April 15, 2016

SOIL GAS INVESTIGATION WORKPLAN

BUCKLEY ROAD VICINITY
San Luis Obispo, California

Submitted to:
Central Coast Regional Water Quality Control Board
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1.0 INTRODUCTION

Roux Associates, Inc. (Roux Associates) has been retained on behalf of the County of San Luis Obispo (County), to evaluate claims made against the County by the Central Coast Regional Quality Control Board (RWQCB) and various claimants regarding alleged groundwater contamination near Buckley Road. Roux Associates is submitting this Soil Gas Investigation Workplan (Workplan) to the RWQCB, to conduct a phased soil gas investigation in the vicinity of the San Luis Obispo County Regional Airport (Airport), located at 901 Airport Drive in San Luis Obispo, California. For the purposes of this workplan, the Site consists of the secure operational areas of the Airport (runways, taxiways and associated security zones) and County owned land, outside of the airport operational zones (Figures 1 and 2). The scope of work described below was developed based upon a letter from the RWQCB dated February 26, 2016, and a meeting with the RWQCB held on March 8, 2016.

As described by the RWQCB (RWQCB, 2015 and 2016) concentrations of the chlorinated solvent trichloroethene (TCE) have been detected in one or more water supply wells located in close proximity to 795 Buckley Road since the 1990s. When the supply wells were initially tested in the early 2000s, monitoring data indicated a maximum TCE concentration of 320 micrograms per liter (µg/L) in groundwater (RWQCB, 2015). Since that time, TCE concentrations have reportedly fluctuated, but there is an overall decreasing trend. The most recent groundwater monitoring data indicate a maximum TCE concentration of 61 µg/L in groundwater, which exceeds the California Department of Public Health's maximum contaminant level for TCE of 5 µg/L in groundwater (RWQCB, 2015).

There are at least two known groundwater wells on the Site (Figure 2). Groundwater samples collected recently by the County detected low levels of TCE. The County conducted reviews of current and past operations, and reviewed records and historical documentation. The County has not found any indications of storage, use, misuse, transfer, spills, or disposal of TCE or products containing TCE (County, 2016A and 2016B; SAIC, 1997A and 1997B; USACE, 1999. Because this extensive research regarding historical activities conducted on County property have revealed no indication that TCE was used or stored on the Site, the source of TCE in groundwater in the Buckley Road vicinity is unknown. Beyond information already provided Research into potential additional aerial photographs, aerial photograph advanced analysis, historical airport operations,

and groundwater data are ongoing and have not been completed. Any significant findings will be communicated to the RWQCB promptly, if any meaningful new information is identified.

Despite historical records that show no evidence of TCE use on County property, the February 26, 2016 RWQCB directive required the County to submit a detailed workplan to investigate the potential presence of TCE in soil gas and groundwater along Buckley Road and at other locations in the vicinity of the Site. In summary, the investigation portion of the directive states that the workplan must include:

1. A proposal for collecting groundwater samples along Buckley Road;
2. A proposal for soil gas sampling along Buckley Road, specifically at stormwater drainage pathways;
3. A proposal for soil gas sampling at the former leach field area located east of Runway 25, including a provision for collecting groundwater samples where TCE is detected in soil gas; and
4. A proposal for soil gas sampling at other areas at the Airport, based on a review of aerial photographs, disposal records, and operational records.

Roux Associates is proposing a phased approach to address the RWQCB directive. This workplan will primarily address Items 2, 3, and 4; Item 1 is addressed in a Groundwater Investigation Workplan, which is being submitted concurrently under separate cover. Item 3 as it relates to groundwater is also partially discussed in the Groundwater Investigation Workplan.

2.0 PRELIMINARY CONCEPTUAL SITE MODEL

The following presents a preliminary conceptual site model, as very little to no information is known regarding the potential sources or pathways for TCE impacts detected in industrial/commercial and residential groundwater wells in the Buckley Road and Site vicinity. Sparse information is currently available related to the lateral and vertical lithologic and hydrogeologic setting, let alone sub-regional groundwater horizontal and vertical flow characteristics and the localized influences of groundwater extraction on regional groundwater flow.

2.1 Site Description

The Site is located approximately 3 miles south-southeast of the City of San Luis Obispo, California (Figure 2). The Site is situated west of Highway 227, south of Tank Farm Road, and north of Buckley Road. It consists of approximately 340 acres (Coffman, 2005). In addition, there is a fire station located at 4671 Broad Street and leases other locations in this area including a restaurant and car rental businesses. The Airport and these locations are collectively referred to herein as the "Site."

2.2 Topography

The Site elevation ranges from approximately 135 feet along the western Site boundary, to approximately 215 feet at the southeastern Site boundary at the intersection of Buckley Road and Highway 227 (United States Geological Survey [USGS] topographic map, Pismo Beach, California Quadrangle; Appendix A). The Site and vicinity slope generally towards the northwest and west.

