June 1961, camera facing southwest. (Source: Boeing Company/Santa Susana Field Laboratory; Photo #691.)

Although Bravo I has undergone minor alterations over its lifetime, these changes have reflected new technologies and the requirements for testing different engines. Therefore, Bravo I maintains its integrity of location, design, setting, materials, workmanship, feeling, and association.

4.2.7 Bravo II Test Stand (Building 2731)

Photo 4.31. Bravo II Test Stand, west elevation.
(Source: Archaeological Consultants, Inc., 2007.)

The original Bravo II Test Stand (Photo 4.31), designed in 1955, had approximate overall dimensions of 40 feet (ft) in length, 40 ft in width, and 45 ft in height, excluding the fuel tanks. It was built of structural steel, with reinforced concrete footings, and had a flame deflector that opened to the east. A 50-ft-long gunite channel directed the run-off to a small reservoir. The upper half of Bravo II contained two metal decks, the First Deck and the Second Deck, which measured roughly 40 ft in length and width and 30 ft in length and width, respectively. Each deck had an opening in the center for engine exhaust and/or fuel tank connections. Between these two decks was a mezzanine deck, which provided access to the engine's main components. Access stairs to the decks were on the north side of the stand. Above the Second Deck sat two vertical fuel tanks, one on top of the other. Around the lower fuel tank was a truss structure, which supported a work platform. A second work platform sat at the top of the upper fuel tank, and had support posts that projected from the tank.

Bravo II was remodeled from 1959 to 1960 based on designs by Rocketdyne. Much of the original stand was dismantled, including the flame deflector and its support mechanisms, the First Deck dolly and rails, and the fuel vessels, as well as the stairs, handrails, and ladders. The remainder of the original stand was incorporated into the new, larger stand, which presently remains.

Bravo II currently measures approximately 57.5 ft in length, 56 ft in width, and 128 ft in height overall, inclusive of all components except for the crane. The base of the stand is composed of a steel truss support system to support the now completely stationary First Deck. The First Deck sits at ground level and measures roughly 57.5 ft by 56 ft. It contains three separated test positions for various small engines and components (Photo 4.32). At the south end are stairs that lead to the base of the test stand. About 7.5 ft above this level is the Mezzanine, which measures approximately 57.5 ft by 42.5 ft. Projecting from the west end of this deck is a 5-ton bridge crane. Placed across this level are the pressure transistor boxes and the electrical and mechanical valves. The Second Deck sits roughly 19.5 ft above grade and measures about 57.5 ft by 50 ft. This level holds four vertically set fuel tanks, in the middle of which is a support post for a crane. At the top of each fuel tank is an access platform, supported by steel brackets attached to the tank. The Mezzanine and Second Decks are set back from the eastern end of the First Deck by approximately 9 ft, and are accessed by metal stairs on the north elevation.

Photo 4.32. Bravo II Test Stand, igniter cell, camera facing east.
(Source: Archaeological Consultants, Inc., 2007.)

The most distinct features of the Bravo II Test Stand are the three 24-inch-diameter Turbine Exhaust Pipes on the south elevation (Photo 4.33). These pipes were part of the 1960 upgrades, and included one vent pipe, A, B, and C, for each test position. Test position A sits 24 ft north of the center point of the test stand; position B is 10 ft north and 27 ft east of the center; and position C is 10 ft south and 27 ft east of the center. The exhaust pipes stand roughly 6 ft high at each test position, through the First Deck and run along underneath to the south side. At the south elevation, they rise for 76 ft, where there is an access platform. From there, they angle 15 degrees to the east, and pipe A extends for an additional 43 ft, pipe B for 39 ft, and pipe C for 35 ft, which allows for the exhaust flames to be directed up and away from the test stand and fuel vessels. By the late 1980s, a fourth vent pipe was added to the test stand, located behind the original three.

Photo 4.33. Bravo II Test Stand, west elevation.
(Source: Archaeological Consultants, Inc., 2007.)

Additional features of the Bravo II Test Stand include the Electrical Control Shack to the northwest, a LOX and a RP-1 vessel to the north (Photo 4.34), and two kerosene tanks to the east, where the gunite channel once sat.

Photo 4.34. Bravo II Test Stand, Run tanks at north, RP-1 to left and LOX to right, camera facing southeast.
(Source: Archaeological Consultants, Inc., 2007.)

Bravo II is considered individually eligible for listing in the NRHP in the contexts of the Cold War (Military) and Space Exploration, under Criteria A and C. The period of significance is defined as 1955, the date of design, through 1991, which reflects the formal conclusion of the sustained conflict between the United States and the former USSR. Because the stand has achieved significance within the past 50 years, Criteria Consideration G applies. Under Criterion A, Bravo II is considered eligible for its underlying associations with multiple static engine tests (Photo 4.35) run between 1956 and 1991, including tests for Atlas ICBM thrust chambers (1950s and early 1960s), E-1 developmental thrust chambers (1950s), the RS-2 rocket sled pre-shipment to Holloman Air Force Base (1950s), F-1 thrust chambers, gas generators, heat exchangers, turbopumps, and components (after 1965), Lunar Module Rocket Engine assemblies (late 1960s), Atlas and Delta RS-27 vernier engines (1960s forward), Atlas sustainer turbopumps and booster engines (1970s forward), and Delta RS-27 turbopumps (1970s forward). Under Criterion C, Bravo II is considered eligible for its design and engineering as a small test stand reflective of the relatively small parameters of thrust ("pounds of thrust") characterizing rocket engines of 1945-1955. The Los Angeles architectural-engineering firm of DMJM designed this test stand, with the aid of German engineer Walter Riedel. The base foundations of Bravo II are tied into the existing natural rock, and integrated with the landscape to a much greater extent than typically found after the early 1950s. This is interpreted as reflective of the design and engineering of similar test stands of 1945 in Nazi Germany; as a precaution against explosions on the test stands; and as over-engineering to accommodate the uprated rocket engines of the future.

Photo 4.35. Bravo II Test Stand, engine test, December 1960, camera facing northeast. (Source: Boeing Company/Santa Susana Field Laboratory; Photo #120.)

Although Bravo II has undergone significant alterations over its lifetime, these changes have reflected new technologies and the requirements for testing different engines. Therefore, Bravo II maintains its integrity of location, design, setting, materials, workmanship, feeling, and association.

4.2.8 Bravo Control House (Building 2213)

Photo 4.36. Bravo Control House, west and south elevations.
(Source: Archaeological Consultants, Inc., 2007.)

Designed in 1955, the Bravo Control House (BCH) (Photo 4.36), or blockhouse, measures approximately 62 ft in length, 55 ft in width, and 12 ft in height. It is constructed of reinforced concrete, with a 12-inch thick west wall and 10-inch thick north, south, and east walls. The floor and roof are also reinforced concrete. The west elevation, which faces the test stands, contains seven observation windows, three of which are grouped at the center with a pair to either side. Between the central and southern groups of windows is a periscope for viewing the test stands (Photo 4.37). The east elevation has two metal swing doors, one on either side of the service room projection, and louvered vents. The north elevation has one louvered vent, and the south elevation is void of openings.

Photo 4.37. Bravo Control House, periscope detail, camera facing southeast.
(Source: Archaeological Consultants, Inc., 2007.)

As originally constructed, the interior of the BCH consisted of a 60-ft-long by 41-ft-wide control room, with a 46-ft by 12-ft projection to the west, which contained a 20-ft by 12-ft mechanical room, a 16-ft by 12-ft electrical room, and a 12-ft by 8-ft restroom. The floor of the control area is composed of 2-ft by 2-ft floor tiles, raised off of the concrete slab, allowing the cables to be run underneath.

In 1987, the interior of the control area was renovated to its present condition (Photo 4.38). During this work, no structural changes were made, and the raised floor was not altered. The exposed ceiling was covered with 2-ft by 4-ft acoustical ceiling tile, and the surface-mounted light fixtures were replaced with recessed light fixtures. Two partitioned rooms were placed along the south wall, a Data Process Area to the east and a Conference Room to the west, both measuring 15 ft by 9.5 ft. Centered along the east wall, a partitioned 32-ft by 20-ft workshop was constructed, and all control consoles were moved into the eastern portion of the control area.

Photo 4.38. Bravo Control House, interior, camera facing west.
(Source: Archaeological Consultants, Inc., 2007.)

The BCH is considered individually eligible for listing in the NRHP in the contexts of the Cold War (Military) and Space Exploration, under Criteria A and C. The period of significance is defined as 1955, the date of design, through 1991, which reflects the formal conclusion of the sustained conflict between the United States and the former USSR. Because the control house has achieved significance within the past 50 years, Criteria Consideration G applies. Under Criterion A, the BCH is considered eligible for its underlying associations with multiple static engine tests run between 1956 and 1991, including tests for Atlas ICBM thrust chambers (1950s and early 1960s), E-1 developmental thrust chambers (1950s), the RS-2 rocket sled pre-shipment to Holloman Air Force Base (1950s), F-1 thrust chambers, gas generators, heat exchangers, turbopumps, and components (after 1965), Lunar Module Rocket Engine assemblies (late 1960s), Atlas and Delta RS-27 vernier engines (1960s forward), Atlas sustainer turbopumps and booster engines (1970s forward), and Delta RS-27 turbopumps (1970s forward). Under Criterion C, the BCH is considered eligible for its design and engineering, which is representative of standard blockhouses, constructed at static rocket components test sites throughout the United States, of the late 1940s and early 1950s. It was designed by the Los Angeles architectural-engineering firm of DMJM, with the assistance of German engineer Walter Riedel. The blockhouse was placed in front of the test stand cluster, just slightly offset at the base of their spillways. The viewing portals that face the test stands are character-defining features of the blockhouse.

Although the BCH has undergone minor alterations over its lifetime, these changes have reflected new technologies and the requirements for testing different engines. Therefore, the BCH maintains its integrity of location, design, setting, materials, workmanship, feeling, and association.

4.2.9 Coca Test Area Historic District

Photo 4.39. Coca Test Area, camera facing southeast.
(Source: Archaeological Consultants, Inc., 2007.)

Designed in mid-1955, and constructed during 1955-1956, the Coca engine test site (Photos 4.39 - 4.41) featured the third cluster of static test stands (Coca I, II, and III) operational for AFP 57 at Santa Susana. The design and construction of the test site followed the design and construction of four similar test sites at the SSFL: the Bowl Area of 1948-1950 and the Canyon Area of 1953, for NAA; and the Alfa and Bravo sites of 1954-1955, two of four test sites for the Air Force. The original complex consisted of three test stands, Coca I, Coca II, and Coca III, each with its own electrical control station to the southwest of its respective stand. Each stand also had a gunite run-off channel that emptied into a Skim Dam, carved within the terrain. Between Coca II and Coca III sat the Terminal House, and across the road were two LOX storage tanks. Southwest from Coca III sat the Pre-Test Building; south of Coca II was the GN2 and GHe bottle bank; and south of Coca I was a Vehicle Shelter. Located on a cliff to the south of the Pre-Test Building was a Pill Box. The Control House for the complex sat across the Skim Dam from the test stands, towards the northwest. To the southwest of the Control House, there was a JP-4 fuel storage facility.

Photo 4.40. Coca Test Area, May 1959, camera facing southwest.
(Source: Boeing Company/Santa Susana Field Laboratory; Photo #18.)

Photo 4.41. Coca Test Area, January 1970, camera facing southeast.
(Source: Boeing Company/Santa Susana Field Laboratory; Photo #170.)

The early 1960s saw large modifications to the CTA. The Coca I stand was essentially disassembled and rebuilt as a larger facility, and the Coca IV Test Stand, which is almost identical structurally, was built to the east. The gunite channel for Coca I was enlarged, and a spillway was constructed for Coca IV. Both of these test stands were given their own terminal room, which sat underneath their respective service towers. In order to connect these terminal rooms to the Control House, an underground cable tunnel was constructed between the Control House and the Coca I terminal room, with a second tunnel between the Coca I and Coca IV terminal rooms. The Control House was also enlarged, in order to accommodate the new test stand, as well as the new engines to be tested in the complex. The remaining facilities built during the original construction period remained in place and intact, with the exception of Coca II, which was dismantled. Due to the changing nature of the complex, additional facilities were required in order to operate the stands. A second pretest shop, known as the Upper Pre-Test Building, was constructed to the east of the existing Pre-Test Building, and to the southeast of the Coca I stand. Additional fuel facilities were also constructed at this time, as the JP-4 propellant would not be needed. As such, a LH2 tank, with its own electrical control station, was built to the southwest of the test stands; a LN2 tank was placed to the east of the two LOX tanks and south of Coca II; and a third LOX tank, with its own electrical control station, was built to the southeast of Coca I. A GH2 tank, with compressor shelters, was placed well to the east of the test stands, along Test Area Road, and a Bulkhead Test Facility was built south of the Control House. In addition, two new observation bunkers were constructed, one on a cliff to the southeast for Coca I, and the other to the northeast, off of Skyline Drive, for Coca IV.