2.3 Drainage

General plans for the Site describe the topography as nearly level, with surface drainage generally running from east to west. An engineered system of surface collection ponds and drainage conveyances help move water off the Site and discharge it in one of several locations, including an outfall near Buckley Road (Mead and Hunt, 2006). Historically, much of the southeastern portion of the Site and drainage onto the Site from the north or east drained first to a detention area or basin onsite, which was then conveyed via a pipeline under Runway 29, toward Buckley Road and thereafter into a swale/depression and under a culvert to south of Buckley Road.

Main Site operations and maintenance, however, are currently drained toward a basin located north of the Site (Mead and Hunt, 2006). The Fire Station appears to be drained toward off-site detentions basins located north of Highway 227 or south of Buckley Road. A figure showing current drainage pathways, as well as previous drainage pathways utilized as late as 2006 are provided as Appendix B.

2.4 Geology

The Site is located within the Coast Range Geomorphic Province of California. The province is characterized by northwest-trending mountains and valleys located between the Great Valley of California and the Pacific Ocean. The Site is situated in the San Luis Valley, which is a basin filled with Holocene-aged alluvium with fan deposits, and a maximum thickness of approximately 160 feet (Dibblee, 2006; shown in Figure 3). The alluvium rests unconformably on bedrock of the Franciscan Formation. The valley is bounded on the northeast by the Santa Lucia Range, on the southwest by the San Luis Range, and on all other sides by contact with impermeable Miocene and Franciscan Group rocks and the Los Osos and Edna Faults (County, 2015).

The Site and vicinity are located in the northeastern portion of the Pismo Beach Quadrangle. The Site and businesses on Buckley Road are situated on older alluvium consisting of clay, dissected gravel, and sand (Dibblee, 2004). The alluvium is thickest (more than 160 feet thick) in the western portion (Cleath, 1987). Immediately to the east of the Site is described as consisting of Franciscan Rocks, pervasively sheared melange, primarily dark claystone and sandstone, marine sedimentary and volcanic rocks from the Jurassic and Cretaceous periods. To the south is described as the Paso Robles Formation from the Pliocene to Pleistocene, consisting of older alluvial gravel, sand, and clay.

According to an environmental assessment performed in 2005, the soils beneath the Site are classified as sandy loam, silt-clay materials, and Cropley clay. This soil is described as "somewhat to very deep and well drained ... (with) very slow permeability, medium surface runoff, and moderate erosion hazard" (County, 2016A). Soil from a boring advanced south of Buckley Road was described as sandy silty clay in the shallow vadose zone. At approximately 25 feet below ground surface (bgs), soil was described as clayey sand with gravel (Beacon, 2009 and Appendix C). A search was performed for boring logs for groundwater wells installed at the

Site, but none were located and a request to the California Department of Water Resources for the boring logs for the two known wells on the Site is still outstanding.

2.5 Hydrogeology

The Site and vicinity lie within the northern/western portion of the San Luis Obispo Valley Groundwater Basin, which consists of Pleistocene to Holocene-age terrestrial deposits of gravel, sand, silt, and clay of fluvial origin (DWR, 2003). Primary groundwater producing formations include the Franciscan Formation, the Squire member of the Pismo Formation, and alluvium, with the alluvium being the primary groundwater-bearing material (Cleath, 1987). Saturated aquifers within the alluvium are typically less than 40 feet thick and are interspersed with clay layers (Cleath, 1987). The Edna Fault is reportedly located east of the Site, but the fault does not appear to affect the movement or quality of groundwater (SWRCB, 2004). Groundwater in the basin is recharged through infiltration of precipitation (between approximately 19 to 23 inches per year), applied irrigation water, and streamflow (Cleath, 1987).

Water supply in the region is obtained primarily from groundwater (Cleath, 1987). Consequently, the region surrounding the Site has many groundwater wells, especially in the more developed areas and along Highway 227 (Cleath, 1987), including those sampled recently for TCE (RWQCB, 2015). Agricultural, municipal, and industrial extractions total approximately 5,800 acre feet per year (SWRCB, 2004). Trend analysis of groundwater levels suggest that groundwater levels are quickly responsive to increased pumping during droughts (Cleath, 1987).

The groundwater gradient in the San Luis Valley generally flows toward San Luis Obispo Creek from the east and north; in the southeast portion of the Site, however, information on groundwater flow is insufficient to draw definitive conclusions, but may be expected to flow toward the west northwest, generally paralleling the topography as it flows into the San Luis Valley Groundwater basin between the Santa Lucia and the San Luis Ranges (Cleath, 1987). Cleath noted a possible depression in groundwater levels south of Buckley Road, possibly due to groundwater pumping practices (Cleath, 1987). The local groundwater flow direction may vary vertically and is also influenced by localized groundwater production for both residential and industrial use along Buckley Road. Well logs and screened intervals for any wells in the region are unknown at this time.

At least six groundwater extraction wells do currently, or have existed in the Buckley Road industrial/commercial area as part of permitted Non-Transient/Non-Community Water Systems associated with industrial/commercial uses, including Strasbaugh, Noll, and Buttonwood Industrial Park (SDWIS, 2016). Where a Non-Transient/Non-Community Water system is defined as, *"A public water system that regularly supplies water to at least 25 of the same people at least six months per year. Some examples are schools, factories, office buildings, and hospitals which have their own water systems."* (USEPA, 2016). The magnitude and frequency of groundwater extraction associated with these non-residential uses and the subsequent local influence of groundwater extractions on the general regional groundwater gradient and flow direction both laterally and vertically is not known.

In 2015, at the Former San Luis Obispo Tank Farm located immediately to the west of the Airport, depth to groundwater ranged between approximately 10 feet to 25 feet bgs. The direction of groundwater flow was calculated to generally flow toward the southwest under a hydraulic gradient of approximately 0.006 ft/ft. (Padre, 2015).

2.6 Hypothetical Sources, Pathways, and Receptors

As stated above, concentrations of TCE in groundwater have been detected in several water supply wells located in close proximity to Buckley Road south of the Site. The source of these impacts is unknown. A Soil Gas Investigation Workplan is being submitted to the RWQCB under separate cover to screen areas of the Site for the presence of VOCs in shallow soil gas, including TCE. Although the RWQCB has issued informational/investigation directives to at least three entities in the Buckley Road vicinity, a comprehensive knowledge of past solvent storage, use and disposal is not known for all of the industrial/commercial entities in the Buckley Road vicinity.

The RWQCB has noted that drainage pathways on the Site, including in particular a storm drain pipe travelling under Runway 29 and flowing toward and south of Buckley Road, may have hypothetically transported discharges from the Site to the subsurface offsite. A search of numerous historical records by the County has not found any indication that TCE was used, disposed of, or spilled on the Site (County, 2016A and 2016B). As discussed in Section 2.5, the groundwater flow direction, although primarily east to west, is also uncertain both: a) laterally and vertically; and, b) due to historical and current pumping activities (Cleath, 1987).

Known and potential receptors of impacted groundwater are water supply wells located south of Buckley Road.

3.0 SITE HISTORY

The historical uses of the Site were researched by reviewing:

- information already submitted and new information that is being sent concurrently by the County with this workplan to the RWQCB (County, 2016A and 2016B);

- historical aerial photographs (Figures 4A through 4L and Appendix D) and historical topographic maps (Appendix A); and

- additional information relating to evaluations of the former military use of County property from the United States Army Corps of Engineers (USACE) are included in Appendix E.

For a discussion of the historical information for the surrounding properties, see Roux Associates' Groundwater Investigation Workplan, dated April 15, 2016.

3.1 County Property Research and Submissions to the RWQCB

A review of the Airport's Material Safety Data Sheet (MSDS) records going back 30 years (provided in a letter from San Luis Obispo County, dated January 20, 2016), shows the only 'solvents' used were two paint thinner products (Ace Paint Thinner and Klean Strip Paint Thinner) which use aliphatic hydrocarbons Stoddard Solvent as active ingredients, and two concrete ·degreaser products (SSS HD Concrete Degreaser, Oil-Eater Cleaner Degreaser), which use sodium hydroxide or terpene hydrocarbons (citrus derivatives) as primary active ingredients. The quantities of these chemicals on the Site were less than 5 gallons at any one time (San Luis Obispo County, 2016A).

The County identified only two spills (both were fuel spills): one in 1990, and another in 1988 (County, 2016A). These spills occurred in an area of the airport that drains to the north. While subsurface petroleum hydrocarbon (jet fuel) impacts were found resulting from drainage off this portion of the Site, the reports do not indicate that TCE was found in the soils or groundwater (County, 2016A). The same location where military operations, if any, would have taken place is believed to have drained into this area of the Site. In 1995, a Phase II environmental assessment of the Filbin site, located immediately west of the Site, found no chlorinated solvents (or other impacts) in the groundwater (County, 2016A).