Photo 4.42. Coca Test Area, May 1974, camera facing southwest.
(Source: Boeing Company/Santa Susana Field Laboratory; Photo #41.)

In the early 1970s, further additions and modifications were made to the CTA, again reflecting a change in the type of engines to be tested. The two original LOX tanks and their adjacent LN2 tanks, to the southwest of Coca I, were replaced with a single LOX tank, and another LOX tank was set to the south of the Coca IV stand; a LH2 tank was installed to the northeast of Coca IV. Between Coca I and Coca IV, at the level of the spillways, a High Pressure GH2 and GN2 Vault was constructed for bottles of GN2 and GHe. In addition, a Hydraulic Supply Building was constructed to the east of Coca I, and a Pump House for deflector water was built to the southeast of Coca IV.

Since the 1970s renovation, no additional facilities have been constructed within the CTA. However, in 2005, a forest fire caused the destruction of the Upper Pre-Test Building and the Vehicle Shelter. Additionally, at an unknown date, the Coca III Test Stand was disassembled, as was the Bulkhead Test Facility and the JP-4 fuel shelter.

The Coca Test Area (CTA) Historic District (Figures 4.5 and 4.6) contains 18 contributing resources and four noncontributing resources. The contributing resources date to three key periods of activity at the location: 1955-1956 (as originally designed and built); 1962-1967 (for testing associated with the Apollo Program); and the 1970s (for testing associated with the Space Shuttle Program). Noncontributing resources are also spread across these timeframes. Contributing to the district are the Control House of 1955-1956, with its addition of 1964 (Building 2218), the Pre-Test Building of 1955-1956 (Building 2222), an observation pill box of 1955-1956 (Building 2B), the Coca I Test Stand of 1962-1963 (Building 2733), the Coca IV Test Stand of 1962-1963 (Building 2787), a large, vertical LOX tank and its Electrical Control Station of 1963-1964 (Vessel V180 and Building 2235, respectively), a large spherical LH2 tank and its Electrical Control Station of 1963-1964 (Vessel V100 and Building 2236, respectively), a large spherical GH2 tank (the “eight ball”, Vessel V99) with its gaseous hydrogen (GH2) compressor station and control center of 1964 (Buildings 2239 and 2237, respectively), two observation pill boxes of 1962-1963 (Buildings 2A and 2614), the cable tunnel between the Coca I and Coca IV test stands and the Control House of 1963, a High Pressure GH2 and GN2 vault of 1972-1973 (Building 2520), the Pump House of 1972-1973 (Building 2241), and the surrounding rocky landscape, inclusive of the integrated man-made flame trenches and the spillway. The four noncontributing resources are the Terminal House of 1955-1956 (Building 2219), the Hydraulic Supply Building of 1972 (Building 2240), a roof shelter for the storage of miscellaneous components from 1967 (Building 2451), and the base of the Coca II Test Stand of 1955 (Building 2734, dismantled in the 1960s). These resources are highly altered (Buildings 2240 and 2734), without an intact primary structure (Building 2219), or served no significant function (Building 2451). Standard tanks and pipelines for fuels and deluge water systems have been excluded from the district as either moveable equipment (typically updated or changed out) or underlying infrastructure; however, three large, more permanent tanks are included in the district as noted above.

Of the 18 contributing resources, seven are structures, ten are buildings, and one is a contributing site. The seven contributing structures consist of the Coca I and Coca IV test stands (described in detail in Sections 4.2.10 and 4.2.11, respectively), four fuel facilities, and a cable tunnel. The four fuel facilities are typically large structures that are permanent to their respective locations. The first of these is a LH2 tank (Vessel V100; Photo 4.43), located to the west of the test stands and south of the Control House. The tank is a large sphere that has a diameter of roughly 58.5 ft and holds 500,000 gallons of LH2. The tank is supported by eight metal pipes, set at 45 degree angles, or about 22.5 ft apart. These pipes are approximately 2.5 ft in diameter and stand 35.5 ft in height, placing the “equator” of the tank at roughly 35 ft above grade. Circa 1993, cross bracing was added to further support these pipes.

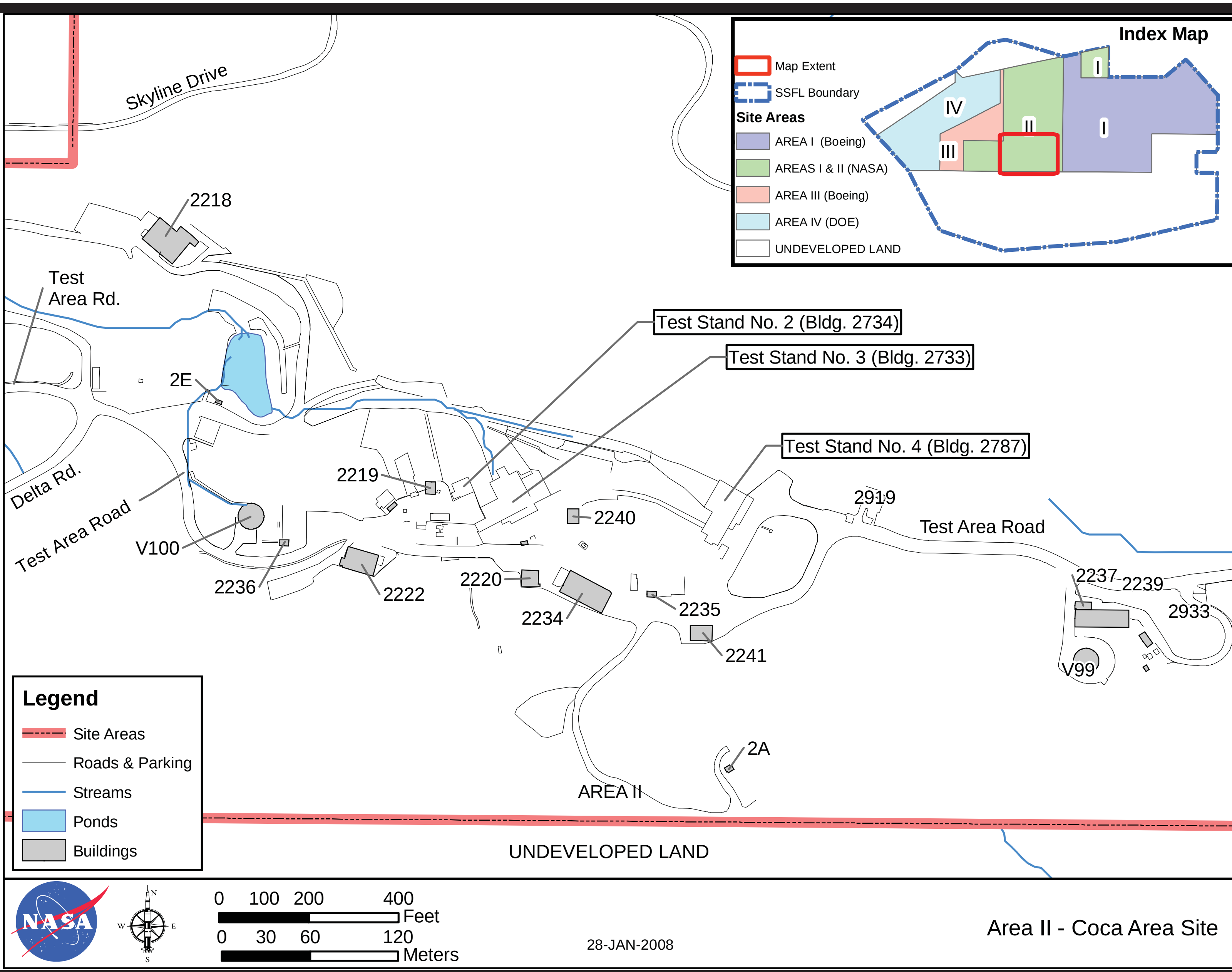

Figure 4.5. Plan of Coca Test Area. The locations of the Roof Shelter (2451), the High Pressure GH2 and GN2 Vault (2520), the Observation Bunker (2614), the Pill Box (2B), the LOX Vessel (V180) and the Cable Tunnel are not indicated (Courtesy of Ralph Allen, MSFC).

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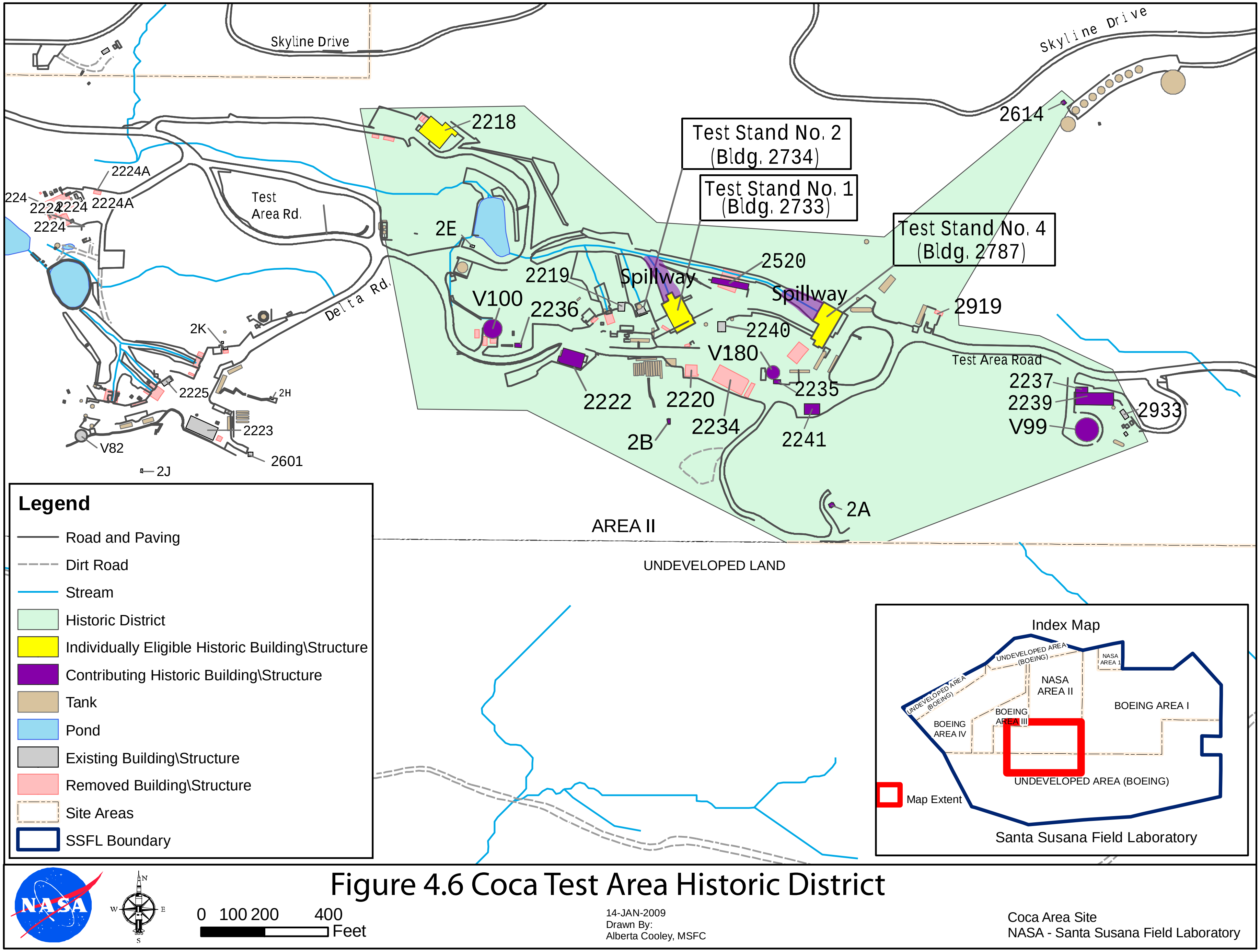

Figure 4.6 Coca Test Area Historic District

14-JAN-2009
Drawn By:
Alberta Cooley, MSFC

Coca Area Site
NASA - Santa Susana Field Laboratory

Map Document: (O:\NASA_GIS_Data\SSFL\maps\GSA_Coca_HistoricDistrict.mxd)

Photo 4.43. Vessel V100, LH2 tank, camera facing southwest.
(Source: Archaeological Consultants, Inc., 2007.)

The second fuel facility is the LOX storage tank (Vessel V108), located to the southwest of the Coca IV Test Stand. This vessel is a cylindrical tank with a diameter of roughly 34 ft and a height of approximately 50 ft. It sits on a 6-inch-thick reinforced concrete slab, with additional reinforced concrete footers. The tank has a domed top, and angles slightly inward toward the ground within the bottom 5 ft. There is also a 6-ft wide access door within the top, reached via a caged metal ladder. The tank holds 210,500 gallons of oxidizer.

Photo 4.44. Coca Test Area, camera facing southeast.
(Source: Archaeological Consultants, Inc., 2007.)

The third fuel facility is the GH2 recovery tank (Vessel V99; Photo 4.44), located at the eastern terminus of the Coca Test Area Historic District. Like the LH2 tank, the GH2 tank is a large sphere; it has a diameter of roughly 73 ft and holds 201,600 cubic feet of GH2. The tank is supported by ten metal pipes, set at 36 degree angles, or about 22.5 ft apart. These pipes are approximately 2.5 ft in diameter and stand 44.5 ft in height, placing the "equator" of the tank at roughly 45 ft above grade. Circa 1993, cross bracing was added to further support these pipes.

The final fuel facility is the High Pressure GH2 and GN2 Vault, located between the Flame Deflectors for the Coca I and Coca IV Test Stands. Designed by the Bechtel Corporation, it is a reinforced concrete structure that measures approximately 115 ft in length, 60 ft in width and 24 ft in height. It has three openings on the north side, separated by concrete columns. Internally, there are wide concrete columns for additional support. The east and west sides of the vault are concrete wedges. Rails are located across the roof for the placement/removal of the gaseous helium and gaseous nitrogen bottles that once occupied this structure. To the west of the vault, just prior to the run-off channel for Coca I, are balloons that were connected to the tanks, allowing the operators to test for leaks in the bottles.

The Cable Tunnel was constructed in the 1960s, when the Coca I and Coca IV test stand service towers were constructed, which included the two-level terminal rooms. The underground tunnel measures approximately 5 ft in width and 7 ft in height, and is composed of 8-inch-thick reinforced concrete walls, and a 10-inch-thick reinforced concrete ceiling and floor. The tunnel begins at the Coca Control House and extends roughly 1,000 ft to the Coca I terminal room, and then continues to the Coca IV terminal room at a length of about 560 ft. Within the tunnel are the cables which connect the electrical components from the test stands to the consoles in the Control House.

The ten contributing buildings are the Coca Control House (described in detail in Section 4.2.12), three observation bunkers/pill boxes, one Pre-Test Building, one pump house, two electrical control stations, and the compressor station complex. The CTA retains three Pill Boxes, or Observation Bunkers, all of which are structurally different from one another, but contain the same basic equipment. The oldest of the three bunkers is the one to the southwest of the test stands. Designed in 1955, Building 2B, originally referred to as a Pill Box, and now called an Observation Bunker, measures approximately 15 ft in length, 5 ft in width, and 8 ft in height. It is composed entirely of reinforced concrete, and has a slight gable to the roof. The east and west elevations of the bunker are void of openings. The south elevation contains a set of concrete steps down to the metal swing door. There are two observation windows on the north elevation, facing the test stand. They are framed with metal and have a small metal awning that extends across both windows.

The North Observation Bunker, Building 2A, designed in 1964, sits to the southeast of the test stands, and was built specifically for the Coca I Test Stand. This pillbox, also built entirely of reinforced concrete, is larger than 2B, at approximate overall dimensions of 13 ft in length, 11 ft in width, and 9.5 ft in height. The west elevation contains a metal swing door, and the east elevation, which faces the test stand, contains three observation windows, with a metal awning across all three. The north and south elevations of 2A are void of openings. On the south elevation, there is a set of metal stairs for access to the roof, where there are two camera mounts.

The third Observation Bunker, Building 614, presently known as the Coca IV Pill Box (Photos 4.45 and 4.46), was designed in 1962, and built to the northeast of the test stands, next to the water tanks along Skyline Drive. This bunker is also composed entirely of reinforced concrete, and is similar in size to 2A, at approximately 12 ft in length, 10 ft in width, and 9.5 ft in height. There is a metal swing door on the east elevation, and three observation windows on the west elevation, with an awning extending across all three.

Photo 4.45. Coca IV Pill Box, camera facing northeast.
(Source: Archaeological Consultants, Inc., 2007.)

Photo 4.46. Coca IV Pill Box, interior, camera facing southwest.
(Source: Archaeological Consultants, Inc., 2007.)

Internally, each bunker is a single room meant for two individuals to occupy during testing procedures. One of these individuals is the supervising engineer of the test, who has control over the Firex (a fire suppression system) switch and a cut-off button, in case an emergency requires the test to be terminated. The other individual in the pillbox during testing is the Standtalker, who has a headset and is audibly connected to the engineers within the Control House.

The Pre-Test Building is original to the Coca Test Area, and was completed in 1956. It measures approximately 70 ft in length, 40 ft in width, and 15 ft in height. It has a poured concrete slab floor, wood frame walls covered with plywood and batten siding, and a gable roof covered with composition shingles. The north elevation has a pair of metal swing personnel doors, as well as a pair of 24-light fixed windows, toward the west and a sliding door to the east. Originally, the facility contained an office, tool crib, and restroom along the west wall, and an operations area in the remainder of the building. The small shed-type structure at the east end was constructed at an unknown date.

Photo 4.47. Pump House, camera facing east.
(Source: Archaeological Consultants, Inc., 2007.)

The Pump House was completed in 1975, south of the Coca IV Test Stand (Photo 4.47). It has approximate dimensions of 48 ft in length, 32 ft in width, and 17 ft in height. The corrugated metal walls are supported by a steel skeleton, which rests on a concrete slab foundation. It is topped by a gable roof, also of corrugated metal. Both the east and west elevations have an 8-ft by 8-ft sliding metal door, and there are two air intake louvers on both the north and south elevations. Inside the facility are the three original Worthington pumps, each of which sits on a concrete pad (Photo 4.48). The pressure gauges for the pumps are located on the north wall; the original General Electric control panels are on the south wall. Each of the pumps has a pair of pipes, one incoming and one outgoing, that are evidenced to the north of the building. Here, elbow bends of each pipe can be seen.

Photo 4.48. Pump detail, camera facing northeast.
(Source: Archaeological Consultants, Inc., 2007.)

There are two contributing Electrical Control Stations (ECS) within the Coca Test Area. One of these stations serves the LH2 tank, the other serves the LOX tank (described above). Both were constructed ca. 1964, when their respective fuel tanks were placed within the test area. Each ECS measures roughly 20 ft in length, 12 ft in width, and 8 ft in height, and has a concrete slab floor, corrugated metal walls, and a corrugated metal shed roof. The LH2 ECS has one metal swing door on the east elevation; the LOX ECS has two metal swing doors, one on the east and one on the west. These buildings contain the control panels for their respective tank's operation.

There are two buildings within the compressor station complex that correspond to the GH2 tank. The first of these is the GH2 Compressor Building (Building 2239), which houses the compressors. This structure was designed in 1966, and, with a 1973 addition, measures approximately 114 ft in length, 35 ft in width, and 28 ft in height. It has a concrete slab foundation, and corrugated metal walls and gable roof. Across the roof are six vents. There is a 16-ft by 16-ft sliding door on the east elevation, and metal swing doors on both the north and south elevations. Inside are the compressors which draw the liquid hydrogen from the LH2 vessel to the GH2 vessel. At the west end of the north elevation is a 33-ft-long by 17-ft-wide by 16-ft-high pole barn-type structure, which provides a cover for the Control House (Building 2237), the second building of the complex. The Control House, completed in 1964, measures approximately 20 ft in length, 10 ft in width, and 10 ft in height. Like the main building, it has a concrete slab floor and corrugated metal walls and shed roof. There is a swing door on the west elevation. Inside are the controls for the GH2 tank.

The contributing site to the Coca Test Area Historic District is the natural and man-made landscape within the test complex boundaries. The natural terrain of cliffs, slopes, and rocky out-croppings provided an ideal setting for a test stand complex. The landscape created a natural buffer zone for rocket engine fuel and deluge water, as well as blast and sound protection. The varying elevations allowed the observation bunkers to be placed at safe distances from the test stands, while providing an excellent visual advantage. In addition, water tanks and wells which fed the CTA were placed at higher altitudes than the test stands, allowing gravity to aid the water flow. The natural terrain also dictated the design of the man-made elements within the test complex site.

The main road through the CTA Historic District provides direct access to the First Deck of each test stand, as well as all contributing and noncontributing buildings and structures except for the Control House, the terminal house, the compressor station complex, and the three observation bunkers. An access road to the CCC breaks off of the main road just before the LH2 tank. Across from the Lower Pre-Test Building, another small road slopes down to the terminal house. Just to the west of the Deflector Water Pumphouse, a third access road leads to one of the observation bunkers, Building 2A; Building 2B had wooden access stairs, which are no longer extant. Near the eastern boundary of the CTA Historic District is another small access road, which services the GH2 tank and its compressor buildings. Unlike the Alfa and Bravo Test Areas, the Coca test stands do not have designed gunite channels, although gunite was sprayed on the rock formations surrounding the flame deflectors.

Photo 4.49. Remnants of Coca II Test Stand, camera facing southwest.
(Source: Archaeological Consultants, Inc., 2007.)

There are four noncontributing resources within the Coca Test Area Historic District, including two structures and two buildings. The Roof Shelter, or “Carousel,” was constructed ca. 1967 as a storage facility. Therefore, it has served no significant purpose. The base of the Coca II Test Stand (Photo 4.49) is the only remnant of this structure, designed in 1955 and dismantled in the early 1960s to create additional room for the enlarged Coca I. Since then, it has served as a support structure for a vent pipe. As such, it lacks integrity of design, materials, workmanship, and feeling.

The Coca Terminal House, designed in 1955, became obsolete in the 1960s, when the Coca I and Coca IV Test Stands received individual terminal rooms within their service towers, and the Coca II and Coca III stands were deactivated/dismantled. Nearly all of its internal electrical panels and wiring have been removed; therefore, it lacks integrity of materials, feeling, and association. The Hydraulic Pump House, constructed ca. 1975, no longer retains its four pumps, and the original 10-ft by 8-ft removable panels from the west elevation are missing. Thus, it lacks integrity of design, materials, workmanship, and feeling.

Presently, there are two additional LOX vessels, one additional LH2 vessel, and one GN2 and GHe bottle bank within the Coca Test Area complex. Smaller fuel facilities, such as these, have been present within the test area throughout its history, but it is unclear if these tanks are original or replacement tanks. Therefore, they can not be evaluated as contributing or noncontributing.

The CTA Historic District is considered eligible for listing in the NRHP in the contexts of the Cold War (Military) and Space Exploration, under Criteria A and C. The period of significance is defined as 1955, the date of design, through 1988, which reflects the formal conclusion of testing for the Space Shuttle program. Because the district has achieved significance within the past 50 years, Criteria Consideration G applies. Under Criterion A, the CTA Historic District is considered eligible for its underlying associations with multiple static engine tests run between 1956 and 1988, including tests for Atlas ICBM developmental engines (1950s), Atlas flight engines (hot environment run-ups, 1950s), Navaho cruise missile engines (1950s), the Saturn V J-2 engine cluster (1960s), the Saturn V second-stage vehicle (1960s), SSME developmental components (1970s), complete SSMEs (as of 1978), and the SSME turbopump (acceptance testing into 1988). Under Criterion C, the CTA Historic District is considered eligible for the design and engineering of the test site, inclusive of the test stands and blockhouse, the associated ancillary buildings and structures (both contributing and noncontributing to the district), and that portion of the natural landscape integrated into the man-made complex. The original Coca complex was designed by the Los Angeles architectural-engineering firm of DMJM, with the aid of German engineer Walter Riedel. The design and engineering of the Coca site is representative of a static rocket engine test site of two very different periods. The original Coca facilities of the middle 1950s, inclusive of the adaptation of the existing land forms, are representative of the late 1940s and early 1950s, and reflect site planning and design tenets adapted from late World War II Germany. The additions to the Coca site of 1962-1974 are representative of a standard static engine test complex of the early-middle 1960s and reflect the changing functions of the district.