3.2 Department of Defense, Formerly Used Defense Site Evaluation

On behalf of the USACE and the Department of Defense, SAIC performed a thorough evaluation of the past operations of the Site as a former defense site and general activities since then (key documents provided in Appendix E). The general findings of that process (corroborated by historical aerial photographs and topographic maps) which culminated in a formal Findings of Fact document include, but are not limited to:

- The Airport existed prior to military involvement. Reportedly, the County leased 116 acres of land in 1938 (SAIC, 1997A [Appendix E.1]). The airport reportedly opened in March, 1939 (County, 2014). While starting in November 1938, the Airport was also used by the U.S. Army Air Corps and the California National Guard (USACE, 1999). Starting in 1938, the first use of the Airport by the Military was reportedly related to, "the 40th Division Aviation of the California National Guard approved use of the airport for training purposes," and indicated that, "the airport was to consist of 4,000 foot main runway, an administration building, hangars, photographic unit, barracks, mess halls, mechanic shops, two 47s reconnaissance/photograph planes, and five Douglas 32s" (SAIC, 1997A). What appear to be dirt strips are visible on the earliest available aerial photograph dated 1939 (Appendix D);

- During and immediately after the War (starting in 1943 [USACE, 1999]), reportedly ending in 1946, the U.S. Navy leased the airport as an auxiliary backup field to the Alameda Naval Air Station for emergency landings and to support land and sea operations. However, the airport was reportedly not frequently used, and only five people were stationed at the Airport (SAIC, 1997A). The Navy's use of the airport reportedly did not even include fuel storage, and no military planes were reportedly stored at the airport during the Navy's occupancy (SAIC, 1997A);

- In 1946, reportedly the first commercial airline operations (Southwest Airways) began at the Airport (SAIC, 1997A and County, 2014). The Southwest Airways operations reportedly stopped in 1955 (San Luis Obispo County, 2014). Development of more landing strips and an airplane hangar is visible in the 1949 aerial photograph and airport development is evident in the 1952 topographic map;

- In the 1960s, Coastal Air reportedly operated one Underground Storage Tank selling fuel to private planes, while reportedly no commercial airline operations were based at the airport in the early 1960s (SAIC, 1997A);

- Reportedly, in the late 1960s, commercial airline operations resumed at the Airport (County, 2014). Swift Aire was based at the Airport between 1969 and 1981. Significant building development is visible on the 1965 topographic map (Appendix A) and the 1972 aerial photograph (Appendix D); and

- There is only one mention of any non-petroleum related hazardous materials storage in the SAIC documentation relating to the American Eagle/Wings West hangar (SAIC, 1997B [Appendix E.2])

In all of the information reviewed by SAIC on behalf of the Department of Defense, it appears that the only documented, or even suspected, underground storage of fluids at the Airport included petroleum hydrocarbons, with the exception of one or two waste oil or underground slop storage tanks (SAIC, 1997A). No indications of chlorinated solvent (or TCE) use, handling or disposal or explicit mention of any hazardous materials disposal areas during, or after military use at the Airport were noted by SAIC.

The military use of the Airport at maximum intensity between 1938 and 1946 appears to have involved basing of approximately seven military airplanes for aerial observation and civilian training. Although mechanic shops were noted as being present, it is relatively unlikely based upon historical evaluations of military chlorinated solvent use; that such a small military operation would rise to the level of obtaining highly controlled and prioritized chlorinated solvents (Doherty, 2012, attached as Appendix E.4).

The only two significant commercial operators at the Airport until the 1980s were Southwest Airways between approximately 1946 and 1955 and Swift Aire between approximately 1969 and 1981 (San Luis Obispo County, 2014).

3.3 Historical Aerial Photographs

Scaled and aligned selected aerial photographs are presented in Figures 4A through 4L and are electronically provided in Appendix D. The aerial photograph acquisition, review and analyses task is not complete; however, the aerial photographs as currently presented are informative for evaluating general geographical/land-use changes in the Buckley Road vicinity.

Historical aerial photographs were obtained from EDR for the years 1939, 1949, 1956, 1959, 1963, 1965, 1972, 1978, 1987, 1994, 2002, 2005, 2009, 2010, and 2012. Historical aerial photographs for the years 1939, 1949, 1956, 1999, 2003, 2007, 2011, and 2014 were obtained from San Luis Obispo County. The historical aerial photographs for the years 1960, 1963, 1981, 1994, and 2011 were obtained from the United States Geologic Survey (USGS). Copies of these photographs are included as Appendix D.

3.4 Historical Topographic Maps

Historical topographic maps of the Site were obtained from the USGS for the years 1942, 1952, 1965, 1978, and 1998 and are presented in Appendix A. The topographic maps corroborate the reported general development of the Site and surrounding area, as shown in the historical aerial photographs.

4.0 PROPOSED SCOPE OF WORK

All work will be performed under the direction of a California-registered Professional Geologist. The soil gas investigation will be implemented by means of a phased approached and will include the following:

- Soil Gas Sampling Adjacent to Buckley Road; and
- Soil Gas Sampling at the Former Leach Field East of Runway 25 and in Historical and Current Operations Areas.