The CTA Historic District maintains its integrity of location, design, setting, materials, workmanship, feeling, and association, with 82% of the extant resources contributing to the district.

4.2.10 Coca I Test Stand (Building 733)

Photo 4.50. Coca I Test Stand, south elevation.
(Source: Archaeological Consultants, Inc., 2007.)

The original Coca I Test Stand, as designed by DMJM, had approximate overall dimensions of 40 feet (ft) in length (north-south), 37 ft in width (east-west), and 48 ft in height, excluding the fuel tank. It was built of structural steel, with reinforced concrete footings, and had a flame deflector that opened to the north. The upper half of Coca I contained two metal decks, the 1st Deck and the 2nd Deck, which measured roughly 40 ft in length and 36 ft in width and 30 ft in length and width, respectively. Each deck had an opening in the center for engine exhaust and/or fuel tank connections. Between these two decks was a mid-deck, which provided access to the engine's main components. Access stairs to the decks were on the south side of the stand. The fuel tank sat vertically above the 2nd Deck, and had a structural steel support system.

In 1962, Bechtel Corporation and Rocketdyne designed a new, larger test stand to replace the original Coca I. It is this stand that remains extant to this day, albeit with later modifications for different engines. The present Coca I Test Stand (Photo 4.50), which is structurally similar to the Coca IV Test Stand, has overall dimensions of approximately 98 ft in length, 73 ft in width, and 105 ft in height, inclusive of the flame deflector, but excluding the fuel tank. The base of the test stand is formed of 5-ft-thick reinforced concrete walls along the west, south and east; the north side is open for the flame deflector. To each side of this opening is a 6-ft-thick reinforced concrete buttress that arches out towards the bottom. The flame deflector sits within the concrete base, and is connected to it with steel girders for stability. In addition, steel posts with concrete footers provide a foundation for the deflector, which is itself constructed of steel. Across the extent of the deflector are thousands of holes for water to run over the surface during testing, which helps prevent the steel from melting due to the heat produced by the engines. Above the concrete base and flame deflector, Coca I is composed of structural steel. Supported by the concrete walls is a large, rectangular steel frame, roughly 45 ft in height, which angles inward similar to a pyramid. This frame helps support the various decks set in for various engine testing.

Photo 4.51. Coca I Test Stand, west elevation.
(Source: Archaeological Consultants, Inc., 2007.)

In 1963, Rocketdyne designed a service tower, which sits to the west of the test stand, and measures approximately 45 ft in length, 37 ft in width, and stands roughly 160 ft in height, inclusive of the crane (Photo 4.51). The service tower has six platform levels, including the ground level and the top level, and supports vent stack piping, and other service pipes. An elevator sits at the southwest corner tower, and rises to the 103-ft level. Below the service tower is the terminal room for the Coca I Test Stand, designed in 1962 by the Bechtel Corporation. This two-level structure is composed of reinforced concrete and has approximate overall dimensions of 43 ft in length, 37 ft in width, and 26 ft in height. Each floor level has a metal swing door on the west elevation, and there is a set of metal steps on this side, which provides access to the second level of the terminal room, as well as the various levels of the service tower.

Through the 1960s and early 1970s, Coca I was set-up to perform testing on the Saturn V "Battleship" engine configuration, which included five, J-2 engines (Photo 4.52). Above the concrete base were three deck levels, the first of which sat right above the flame deflector, and had an open-grate metal floor that was removed during testing procedures. Approximately 15 ft above this deck was the working level, where the engines were placed and connected to the liquid hydrogen fuel tank, which sat on the third level.

Photo 4.52. Coca I Test Stand, J-2 Five Engine Cluster hot fire test, August 1965, camera facing south.
(Source: Boeing Company/Santa Susana Field Laboratory; Photo #140.)

Between 1972 and 1973, Bechtel Corporation, with the help of Rocketdyne, designed further modifications for the Coca I Test Stand, in preparation for SSME tests, the configuration that currently remains in place. With this modification, no changes were made to the concrete base or the steel flame deflector, nor were there changes to the basic steel frame. The first platform, which sits just above the concrete at the 0-ft level, or road level, also remained from the previous arrangement, but received a 39-ft by 30-ft extension to the north over the flame trench. This level is commonly referred to as the "dance floor" and contains valves and control panels for various auxiliary systems, such as the Firex fire suppression system. The second platform from the Apollo configuration was raised just over one foot, and placed at the 10.5-ft level. Like the lower platform, an extension was built towards the north, which measured approximately 48 ft by 18 ft. This level is accessed via two sets of metal steps on the south side, and one set of steps at both the northwest and northeast corners. Commonly referred to as the "work deck," this level is where job assignments are handed out to the various personnel.

The third platform, which generally sits at the 19.5-ft level, is the engine deck. Like the lower two decks, this was raised and retrofitted from its previous location and arrangement, which included an extension to the north. As its name suggests, this deck is where the engine is placed for testing procedures. There are three different positions in which the engine can be set, position "1A" to the northwest, position "IB" to the northeast, and position "IC" at the south. In any case, the metal platform opens to allow the engine to be placed at the required location, where it is then bolted down. Access stairs for this level are on the west and on the east. The fourth platform consists of an entirely new deck, at the 45-ft level, just above the pyramidal steel frame from the stand's first retrofit. Commonly referred to as the valve deck, this level contains various control and test panels to verify that the stand is functioning properly. In addition, the fuel tanks, a white "ball" tank (V-84) for LH2 to the east and a cylindrical LOX tank (V-109) to the west, sit at this level. There are also additional platforms and stairs for access to the fuel tanks. In 1989, an additional LOX tank (V-120) was placed on the fourth platform.

Photo 4.53. Coca I Test Stand, SSME Solid Wall Hot Gas Manifold, date unknown, camera facing south.
(Source: Boeing Company/Santa Susana Field Laboratory; Photo #140.)

Coca I is considered eligible for listing in the NRHP in the contexts of the Cold War (Military) and Space Exploration, under Criteria A and C. The period of significance is defined as 1955, the date of its original design, through 1988, which reflects the formal conclusion of testing for the Space Shuttle Program. Because the stand has achieved significance within the past 50 years, Criteria Consideration G applies. Under Criterion A, Coca I is considered eligible for its underlying associations with multiple static engine tests run between 1956 and 1988, including tests for Atlas ICBM developmental engines (1950s), Atlas flight engines (hot environment run-ups, 1950s), Navaho cruise missile engines (1950s), the Saturn V J-2 engine cluster (1960s), the Saturn V second-stage vehicle (1960s), SSME developmental components (1970s), complete SSMEs (as of 1978), and the SSME turbopump (acceptance testing into 1988). Under Criterion C, Coca I is considered eligible for its original base design and engineering of the middle 1950s, and for its superstructure design and engineering as a large static test stand reflective of the early 1960s. The base foundations of the 1950s Coca test stands are tied into the existing natural rock, integrated with the landscape to a much greater extent than typically found after the early 1950s. This is interpreted as reflective of design and engineering of similar test stands in Nazi Germany of 1945; as a precaution against explosions on the test stands; and as over-engineering to accommodate the uprated rocket engines of the future. The improvements of the 1960s, especially the enhancement to the flame bucket, created a second layer of important infrastructure to Coca I. The size of the stand, seen primarily in the superstructure and the flame bucket, reflects the increased thrust ("pounds of thrust") characterizing single and clustered rocket engines of the early 1960s forward.

Although Coca I has undergone significant alterations over its lifetime, these changes have reflected new technologies and the requirements for testing different engines. Therefore, Coca I maintains its integrity of location, design, setting, materials, workmanship, feeling, and association.

4.2.11 Coca IV Test Stand (Building 787)

Photo 4.54. Coca IV Test Stand, east elevation.
(Source: Archaeological Consultants, Inc., 2007.)

The Coca IV Test Stand (Photo 4.54) was originally designed in 1962-63 by the Bechtel Corporation and Rocketdyne; construction was completed by 1964. The basic structural elements are the same as the Coca I Test Stand, and remain extant to this day. The present Coca IV Test Stand has overall dimensions of approximately 98 ft in length, 73 ft in width, and 134 ft in height, inclusive of the flame deflector. The base of the test stand is formed of 5-ft-thick reinforced concrete walls along the north, east, and south; the west side is open for the flame deflector (Photo 4.55). To each side of this opening is a 6-ft-thick reinforced concrete buttress that arches out towards the bottom. The flame deflector sits within the concrete base, and is connected to it with steel girders for stability. In addition, steel posts with concrete footers provide a foundation for the deflector, which is itself constructed of steel. Across the extent of the deflector are thousands of holes for water to run over the surface during testing, which helps prevent the steel from melting due to the heat produced by the engines. Above the concrete base and flame deflector, there is a 16-ft-high reinforced concrete pier to support a large steel frame, roughly 45 ft in height, which angles inward similar to a pyramid. This frame supports the steel decks of the upper levels. Surrounding this frame, and supported by the four concrete piers, is a lighter, steel truss system, that provides additional support for the decks and other equipment. This system stands approximately 76 ft in height, and is roughly 73 ft square in plan. It has one circumferential level, at 45 ft above grade, and a U-shaped level, open to the east, at the top.

Photo 4.55. Coca IV Test Stand, flame deflector, camera facing east.
(Source: Archaeological Consultants, Inc., 2007.)

In 1963, Rocketdyne designed a service tower, which is located to the south of the test stand, and measures approximately 45 ft in length, 37 ft in width, and stands roughly 160 ft in height, inclusive of the crane. The service tower has six platform levels, including the ground level and the top level, and supports vent stack piping, and other service pipes. Below the service tower is the terminal room for the Coca IV Test Stand, designed in 1962 by the Bechtel Corporation. This two-level structure is composed of reinforced concrete and has approximate overall dimensions of 43 ft in length, 37 ft in width, and 26 ft in height. Each floor level has a metal swing door on the west elevation, and there is a set of metal steps on this side, which provides access to the second level of the terminal room, as well as the various levels of the service tower.

Photo 4.56. Coca IV, “dance floor”, January 1970, camera facing southwest. (Source: Boeing Company/Santa Susana Field Laboratory; Photo #181.)

Through the 1960s and early 1970s, Coca IV was set up to perform testing on the J-2 engine (Photo 4.56). Above the concrete base were three deck levels, the first of which sat right above the flame deflector, and had an open-grate metal floor that was removed during testing procedures. Approximately 11 ft above this deck was the working level, where the engines were placed and connected to the liquid hydrogen fuel tank, which sat on the third level.

Between 1972 and 1973, Bechtel Corporation designed further modifications for the Coca IV Test Stand, in preparation for SSME tests. With this modification, no changes were made to the concrete base or the steel flame deflector, nor were there changes to the basic steel frame. The first platform, which sits just above the concrete at level 0’-0”, or the road level, also remained from the previous arrangement. The second platform from the Apollo configuration, commonly referred to as the “work deck,” was left in place at the 10’-6” level, and an extension was built towards the north, which measured approximately 44 ft by 15 ft. This level is accessed via two sets of metal steps on the east side. A third platform, the valve deck, was built at the 19’-6” level. This level contained various control and test panels, as well as the fuel tanks. Two additional work decks were added to Coca IV at this time, one at the 41’ level and one at the 50’ level. The 41’ level deck sat within the northeast corner of the stand; the 50’ level deck sat within the northwest corner. A combination of metal steps and caged ladders provided access to the various levels of the test stand. Also at this time, a new vent stack was built within the service tower.

Photo 4.57. Coca IV Test Stand, working level, camera facing northwest.
(Source: Archaeological Consultants, Inc., 2007.)