The soil gas investigation will utilize passive sampling techniques as a means of screening for vadose zone impacts. Because Site records do not mention historical use of TCE, the targeted areas of investigation are large. Passive sampling techniques present a cost-effective way to develop a screening-level picture of a large site and evaluate whether the subsurface has been impacted (Cal-EPA, 2015).

If the results of the passive soil gas sampling activities show positive, or significant detections of TCE in soil gas, Roux Associates may recommend active soil gas sampling in order to report TCE concentrations present in the subsurface with greater specificity, in accordance with RWQCB protocols (Cal-EPA, 2015).

4.1 Proposed Passive Soil Gas Sampling Locations

As shown in Figures 5 and 6A, the proposed scope of work involves the collection of passive soil gas samples on the Site. The scope of work requested by the RWQCB has been divided into two phases. Phase I is centered south of the runways near Buckley Road and a known current and historical stormwater drainage channel (Figure 5). This phase is designed to satisfy Item Number 2 of the RWQCB directive. Phase II will be a screening of the historical leach field as depicted by Cleath (1987) and current and historical operational areas, which as discussed in Section 3.0, have primarily been concentrated north of the runways (Figures 6A and 6B). This phase is designed to satisfy Item Numbers 3 and 4.

4.1.1 Phase I – South of Runways

As shown in Figure 5, the proposed scope of work for Phase I, involves the collection of passive soil gas samples from an area spanning approximately 2,000 feet south of the runways and parallel

to Buckley Road. Passive sampling modules will be spaced in a transect with approximately 100-foot spacing in most areas, per manufacturer recommendations. In the area immediately surrounding the drainage channel, passive sampling modules will be spaced approximately 50 feet apart. A secondary transect line will be stepped back approximately 50 feet to the north and will be spaced approximately 200 feet apart. See Figure 5 for proposed sample locations. As requested by RWQCB in the February 26, 2016 letter, this initial scope of work (Phase I) will be scheduled immediately after approval of this workplan.

4.1.2 Phase II – Soil Gas Sampling at the Former Leach Field and Operational Areas

As requested in Item Number 3 of the workplan requirements, soil gas samples will be collected within and around the boundaries of the former leach field, as drawn in Cleath's 1987 Groundwater Study (see Figure 6A).

As requested in Item Number 4 of the workplan requirements, soil gas samples will also be collected in the primary current and historical operational areas of the Site (Figures 6A and 6B, respectively). As described in Section 3.0 and noted in historical aerial photos and current Site layout maps, operations and maintenance activities have almost exclusively been located north of the runways. In addition to these operational areas, the former Aircraft Rescue and Fire Fighting (ARFF) facility, also known as Fire Station 21, will also be targeted in this phase of investigations. This facility was approximately located within the former leach field along Highway 227 (Figure 6B).

Because of the need to preserve the integrity of the Airport concrete pads and aprons, passive soil gas samplers will be deployed in unpaved accessible areas of vegetation or bare soils in transects with either approximately 50 to 100-foot spacing (See Figure 6A).

Following the completion of each phase of the proposed soil gas investigation, a soil gas investigation report will be submitted to the RWQCB with recommendations for additional characterization, if necessary. An addendum to this workplan with additional sample locations will then be drafted and submitted to the RWQCB for approval.

4.2 Pre-Field Activities

Prior to intrusive work at the Site, the field work contractor will arrange for appropriate training and security clearances, make appropriate notifications of intended subsurface sampling activities, clear boring locations, and prepare a Site-specific health and safety plan. These activities are detailed below. Because the soil gas samples are shallow, less than 25 feet bgs, and groundwater is not expected to be encountered, no permitting is required for this investigation.

4.2.1 Airport Security Clearance/Soil Gas Sample Locations

Proposed locations will first be cleared with Airport staff. Required clearances and escorts for personnel will be arranged, as well as any training, as necessary. Work on the Site will be consistent with all applicable FAA guidance (FAA, 2011). Sample locations may be modified slightly as part of this process.

4.2.2 Dig-Alert

The proposed sample areas will be pre-marked with white paint, and Underground Service Alert (USA) of Southern California will be notified at least 48 hours in advance of drilling to demarcate utilities coming to and through the Site. Intended drilling locations will be modified or relocated, as necessary, based on the proximity to subsurface utilities.

4.2.3 Geophysical Investigation

A private geophysical services and utility locating firm may be contracted to evaluate the proposed sample locations and mitigate the risk of disrupting potentially buried utility lines. As part of the investigation, the geophysical services company may use a variety of tools, including ground penetrating radar (GPR), radio detection (RD-4000), Dynatel diagnostic testing equipment, and M-Scope metal detection equipment. Intended sample locations will be modified or relocated, as necessary, based on the results of the geophysical investigation.

4.2.4 Health and Safety Plan

A Site-specific Health and Safety Plan will be prepared to identify significant risks and hazards to be potentially encountered during implementation of field work. During the implementation of field work, exclusion and work zones will be clearly demarcated with orange cones to indicate limited access areas for drilling and sampling activities. Field workers will acknowledge their

familiarity with all safety procedures and indicate their intent to follow the HASP by signing the HASP after tailgate safety meetings, which will take place at the beginning of each field day. All personnel working in the exclusion zone will be OSHA trained, consistent with federal regulation 29 CFR 191.120. The HASP will be submitted to the RWQCB at least two-weeks prior to the initiation of fieldwork.

4.3 Passive Soil Gas Sampling

Because of the extensive area to be characterized, Roux Associates is proposing a passive soil gas sampling methodology. Each passive sampler module contains an equal amount of engineered sorbent material, specifically selected for affinity to a broad range of volatile organic compounds (VOCs), while minimizing uptake of water vapor (the principal soil gas constituent in most areas). The modules are sheathed in a vapor permeable retrieval cord looped at the top. The loop is used as a means of tying the module to a string for installation and retrieval. The retrieval cord and the sorbent containers are constructed of an inert, hydrophobic, microporous expanded polytetrafluoroethene (ePTFE) membrane. The microporous structure of the membrane allows vapors to move freely across the membrane and onto the sorbent material (AGI, 2016).

Each passive sampling module will be installed in general accordance with the manufacturer instructions. In vegetation, soil, and/or gravel covered areas; the subsurface soil will be accessed by making a pilot hole utilizing an appropriate hand tool to a depth of approximately 3 feet. The passive sampling module will then be inserted into the pilot hole using a stainless steel insertion rod. The module will be inserted to a depth of approximately 3 feet bgs utilizing string and a cork with a screw eye hook attached, which will facilitate retrieval. The string will be fastened to the cork screw eye and the cork tamped about 2-inches below ground surface and sealed with hydrated granular bentonite to ground surface. Large steel washers will be placed on the top of the cork before covering with bentonite to assist in retrieval of the modules. The location of each module will be surveyed using a hand-held global positional system (GPS) unit.

The passive sampling modules will remain in the pilot hole approximately 10 days and subsequently will be removed using the cork and attached string. After retrieval of the passive sampling module, each pilot hole will be filled with hydrated bentonite to about 0.5 feet bgs and the remaining hole will be patched with similar material surrounding the hole.

All samples will be properly labeled and handled in accordance with approved protocols. The samples will carefully be packaged and mailed to an appropriate certified laboratory under standard chain-of-custody procedures. Additional details regarding field quality assurance/quality control (QA/QC) procedures are discussed in Section 5.0. Samples will be analyzed for VOCs using USEPA Method 8260; results will be reported in micrograms (µg).

4.4 Active Soil Gas Sampling

If the results of the passive soil gas sampling activities show positive, or significant detections of TCE in soil gas, Roux Associates may recommend active soil gas sampling in order to report TCE concentrations present in the subsurface with greater specificity. If such is the case, an addendum to this workplan will be submitted to the RWQCB with specific recommended sampling locations and procedures. All protocols and procedures utilized by Roux Associates will be conducted in strict accordance with the July, 2015, California Environmental Protection Agency (Cal/EPA), Department of Toxic Substances Control (DTSC), Los Angeles Regional Water Quality Control Board (LA-RWQCB), and San Francisco Regional Water Quality Control Board (SF-RWQCB), *Advisory, Active Soil Gas Investigations* (Soil Gas Advisory).

4.5 Reporting

The investigative activities for each phase will be documented in a single report, which will be will be submitted to the RWQCB for review, comment, and approval. The report will include an updated conceptual site model, as applicable, figures, and tables. The report will also include conclusions relative to potential TCE vadose zone impacts at the Site and recommendations for additional actions (if any), including recommendations for groundwater sampling in areas on the Site where TCE is found to be present, as directed by the RWQCB. The report will include the following sections:

1. Introduction
2. General Background
3. Investigation Objectives
4. Scope of Work
5. Sample Collection and Procedures

6. Field Observations and Analytical Results
7. Discussion of Results
8. Summary, Conclusions, and Recommendations
9. Closing
10. References

It is expected that the report documenting each phase of sampling will be submitted to RWQCB in late summer 2016 (see Section 6.0).

5.0 QA/QC PROCEDURES

To document the quality of the data being collected, and to assess whether reported concentrations of chemicals identified through results of analytical testing are of acceptable quality, several control checks for both field and laboratory data will be performed as described in the sections below.

5.1 Field Record Keeping

Bound field logbooks will be maintained by the field supervisor and any other team members to provide a daily record of significant events, observations, and measurements during the field investigation. All entries will be signed and dated. All information pertinent to the field survey and/or sampling will be recorded in the logbooks. The logbooks will be bound, with sequentially numbered pages.