Between 1999 and 2000, Coca IV was modified to support testing of the Delta IV Expendable Launch Vehicle Tank, the configuration that remains present to this day (Photo 4.57). At this time, all platforms from the previous renovations were removed, while the basic 1962 structure remained intact. A separate steel support system was constructed near the center of the 0' level, which held the Delta IV tank in place. The valve consoles were placed along the north side of this level, within the steel truss system.

Coca IV is considered eligible for listing in the NRHP in the contexts of the Cold War (Military) and Space Exploration, under Criteria A and C. The period of significance is defined as 1962, the date of design, through 1988, which reflects the formal conclusion of testing for the Space Shuttle Program. Because the stand has achieved significance within the past 50 years, Criteria Consideration G applies. Under Criterion A, Coca IV is considered eligible for its underlying associations with multiple static engine tests run between 1962 and 1988, including tests for the Saturn V J-2 engine cluster (1960s), the Saturn V second-stage vehicle (1960s), SSME developmental components (1970s), complete SSMEs (as of 1978), and the SSME turbopump (acceptance testing into 1988). Under Criterion C, Coca IV is considered eligible for its design and engineering as a large static test stand reflective of the early 1960s. The size of the stand, seen primarily in the superstructure and the flame bucket, reflects the increased thrust ("pounds of thrust") characterizing single and clustered rocket engines of the early 1960s forward.

Although Coca IV has undergone minor alterations over its lifetime, these changes have reflected new technologies and the requirements for testing different engines. Therefore, Coca IV maintains its integrity of location, design, setting, materials, workmanship, feeling, and association.

4.2.12 Coca Control House (Building 218)

Photo 4.58. Coca Control House, east elevation.
(Source: Archaeological Consultants, Inc., 2007.)

As originally constructed in 1956, the CCH measured approximately 62 ft north-south, 55 ft east-west, and 11 ft in height. It was constructed of reinforced concrete, with a 12-inch thick east wall and 10-inch thick north, south, and west walls. The floor and roof were also reinforced concrete. The east elevation contained seven observation windows; the west elevation contained two metal swing doors, one on each side of the service room projection. Internally, the CCH consisted of a 60-ft-long by 41-ft-wide control room, with a 46-ft by 12-ft projection to the west, which contained a mechanical room, an electrical room, and a restroom.

The 1965 addition to the west end enlarged the CCH to approximate overall dimensions of 102 ft east-west and 75 ft north-south; it remained 11 ft in height. The new walls were constructed of reinforced concrete, as were the new foundation and roof sections. Across the east elevation, which faces the Coca test stands, remained the seven observation windows, three of which are grouped at the center with a pair to either side. Each window is triple-paned to withstand shock waves and has an external hood with mirrors on each of the sides. This provided additional visual contact for the test operators by reflecting the image of the test stands. The south elevation of the CCH is void of openings; the west elevation has a single set of double doors, which serve as the main entrance to the control building. The north elevation has a metal swing door near the center, with a 53-ft by 14-ft projection to its east, which extend 14 ft past the east elevation of the main portion of the building. The west elevation of this projection has a pair of metal swing doors.

Internally, the original section of the CCH remained mostly intact. The Test Operations Room remained in place at the east end; the Mechanical Room and toilet were also unchanged. The Electrical Equipment Room was moved to the west end of the north projection, which was larger in size to accommodate the additional computer and recording equipment. The west addition was divided into three areas. To the south sat a 42-ft by 31-ft Recording Room, which contained recording equipment and oscillographs. Within the northwest corner of the addition was the 12-ft by 11-ft Oscsillograph Darkroon, and to the northeast was a 20-ft by 18-ft Computer Complex.

Photo 4.59. Coca Control House, Test Operations Room, camera facing northeast. (Source: Archaeological Consultants, Inc., 2007.)

In the 1970s, the internal arrangement of the CCH was modified to its present configuration. Today, the interior of the CCH is divided into three main areas. At the east end remains the Test Operations Room, which measures approximately 61 ft by 41 ft (Photo 4.59). It consists of a large open area with a 17-ft by 13-ft Computer Room at the northwest corner. The room has a raised tile floor, enabling wires to be run underneath, and a perforated tile ceiling. To the northeast corner is the entrance to the Stage Terminal Room, located within the north projection, which contains wiring panels (Photo 4.60). At its east end is an underground cable tunnel, with branches to each of the Coca test stands. The west end of the CCH contains the Instrumentation Room. It measures approximately 52 ft by 31 ft, and is also a large open space. Throughout the room is additional data collection equipment, as well as office equipment and work benches. Within its northwest corner is a 10-ft by 11-ft Dark Room. To its south is a corridor, which extends from the western entrance to the Test Operations Room. Between the Instrumentation Room and the Test Operations Room are the restroom facilities (to the north) and the air conditioning equipment room (to the south). The Electrical Equipment Room remains at the west end of the north projection.

Photo 4.60. Coca Control House, stage terminal room, camera facing northeast. (Source: Archaeological Consultants, Inc., 2007.)

The CCH is considered eligible for listing in the NRHP in the contexts of the Cold War (Military) and Space Exploration, under Criteria A and C. The period of significance is defined as 1955, the date of design, through 1988, which reflects the formal conclusion of testing for the Space Shuttle Program. Because the control house has achieved significance within the past 50 years, Criteria Consideration G applies. Under Criterion A, the CCH is considered eligible for its underlying associations with multiple static engine tests run between 1956 and 1991, including tests for Atlas ICBM developmental engines (1950s), Atlas flight engines (hot environment run-ups, 1950s), Navaho cruise missile engines (1950s), the Saturn V J-2 engine cluster (1960s), the Saturn V second-stage vehicle (1960s), SSME developmental components (1970s), complete SSMEs (as of 1978), and the SSME turbopump (acceptance testing into 1988). Under Criterion C, the CCH is considered eligible for its design and engineering, which is representative of standard blockhouses, constructed at static rocket components test sites throughout the United States, of the late 1940s and early 1950s. It was designed by the Los Angeles architectural-engineering firm of DMJM, with the assistance of German engineer Walter Riedel. The blockhouse was placed in front of the test stand cluster, just slightly offset at the base of their spillways. The viewing portals that face the test stands are character-defining features of the blockhouse.

Although the CCH has undergone an addition and other alterations over its lifetime, these changes have reflected new technologies and the requirements for testing different engines. Therefore, the CCH maintains its integrity of location, design, setting, materials, workmanship, feeling, and association.

4.3 Non-Eligible Facilities and Properties

Of the total 75 assets surveyed, 34 (Table 4.1) have no exceptionally important historical associations with significant events (NRHP Criterion A) or persons (Criterion B) in the contexts of the Cold War (Military) and Space Exploration, as revealed by research, field survey, and informant interviews. In addition, none is distinguished by its architecture or engineering (Criterion C). Brief summary evaluations follow.

Delta Test Area: The Delta test area (Photo 4.61) originally consisted of three test stands (Delta I, Delta II and Delta III), which were used to test rocket engines that relied on petroleum-based fuels. Active between 1953 and 1970, the Delta area, like the other test areas, used large quantities of water to cool the engine during testing. Afterwards, trichloroethylene was used to flush the engine of any excess fuel, and was then recycled through a system put in place in 1961. Since the site was deactivated, all three test stands were dismantled, and the control house (2224), also known as the Propellant Load Facility, was destroyed by a fire in 2006 (NASA 2006d). Presently, five assets, the Delta Pre-Test Building (2223) (Photo 4.62), the Delta Terminal House (2225), and the three Delta Pillboxes (2601, 2H, and 2J), are located within the Delta Test Area (Figure 4.7). Unlike the Alfa, Bravo, and Coca complexes, the integrity of the Delta complex has been severely compromised by the loss of all three test stands, their adjacent electrical control stations, and the control house. The extant facilities, which generally served as support buildings within the complex, do not retain significant associations with historical events or persons to be individually eligible for the NRHP, nor do they convey unique design features when compared to similar facilities in the Alfa, Bravo, or Coca areas. In addition, with the significant loss of building fabric, there is no strong justification for a historic district as with the other test complexes.

Photo 4.61. Delta Test Complex, Delta I rails in foreground, camera facing west. (Source: Archaeological Consultants, Inc., 2007.)

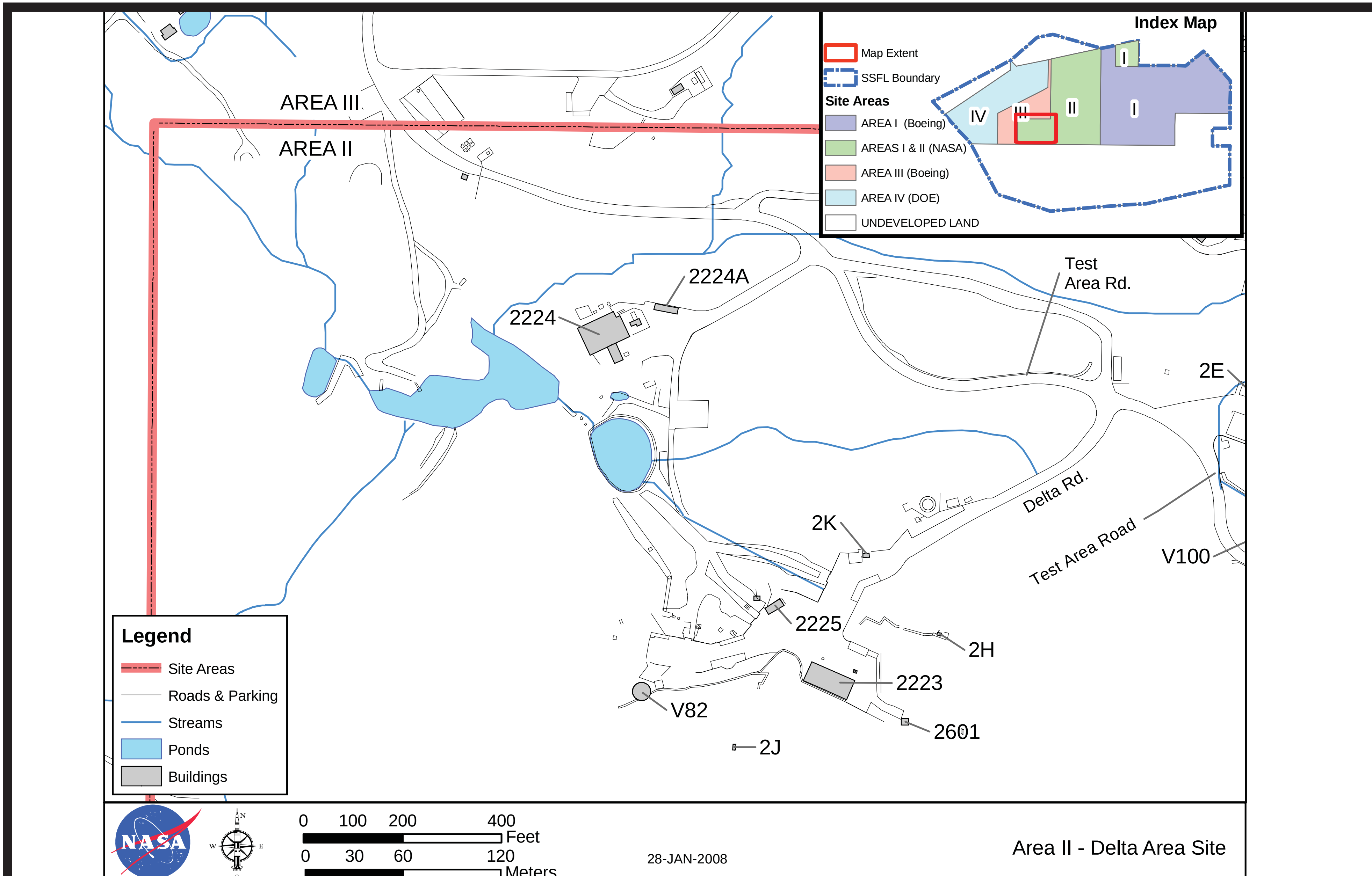

Figure 4.7. Plan of Delta Test Area. Note that 2224 and 2224A were destroyed by a fire in 2006 (Courtesy of Ralph Allen, MSFC).

Photo 4.62. Delta Pre-Test Building, camera facing southeast.
(Source: Archaeological Consultants, Inc., 2007.)

Service Area/CTL II: Seven buildings within the Service Area (Photo 4.63), including the Engineering Building (2201), the Maintenance Stock Building (2202), the Laser Labs Facility (2203), the Maintenance Building (2204), the Maintenance Paint Building (2205), the Security Control Center (2207), and the Engineering Offices (2211), were included in the field survey. All were built between 1954 and 1958. These facilities served as general office areas for the engineering and maintenance staffs, as well as security and fire protection forces. As such, none is distinguished by its association with significant events or persons. In addition, all seven buildings are of simple steel frame or masonry construction, are covered with corrugated metal, and therefore, retain no distinguishing design features.

Photo 4.63. Service Area, Building 2201 to right, Building 2203 in center, and Building 202 to left, camera facing east.
(Source: Archaeological Consultants, Inc., 2007.)

The Components Test Laboratory (CTL) II (2206, presently the ELV Final Assembly Building) (Photo 4.64) was designed in 1955 by Los Angeles area architect, Kenneth H. Neptune, and activated in 1956. By 1967, CTL II supported NASA's activities in Area II. It contained a 45,000 square foot workshop, five test cells, a control center, and a propellant storage area. At an undetermined date, CTL II was renovated into the ELV Final Assembly Building. The test cells have been stripped of their equipment (Photo 4.65), as has the workshop area. Therefore, the facility has suffered a loss of integrity, and no longer conveys its historic functions.

Photo 4.64. Components Test Laboratory (2206), camera facing northeast.
(Source: Archaeological Consultants, Inc., 2007.)

Photo 4.65. Test Cell at CTL II, later a fish pond, camera facing north.
(Source: Archaeological Consultants, Inc., 2007.)

Storable Propellant Area: Eight of the facilities within the Storable Propellant Area (SPA): the Scale Shelter (2761), the Awning Shelter (2769), the Storage Propellant Office (2770), two Oxidizer Storage Shelters (2777 and 2928), the Fuel Mix Shed Awning (2925), the Equipment Storage (2926), and the Storage Shelter for Fuels (2927) (Photo 4.66), were also surveyed. The SPA was operational from the 1960s until 1993, and had designated areas for fuel and oxidizer drum storage. These eight resources strictly served as storage support facilities for Area II. The shelters no longer contain fuel or oxidizer tanks, and the scale (2761) (Photo 4.67) was destroyed by fire in 2006. As such, the SPA and its components have suffered a loss of integrity.

Photo 4.66. Storage Shelter for Fuels (2927) within SPA, camera facing southwest. (Source: Archaeological Consultants, Inc., 2007.)

Photo 4.67. Scale Shelter (2761) within the SPA, camera facing south. (Source: Archaeological Consultants, Inc., 2007.)

Skyline Drive: Twelve water tanks (2818 through 2829) (Photo 4.68) are located along Skyline Drive. Designed and built between 1956 and 1957, they are typical water tanks, with no outstanding engineering or design features. They have no outstanding historical functions, nor are they associated with significant historical persons. Additionally, they are not associated with any particular test complex.

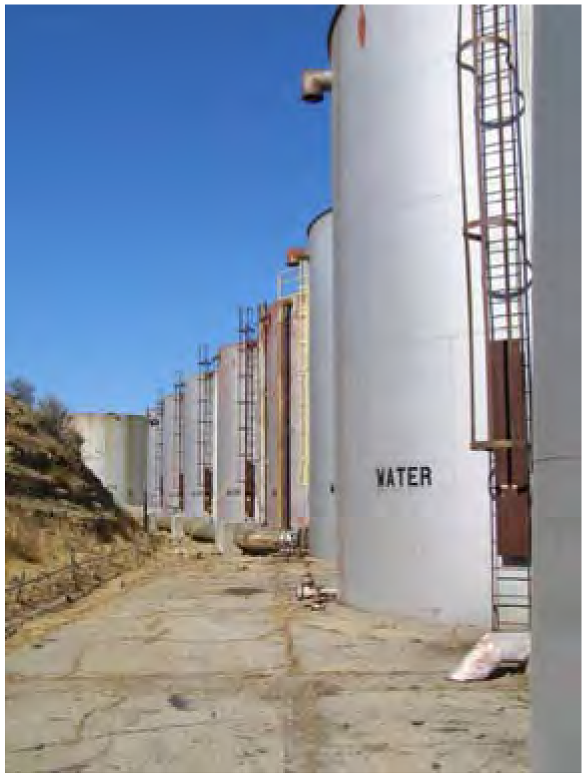

Photo 4.68. Water Tanks along Skyline Drive, camera facing west.
(Source: Archaeological Consultants, Inc., 2007.)

5.0 CONCLUSIONS

The evaluation of the SSFL included an initial review of a list of 135 NASA-owned buildings, structures, and sites located within Areas I and II of the SSFL, provided to ACI by MSFC HPO, Ralph Allen. With the exception of a single well in Area I, all of the facilities are located within Area II. This initial review revealed that 60 of the facilities within Areas I and II are temporary structures, small storage sheds, roadways, pipelines, or other small objects, such as light fixture poles, which are used for generic purposes, with no specific historic function. The remaining 75 facilities are all buildings and structures located within the Alfa, Bravo, Coca, Delta, Storable Propellant Area (SPA), and Service Area complexes of Area II; field survey focused on these 75 facilities (Table 4.1). Although many of these resources were previously assessed by various contractors (Calvit and Barrier 2006; Deming, Slovinac and Weitze 2007b) as meeting the criteria of eligibility for inclusion in the NRHP, none of the surveyed facilities is currently listed in the NRHP or has been formally determined eligible. As a result, 12 NRHP-eligible historic properties were identified, including nine individually eligible test stands and associated control houses in the Alfa, Bravo and Coca test areas: the Alfa I Test Stand (1954), the Alfa III Test Stand (1954), the Alfa Control House (1954), the Bravo I Test Stand (1955), the Bravo II Test Stand (1955), the Bravo Control House (1955), the Coca I Test Stand (1955/1962-1963), the Coca IV Test Stand (1962-1963), and the Coca Control House (1955). The relevant historic contexts include the Cold War (Military) and Space Exploration.

In addition, three historic districts were identified within Area II of the SSFL: the Alfa Test Area Historic District which contains 10 contributing resources and four noncontributing resources; the Bravo Test Area Historic District, which contains eight contributing resources and one noncontributing resource; and the Coca Test Area Historic District, which has 18 contributing resources and four noncontributing resources.

The **Alfa Test Area Historic District** is considered eligible for listing in the NRHP in the contexts of the Cold War (Military) and Space Exploration, under Criteria A and C. The period of significance is defined as 1954, the date of design, through 1991, which reflects the formal conclusion of the Cold War. The relevant areas of significance are Military, Engineering, Transportation, and Space Exploration. Because the Alfa Test Area Historic District has achieved exceptional importance within the past 50 years, Criteria Consideration G applies. Constructed during 1954-1955, the Alfa test site featured the first cluster of static test stands operational for AFP 57 at Santa Susana. Beginning in the mid-1950s, the Alfa test site supported early rocket engine static testing, including the Atlas, Navaho, Jupiter, and Thor engines, and provided pivotal data for the development and improvement of many weapons and space vehicle booster systems (Criterion A). The Alfa Test Area Historic District is also considered eligible under Criterion C for the design and engineering of the test site, by the Los Angeles architectural-engineering firm of DMJM with German engineer Walter Riedel, a rocket engine expert who had worked with Dr. von Braun, inclusive of the test stands and blockhouse, the ancillary buildings and structures, and the elements of the natural and man-made landscape.

The **Bravo Test Area Historic District** is considered eligible for listing in the NRHP in the contexts of the Cold War (Military) and Space Exploration, under Criteria A and C. The period of significance is defined as 1955, the date of design, through 1991, which reflects the formal conclusion of the Cold War. The relevant areas of significance are Military, Engineering, Transportation, and Space Exploration. Because it has achieved exceptional importance within the past 50 years, Criteria Consideration G applies. Constructed during 1955-1956, the Bravo test site featured the second cluster of static test stands operational for AFP 57 at Santa Susana. Under Criterion A, it is considered eligible for its underlying associations with multiple static engine tests run between 1956 and 1991, beginning with tests of Atlas thrust chambers in 1956. The Bravo test stands also supported testing of F-1 components; Lunar Module Rocket Engine assemblies; as well as Atlas and Delta RS-27 vernier engines and turbopumps. Like the Alfa Test Area, the Bravo Test Area Historic District is also significant under Criterion C for the design and engineering of the test site, by DMJM, as well as rocket expert Walter Riedel, inclusive of the test stands and blockhouse, the ancillary buildings and structures, and the elements of the natural and man-made landscape.

The **Coca Test Area Historic District** is considered eligible for listing in the NRHP in the contexts of the Cold War (Military) and Space Exploration (Apollo and Space Shuttle Programs), under Criteria A and C. The period of significance is defined as 1955, the date of design, through 1988, which reflects the formal conclusion of testing of the SSME for the Space Shuttle Program. The relevant areas of significance are Military, Engineering, Transportation, and Space Exploration. Because it has achieved exceptional importance within the past 50 years, Criteria Consideration G applies. Originally constructed during 1955-1956, the Coca test site featured the third cluster of static test stands operational for AFP 57 at Santa Susana. Some of the facilities were modified/redesigned between 1962 and 1964; additional facilities were designed between 1973 and 1978. Under Criterion A, the Coca Test Area Historic District is considered eligible for its underlying associations with multiple static engine tests run between 1956 and 1988, beginning with tests of Atlas and Navaho engines in the late 1950s; the J-2 engine in the 1960s in support of Saturn/Apollo; and the SSME in the 1970s and 1980s in support of the Space Shuttle Program. Like the Alfa and Bravo Test Areas, the Coca Test Area Historic District is also significant under Criterion C for the design and engineering of the test site, by DMJM, as well as rocket expert Walter Riedel, inclusive of the test stands and blockhouse, the ancillary buildings and structures, and the elements of the natural and man-made landscape.

In addition, of the total 75 assets surveyed, 34 facilities within the Delta Test Area, Service Area/CTL II, Storable Propellant Area, and along Skyline Drive have no exceptionally important historical associations with significant events (NRHP Criterion A) or persons (Criterion B) in the contexts of the Cold War (Military) and Space Exploration, as revealed by research, field survey, and informant interviews, and none is distinguished by its architecture or engineering (Criterion C).