Instruments and equipment used to gather, generate, or measure environmental data will be calibrated according to manufacturer's specifications with sufficient frequency to ensure accuracy and reproducibility of results. At a minimum, monitoring equipment used in the field will be calibrated daily against a known standard. If the results show that the concentration is within 5 percent of the known standard, the equipment will be considered calibrated.

5.2 Sample Handling

All samples will be properly labeled, preserved (where appropriate), and handled in accordance with approved protocols. All laboratory analyses will be conducted by a California-certified laboratory approved for standard quality assurance and quality control procedures (QA/QC).

5.3 Field QC Samples

As a check on field sampling, QA/QC samples will be collected. Definitions for field QA/QC samples are presented below.

5.2.1 Field Duplicates

Field duplicate samples will be collected at 10% of the sample locations. That is, 10% of the passive sampling modules will be deployed in pairs. For these locations, the primary module will be installed according to manufacturer instructions, and then a second module will be installed

according to manufacturer instructions immediately adjacent to the primary location. These secondary modules will be submitted as field duplicate samples to evaluate the precision of the sampler and the analytical laboratory. Duplicate samples will be handled in the same manner as primary samples and will be given the sample designation "D" to indicate that it is a duplicate sample. Field duplicate samples will be analyzed for VOCs and oxygenates via USEPA Method 8260.

5.2.2 Trip Blanks

Trip blanks will be collected daily during deployment and retrieval to document sample integrity associated with the shipment, collection, and storage of environmental samples. Trip blanks will be treated the same as samples, except they will not be removed from the sheath during sample deployment. The trip blanks will be stored with the samples following deployment to measure potential artifacts introduced during storage in the field and shipping for analysis.

5.4 Data Validation and Verification

The initial data interpretation, validation, and reporting will be performed by the laboratory. Data will then be validated outside the laboratory at Level II. All data validation will be in accordance with the USEPA's Contract Laboratory Program National Functional Guidelines, dated January 2010, for both organic and inorganic data review.

5.5 Data Review

The Project Manager (PM), Project Geologist, Project Scientist, or appropriate Task Leader assigned by the PM, will initially review the laboratory data for consistency with historical Site data and among primary and duplicate samples. A review of data qualifiers assigned by the laboratory will also be performed. If anomalies are found, the laboratory will be instructed to review the reported data and/or re-analyze certain samples. Acceptable data will then be compared to their and other applicable screening levels.

5.6 Corrective Actions

Corrective actions may be initiated if the precision or accuracy goals are not achieved. The first step in corrective action will be to instruct the analytical laboratory to examine its procedures to assess whether analytical or computational errors caused anomalous results. At the same time,

sample collection and handling procedures will be reviewed to assess whether they may (also) have contributed to anomalous results. Based on this evaluation, the PM, Project Geologist, Project Scientist, or appropriate Task Leader assigned by the PM, will evaluate the laboratory Method Detection Limits (MDLs) and MRLs, the sample collection procedures, the analytical parameters, sample custody and sample documentation, and will assess whether re-analysis or re-sampling is required or whether any protocol should be modified for future sampling events.

6.0 PROJECT SCHEDULE

As requested the RWQCB, below is a detailed projected schedule of events following the submittal of this workplan. The schedule is subject to change based on final workplan approval from the RWQCB, County contracting process, subcontractor scheduling, and other unforeseen delays regarding Site access on an actively operating Airport.

Activity	Start	Duration	End
RWQCB Workplan Review	4/18/16	Two weeks	5/2/16
Airport Access, Safety and Logistics	4/18/16	Six weeks	5/30/16
Meet with RWQCB	5/4/16	---	---
Revise Workplan	5/4/16	2 weeks	5/18/16
Workplan Approval	5/18/16	3 work days	5/23/16
Contracting	5/23/16	Four weeks	6/17/16
Contractor Health and Safety, Scoping, Scheduling, Permitting	6/20/16	3 weeks	7/8/16
Start Soil Gas Fieldwork, Install Probes	7/11/16	One work week	7/15/16
Soil Gas Probe Equilibration	7/15/16	Ten days	7/25/16
Retrieve Soil Gas Probes	7/25/16	Three days	7/27/16
Soil Gas Lab Analyses	7/28/16	Two weeks	8/11/16
Transmit Draft Soil Gas Results to RWQCB	8/15/16	---	---
Soil Gas Investigation Report	8/11/19	Three Weeks	9/1/16

7.0 CLOSING

Roux Associates is available to answer any questions that the RWQCB may have regarding this Workplan. Please contact Kaleena Johnson at 310-879-4930, or kjohnson@rouxinc.com or Jon Rohrer at 310-879-4921, or jrohrer@rouxinc.com.

Sincerely,

ROUX ASSOCIATES, INC.