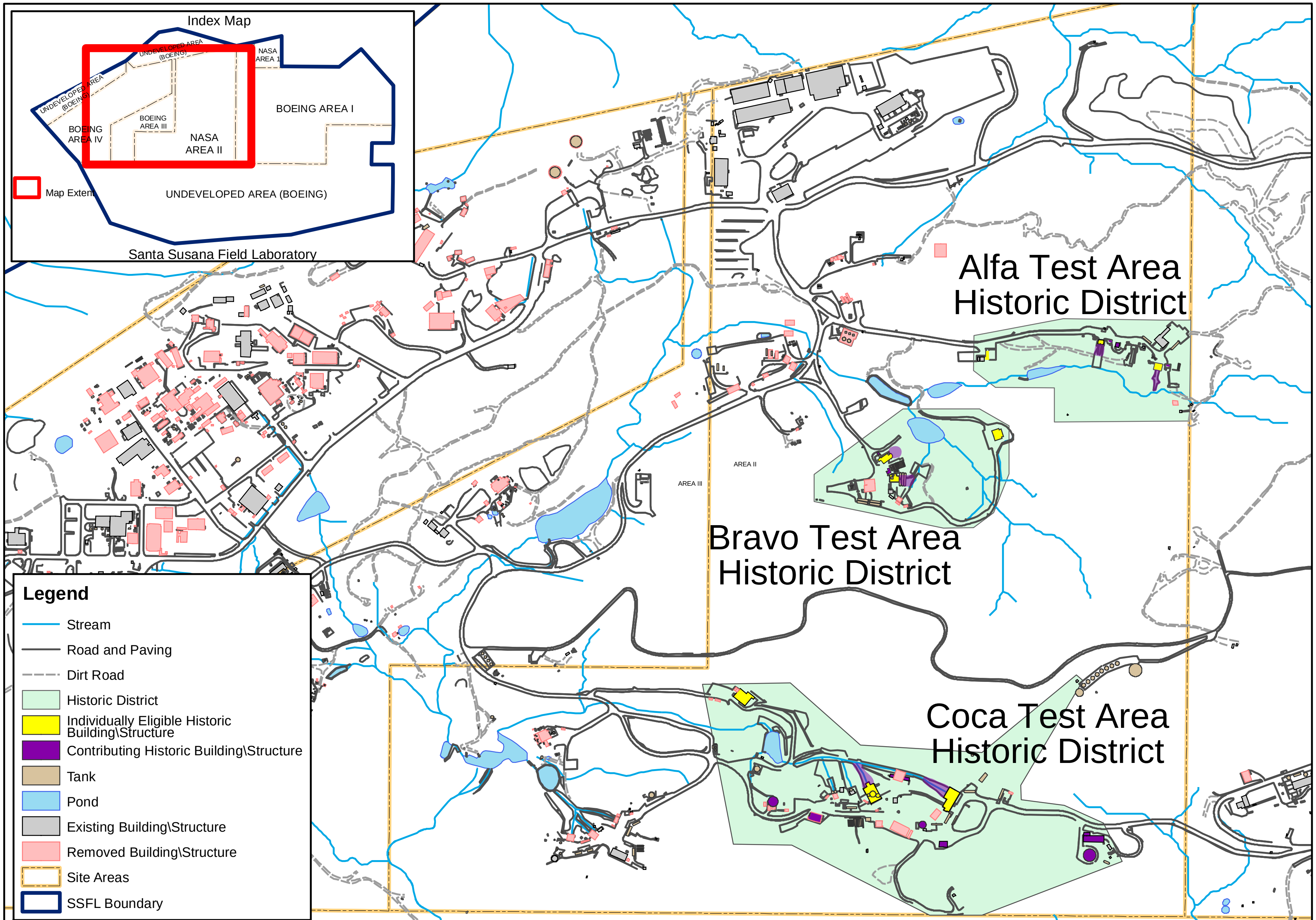

Figure 4.8 SSFL Historic Districts - Composite Map

500 250 0 500 Feet

16-JAN-2009
Drawn By:
Alberta Cooley, MSFC

Historic Districts, Area II
NASA - Santa Susana Field Laboratory

Map Document:(O:\NASA\SSFL\maps\GSA_All_HistoricDistrict.mxd)

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APPENDIX A:
Santa Susana Field Laboratory Building Summary

Bldg No	Bldg Description	Year Constructed	Actual Year Closed	SQ FT	AOPCs and Descriptions
2201	Engineering Offices	1956	2001	25,956.00	
2202	LEOS storage	1956	UNK	13,272.00	**2202 Oil Storage Area** - A former oil storage area located on concrete behind Building 2202. Interview reported a potential for excess oil to run down the hillside.
2203	Lasers Lab Facility	1954	UNK	32,206.00	**2203 Oil Storage Area** - A former oil storage area located on asphalt behind Building 2202. Interview reported a potential for excess oil to run down the hillside.
2204	Maintenance Building	1956	UNK	11,547.00	**2204 Paint Disposal Area** - Residual paint dumped to the west of Building 2204 on dirt embankment. This area has been sprayed with a thin cover of concrete most likely to control erosion or to cap the area. Area was 20 feet by 100 feet. Unknown when the practice was initiated, but it continued until approximately 1991.
					2204 Vehicle Washing Area - Vehicle washing area located behind Building 2204. Employees at the Service Area wash the undercarriages of the maintenance vehicles on a sloping asphalt road that leads to the bone yard.
2205	Maintenance Lunch Room	1956	2001	413.00	
2206 - 2206	ELV Final Assembly Building	1956	UNK	17,204.00	**2206 Secondary Containment Drain** - Drainage hole in the secondary containment for former ASTs located on the south side of Building 2206. The drainage hole may have been added after ASTs were removed to limit the accumulation of rain water.
					2206 Concrete Vault - Concrete vault on the south side of 2206. Purpose of the vault unknown. May have been associated with test bays and drainage pond.
2207	Protective Services Building	1956	UNK	6,634.00	**2207 Vehicle Washing Area** - Vehicle washing area located on the north side of Building 2207. Runoff from vehicle washing activities is directed to a storm drain on the southeast side of Building 2207.
2208	ALFA - Recording Center	1955	UNK	3,196.00	**2208 Corroded Back-up Power Batteries** - Corrosion evident on the floor beneath lead-acid batteries and entering nearby floor drain.
2208A	ALFA - CC Engineering Trailer	UNK	UNK	839.00	
2209	ALFA - Terminal House	1955	UNK	571.00	
2209A	ALFA-2 ECS Shack	UNK	UNK	162.00	
2211	Furniture Storage	1959	2001	16,346.00	
2212	ALFA - Pretest Shop	1956	UNK	2,902.00	
2212B	ALFA - Old Guard Shack	UNK	UNK	52.00	
2212S	ALFA - Pretest Extension (New)	UNK	UNK	1,034.00	
2213	BRAVO - Control Center	1956	UNK	3,220.00	**2213 Corroded Back-up Power Batteries** - Corrosion evident on the asphalt floor beneath lead-acid batteries.
2214	BRAVO - Terminal House	1956	UNK	639.00	
2214A	BRAVO-3 ECS Shack	UNK	UNK	162.00	
2217	BRAVO - Pretest Shop	1956	UNK	3,779.00	
2217A	BRAVO - Pretest Engineering Trailer	UNK	2002	300.00	
2218	COCA - Recording Center	1956	2003	7,916.00	
2219	COCA - Terminal House	1959	2001	668.00	
2219A	COCA - Electrical Control Building, "A"	UNK	2001	240.00	
2219B	COCA - Electrical Control Building, "B"	UNK	2001	240.00	
2219C	COCA - A/C Compress. Shelter, "C"	UNK	2001	832.00	
2219D	COCA - T-House, "D"	UNK	2001	104.00	
2220	COCA - RNTF Storage	1956	2002	1,160.00	
2222	COCA - Lower Pretest (RNTF)	1956	UNK	2,923.00	
2223	DELTA - Tool Engineering Storage	1956	2001	3,794.00	
2224	DELTA - Propellant Load Facility	1956	UNK	2,800.00	
2224A	DELTA - PLF Trailer	UNK	2001	260.00	
2225	DELTA - Terminal House	1956	2001	400.00	
2231	Environmental Equipment Storage	1956	2001	624.00	
2232	LOX Tank Control Building	1956	2001	169.00	
2233	Maintenance Paint Storage	UNK	2002	375.00	
2234	COCA - Upper Pretest	1964	2001	4,885.00	
2235	COCA - Elect. Control Stat - LOX	1964	2001	240.00	
2236	COCA - Elec. Control Stat - LH2	1964	2002	240.00	
2237	Compressor Station - Control Center	1964	2002	240.00	
2239	Compressor Station - Main Building	1967	UNK	4,531.00	**2239 Plunger Oil Coolers** - Staining under GH2 and GN2 plunger oil coolers. Petroleum staining present on the concrete pad and adjacent asphalt. Evidence of cracking of the asphalt in the area of staining.
					2239 Floor Drains - Floor drains from the interior of the building lead to unlined ditches. The interior of the building was washed down two to three times during its operation. Any residual petroleum (plunger oil) or solvents, may have been flushed into the floor drains and then outside to the soil where the pipes exit.
2240	COCA - Hydraulic Pump House	1975	2001	781.00	**2240 Transformer** - Leaking transformer, transformer oil is present on the concrete pad and asphalt adjacent to the transformer.
2241	COCA - Deflector W. Pump House	1975	2001	1,563.00	
2273	BRAVO - Trailer (Grnd Water Res.)	UNK	2001	500.00	
2273A	BRAVO - Shed (Grnd Water Res.)	UNK	2001	UNK	
2357	HVAC Component Storage Building	UNK	2001	176.00	
2451	COCA - Carousel Storage	1967	UNK	95.00	
2507	ALFA/BRAVO - Fuel Farm	1955	UNK	UNK	
2508	Coca/Delta Fuel Farm	UNK	UNK	UNK	
2515	Sewer Treatment Plant Facility	1959	UNK	UNK	
2519	SPA - Storable Propellant Area	1956	2001	UNK	
2520	COCA-Vault (High Pressure Bottles)	1975	2001	7,200.00	
2601	DELTA - Pillbox #3	1964	2001	50.00	
2614	COCA - 4 Pillbox	1965	2001	135.00	
2679	COCA - Engineering Trailer	UNK	2001	400.00	
2711	Radio Signal Boost Station	UNK	2003	104.00	
2712	Security Radio Building #2	UNK	UNK	870.00	**2712 Secondary Containment Drain** - Drainage hole in the secondary containment for an active Diesel AST.
2727	ALFA-1 Test Stand	1955	UNK	UNK	**2727 TCE Parts Cleaner Tray** - Potential for releases of TCE from the parts cleaner. No secondary containment present under the tray. Area beneath the tray is unpaved.
2727A	ALFA-1 ECS Shack	UNK	UNK	162.00	
2729	ALFA-3 Test Stand	1956	UNK	UNK	
2729A	ALFA-3 ECS Shack	UNK	UNK	162.00	
2730	BRAVO-1 Test Stand	1956	UNK	UNK	
2730A	BRAVO-1 ECS Shack	UNK	UNK	162.00	
2731	BRAVO-2 Test Stand	1956	UNK	UNK	**Bravo Test Stand No. 2, Asbestos Gasket Disposal Area** - Asbestos gaskets discarded on hillside during disassembly of engines.

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Bldg No	Bldg Description	Year Constructed	Actual Year Closed	SQ FT	AOPCs and Descriptions
2731A	BRAVO-2 ECS Shack	UNK	UNK	162.00	**2731A Corroded Back-up Power Batteries** - Corrosion evident on the concrete floor beneath lead-acid batteries.
					2731A Secondary Containment Drain - Floor drain present inside secondary containment for hydraulic AST and equipment. Standing water inside secondary containment. Drain appeared to be plugged. Past releases inside this secondary containment area may have entered the floor drain.
2732	Bravo storage	UNK	UNK	275.00	
2733	COCA-3, Test Stand	1964	UNK	UNK	
2734	COCA - Old COCA-2 Test Stand	1956	UNK	UNK	
2739	ALFA - Stand Talker Shack	UNK	2001	50.00	
2758	Incinerator	UNK	2002	90.00	
2758A	Incinerator - Staging Platform	UNK	2002	203.00	
2760	Maintenance Supply Shed	UNK	UNK	678.00	
2761	SPA - Scale Shelter	1952	2002	146.00	
2769	SPA - Awning Shelter	1961	2002	300.00	
2770	SPA - Storage Propellant Office	UNK	2001	UNK	
2775	Maintenance Wood Shop Storage	UNK	2001	358.00	
2775A	Storage Shed - Electrical Equipment	UNK	2001	60.00	
2775B	Storage Shed - Janitorial Equipment	UNK	2001	36.00	
2775C	Storage Shed - Electrical Equipment	UNK	2001	120.00	
2775D	Storage Shed - Utility Equipment	UNK	2001	175.00	
2775E	Storage Shed - Lumber	UNK	2001	195.00	
2776	Sewer Treatment Plant Building	1961	UNK	64.00	**Contamination Pond** - A 1966 Master Plan identified a contamination pond on the west side of the Sewage Treatment Plant. No information was available during the document reviews or interview regarding whether this contamination pond was ever present or used.
2777	SPA - Oxidizer Storage Shelter	1960	2003	UNK	
2787	COCA-4, Test Stand	1964	UNK	UNK	
2796	Maintenance Paint Shop	UNK	UNK	1,333.00	**2796 Waterfall Curtain** - A paint booth included a waterfall curtain on the northwest corner of the building. No information on the operational dates or when it was closed/removed.
2818	Water Tank - Skyline Drive	1956	UNK	UNK	
2819	Water Tank - Skyline Drive	1956	UNK	UNK	
2820	Water Tank - Skyline Drive	1956	UNK	UNK	
2821	Water Tank - Skyline Drive	1956	UNK	UNK	
2822	Water Tank - Skyline Drive	1956	UNK	UNK	
2823	Water Tank - Skyline Drive	1956	UNK	UNK	
2824	Water Tank - Skyline Drive	1956	UNK	UNK	
2825	Water Tank - Skyline Drive	1957	UNK	UNK	
2826	Water Tank - Skyline Drive	1957	UNK	UNK	
2827	Water Tank - Skyline Drive	1957	UNK	UNK	
2828	Water Tank - Skyline Drive	1963	UNK	UNK	
2829	Water Tank - Skyline Drive	1965	UNK	UNK	
2919	COCA-4, Compressor Shelter	1977	2001	320.00	
2920	SPA - Fuel Mix Shed Awning	1961	2002	150.00	
2926	SPA - Equipment Storage	UNK	2001	UNK	
2927	SPA- Storage Shelter for Fuels	1959	UNK	UNK	
2928	SPA - Oxidizer Storage	1960	UNK	0.00	
2932	Material Prep Shelter	UNK	2001	UNK	
2933	Compressor Station - Shelter	1976	UNK	UNK	
2A	COCA - A3 Pillbox	UNK	2001	136.00	
2B	COCA - Old Pillbox	UNK	2001	90.00	
2D	COCA - Guard Shack (East)	UNK	2001	35.00	
2E	COCA - Elect Control Building (BTF)	UNK	2001	84.00	
2F	COCA - Ruins (Bulkhead Test Facility)	UNK	2001	3,758.00	
2G	COCA - Guard Shack (West)	UNK	2001	63.00	
2H	DELTA - Pillbox #1	UNK	2001	50.00	
2J	DELTA - Pillbox #2	UNK	2001	50.00	
2K	DELTA - T-House	UNK	2001	150.00	
2M	Skyline Drive - Water Tank Cont. Stat.	UNK	UNK	98.00	
2R	ALFA/BRAVO GHe Comp. Shelter-1	UNK	2004	200.00	
2S	ALFA/BRAVO GHe Comp. Shelter-2	UNK	2004	200.00	
2T	GN2 Cascade Storage Building	UNK	2004	252.00	
2V	BRAVO Area Entry Guard Shack	UNK	UNK	52.00	
2X	ALFA - 1 Pillbox	UNK	2001	50.00	
2Y	ALFA - 3 Pillbox	UNK	2001	50.00	
2Z	BRAVO Pillbox	UNK	2001	50.00	
UNK	SPA shelter	UNK	UNK	UNK	
809	Area I Former LOX Plant Water Tank	UNK	UNK	UNK	
N/A	Bravo Area	UNK	UNK	UNK	**Bravo Pipe** - Former 6-inch pipe was reported by "old-timers" to have been used for dumping of wastes at the Bravo Backyard Driveway southeast of the Bravo Stripping Towers. The pipe has since been paved over with asphalt.
N/A	Coca Area	UNK	UNK	UNK	**V186 Vacuum Shed** - Heavy petroleum staining under electric motor and vacuum equipment. A small process tank (approx. 4 gallons) for the lubricating oil is associated with the vacuum equipment. Vacuum equipment is enclosed within a metal shed with a metal floor. No seepage is visible through the metal sides of the metal shed. Integrity of metal floor unknown.
N/A	Delta Area	UNK	UNK	UNK	**V99 Bleed-Off Valves** - Soil staining observed under bleed-off valves along the route of a vent stack for a GH2 compressed gas AST (V95). The plunger oil potentially was blown out of the end point (on top of the hill) of the vent pipe during operations, spraying an approximate 200- to 300-square foot area.
N/A	Service Area	UNK	UNK	UNK	**Heli-pad Soil Staging** - Heli-pad used as a staging area for soil from cleanup activities in Area IV. Soil staged in this area potentially contained beryllium.
N/A	Miscellaneous	UNK	UNK	UNK	**Burned Building Batteries** - Burned building adjacent to water tanks 2821/2822 on Skyline Drive had batteries that were destroyed by fire. Potential for lead contamination.

10/14/2006

APPENDIX B:
Qualifications of Key Personnel

QUALIFICATIONS OF KEY PERSONNEL

Joan Deming

Joan Deming, co-principal and Vice President of Archaeological Consultants, Inc., has more than 30 years of Cultural Resource Management experience. A Registered Professional Archaeologist (RPA), she received an M.A. in Anthropology/Public Archaeology from the University of South Florida in 1976, and has completed advanced training in Section 106 Agreement Document Preparation, Cultural Resource Management Plans: Preparation and Implementation, and Integrating NEPA and Section 106. She also has specialized training and experience in Native American coordination under the Native American Graves Protection and Repatriation Act (NAGPRA), as well as archaeological collections and records management.

Since 1990, Ms. Deming has managed all ACI's work on behalf of the National Aeronautics and Space Administration (NASA) at the Kennedy Space Center (KSC) and for the U.S. Air Force at Cape Canaveral Air Force Station. These investigations include a multi-year KSC-wide archaeological survey and preparation of a site location predictive model; archaeological surveys of several proposed development parcels conducted in compliance with Section 106 of the National Historic Preservation Act; the development of standard operating procedures for the management of NASA’s records pertaining to cultural resources; an inventory and assessment of archaeological collections and the evaluation of curatorial facilities; survey and evaluation of NASA-controlled facilities within the KCS; and preparation of a Cultural Resource Management Plan (CRMP) for the KSC. She is currently managing a NASA-wide survey and evaluation of historic facilities in the context of the Space Shuttle Program (SSP), including work on behalf of NASA’s Glenn Research Center in Ohio; Dryden Flight Research Center in California; the Marshall Space Flight Center in Alabama; the Johnson Space Center in Texas; the White Sands Flight Facility in New Mexico; and the KSC in Florida. She is also preparing a synthesis report of NASA’s SSP facilities at 13 centers and field installations.

Patricia Slovinac

Patricia (Trish) Slovinac is an Architectural Historian for Archaeological Consultants, Inc. (ACI). She attended The University of Virginia (UVA) where she completed course work for the degree of Master of Architectural History, with a Certificate in Historic Preservation. Prior to joining ACI, Ms. Slovinac was employed by the National Architectural Trust in Washington, D.C., focusing on the donation of Conservation Easements. This involved evaluating historic structures for the purpose of determining their significance as part of a National Register of Historic Places (NRHP) historic district. Ms. Slovinac has experience in the preparation of historic contexts, historical/architectural field survey and site documentation, National Register nominations, and mitigation measures for historic resources, including HABS/HAER documentation. She has experience in hand drafting to HABS/HAER standards, and is skilled in black and white photography.

As part of ACI's NASA-wide survey and evaluation of historic facilities in the context of the Space Shuttle Program, Ms. Slovinac is assisting in the development of a historic context, and has taken the lead on the field survey at various NASA Centers including the KSC, the Marshall Space Flight Center, the Johnson Space Center (JSC), the Glenn Research Center, the Dryden Flight Research Center, and the White Sands Flight Facility. Work consists of a review of the facilities in terms of eligibility for the National Register of Historic Place, and for KSC, the preparation of National Register nominations and updating KSC's Multiple Property cover nomination.

KAREN J. WEITZE *Architectural-Engineering Research, Analysis, and Documentation*
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Expertise and Education

Ph.D. Architectural History, Stanford University, 1978
M.A. Architectural History, Stanford University, 1976
B.A. History and Architectural History, University of Texas, 1973

Employment

2001- Weitze Research
Sole Proprietor / President
1998-2001 KEA Environmental, Inc., San Diego, California
Principal Investigator / Project Manager
1994-1997 Geo-Marine, Inc., Plano, Texas
Principal Investigator /Project Manager
1989-1994 Dames & Moore, Inc., Austin, Texas.
Senior Architectural Historian / Principal Investigator / Project Manager
1978-1988 Assistant Professor, Kansas State University
Assistant Professor, University of California, Davis
Associate Environmental Planner, Caltrans, Sacramento (California DOT)
Architectural Historian, California Office of Historic Preservation, Sacramento

Representative Government Projects

United States Air Force

2007 *Historic Range Context Air Armament Center Eglin Air Force Base (1936/1939-1996)*. Two volumes. Volume I: *Narrative and Appendix A (Radar and Instrumentation Sites / Santa Rosa Island / Water Ranges)*. Volume II: *Land Test Areas*.
2006 *Mountain Home Air Force Base Historic Building Inventory and Evaluations*.
2006 *Historic Buildings and Structures Inventory Douglas Missile Test Facility*.
2006 *PAVE PAWS Beale Air Force Base HAER No. CA-319*
2005-2006 *Air Combat Command Data Base, Phase I*.
2005 *Historic Facilities Groups at Air Combat Command Installations: A Comparative Evaluation*
2005 *Strategic Air Command (SAC) Alert Historic District Request for Determination of Eligibility Eglin Air Force Base*
2003 *Keeping the Edge: Air Force Materiel Command Cold War Context (1945-1991)* Three volumes. Volume I: *Command Lineage, Scientific Achievement, and Major Tenant Missions*. Volume II: *Installations and Facilities*. Volume III: *Index*. Partner, EDAW, Inc.
2003 *Eglin Air Force Base Inventory of Historic Properties 2001-2003. Parts I, II, and III.*
2001 *Eglin Air Force Base, 1931-1991: Installation Buildup for Research, Test, Evaluation, and Training*
2001 *Eglin Air Force Base Inventory of Historic Properties FY 2000.*
1999 *Cold War Infrastructure for Air Defense: The Fighter and Command Missions*

1999 *Cold War Infrastructure for Strategic Air Command: The Bomber Mission*
1998 *PAVE PAWS Large Phased-Array Radar Historic Evaluation and Context*
1997 *Guided Missiles at Holloman Air Force Base: Test Programs of the United States Air Force in Southern New Mexico, 1947-1970*
1996 *Inventory of Cold War Properties. Andrews, Charleston, Dover, Grand Forks, McChord, Scott, and Travis Air Force Bases*
1996 Architectural Inventory and Evaluation of Cold War Structures at Minot Air Force Base
1994 *Aeromedical Evacuation Annotated Bibliography*
1994 *National Register of Historic Places Evaluation Peacekeeper Rail Garrison Vandenberg Air Force Base*
1993 *Historic Architectural Engineering Survey Atlas ABRES-A Vandenberg Air Force Base*
1993 *Request for Determination of Eligibility Atlas 576 G Vandenberg Air Force Base*
1992 *Re-evaluation of the NRHP Eligibility for the White Alice Installations at Bethel, Middleton Island, and Pedro Dome, Alaska* (tropospheric communications network)
1991 *Request for Determination of Eligibility SLC-2W and SLC-2 Blockhouse Structures Vandenberg Air Force Base* (Thor intermediate ballistic missile launch complex)

National Aeronautics and Space Administration
2007 *Hugh L. Dryden Flight Research Center, Edwards, California: Survey and Evaluation of NASA-Owned Historic Facilities and Properties in the Context of the U.S. Space Shuttle Program*.
2004 *Historical Assessment for the Equipment Boneyards at the Marshall Space Flight Center*
2003 *Historical Assessment of Marshall Space Flight Center*

United States Army
2007 *National Stockpile Sites Alpha, Baker, Charlie, and Dog: Design and Development, 1946-1955*.
2005 *Cold War Properties at West Fort Hood: Research Overview and Preliminary Identification*
1999 *Seacoast Fortifications Preservation Manual Golden Gate National Recreation Area San Francisco*
1996 *Dugway Proving Ground, German Village Complex HAER No. UT-35* (Utah)
1996 *Aurora Pulsed Radiation Simulator HAER No. MD-144* (Maryland)
1996 *Detroit Arsenal West Site R&D Facilities HABS Level IV Inventory*

United States Navy
2000 *The Marine Corps Air Station, Tustin, Lighter-than-Air Ship Hangars HABS No. CA-2707* (California)

Government Projects in Progress

2007 Inventory for the Santa Susana Field Laboratory, southern California. For the NASA Marshall Space Flight Center. Team member for Archaeological Consultants, Inc.
2007 Research and analysis of the German Village (World War II incendiary test area) at the Dugway Proving Ground, Utah.
2006-2007 *Inventory and National Register Evaluation Selected Buildings in the Baker Area, Dugway Proving Ground, Utah*.
2006-2007 *Marshall Space Flight Center, Huntsville, Alabama: Survey and Evaluation of NASA-Owned Historic Facilities and Properties in the Context of the U.S. Space Shuttle Program*.
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Public Service and Affiliations

Society of Architectural Historians, 1975 to the present

Texas Review Board, 1991-1995 (governor appointment)

References

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