Kaleena Johnson
Senior Scientist

Jon Rohrer, P.G., C.Hg.
Principal Hydrogeologist

8.0 REFERENCES

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FIGURES

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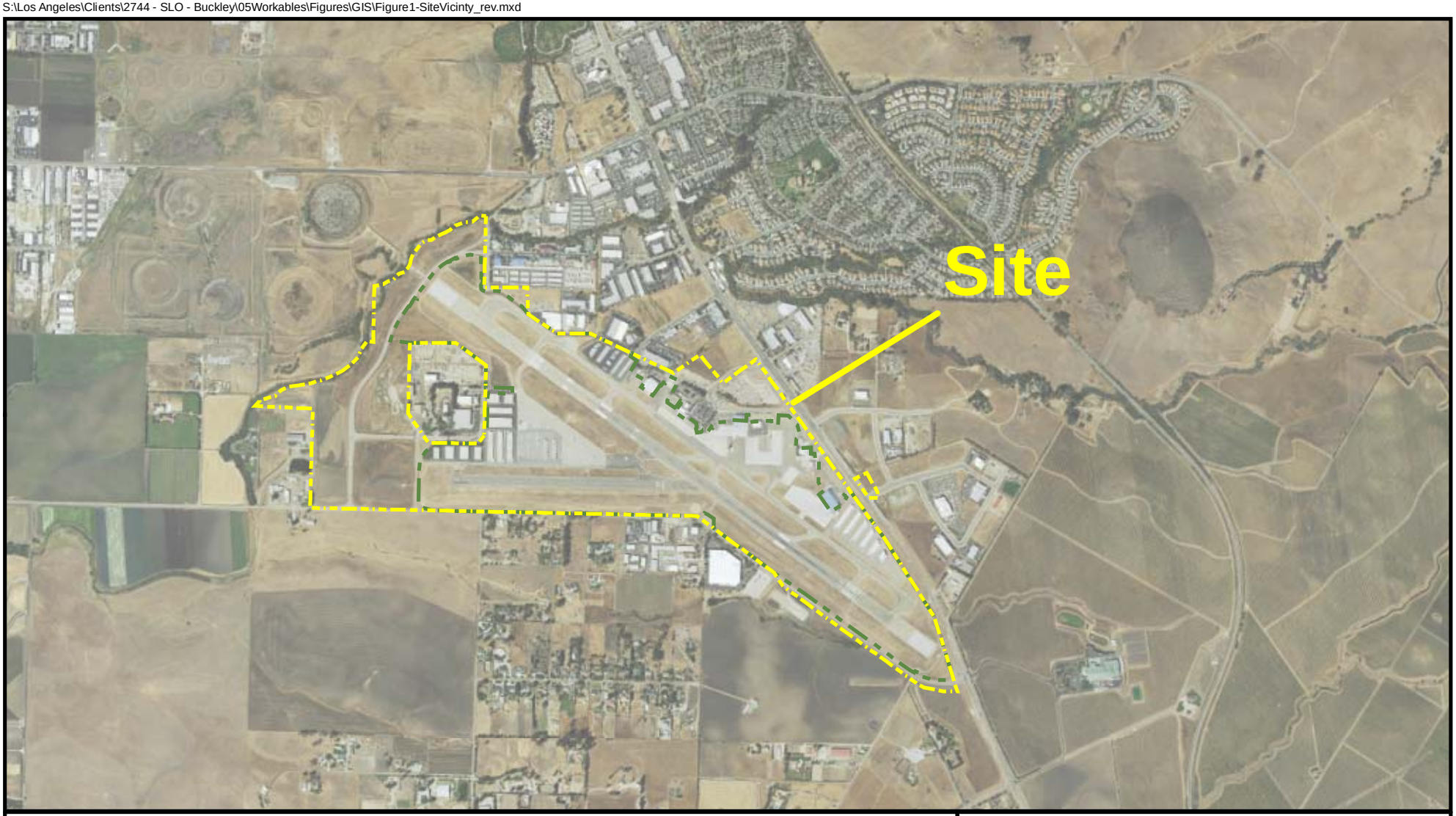

Image Source: ESRI World Imagery 2016

Legend

Site Boundary

Airport Operational Area

N

0.25 0 0.25 0.5 Miles

Title:

SITE VICINITY MAP

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

ROUX

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: PDF	Date: 4/15/2016	FIGURE
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Project Mgr: KJ	Office: LA	
File No: F(AL)	Project: 2744.0001L001	

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Image Source: ESRI World Imagery 2016

Legend

- Site Boundary
- Present Extent of Runways
- Approximate Location of Former Leach Field (Cleath, 1987)
- Existing Groundwater Monitoring Well
- Buckley Road Drainage Outlet

N

0.1 0 0.1 0.2 Miles

Title:

SITE MAP

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: PDF	Date: 4/14/2016	FIGURE 2
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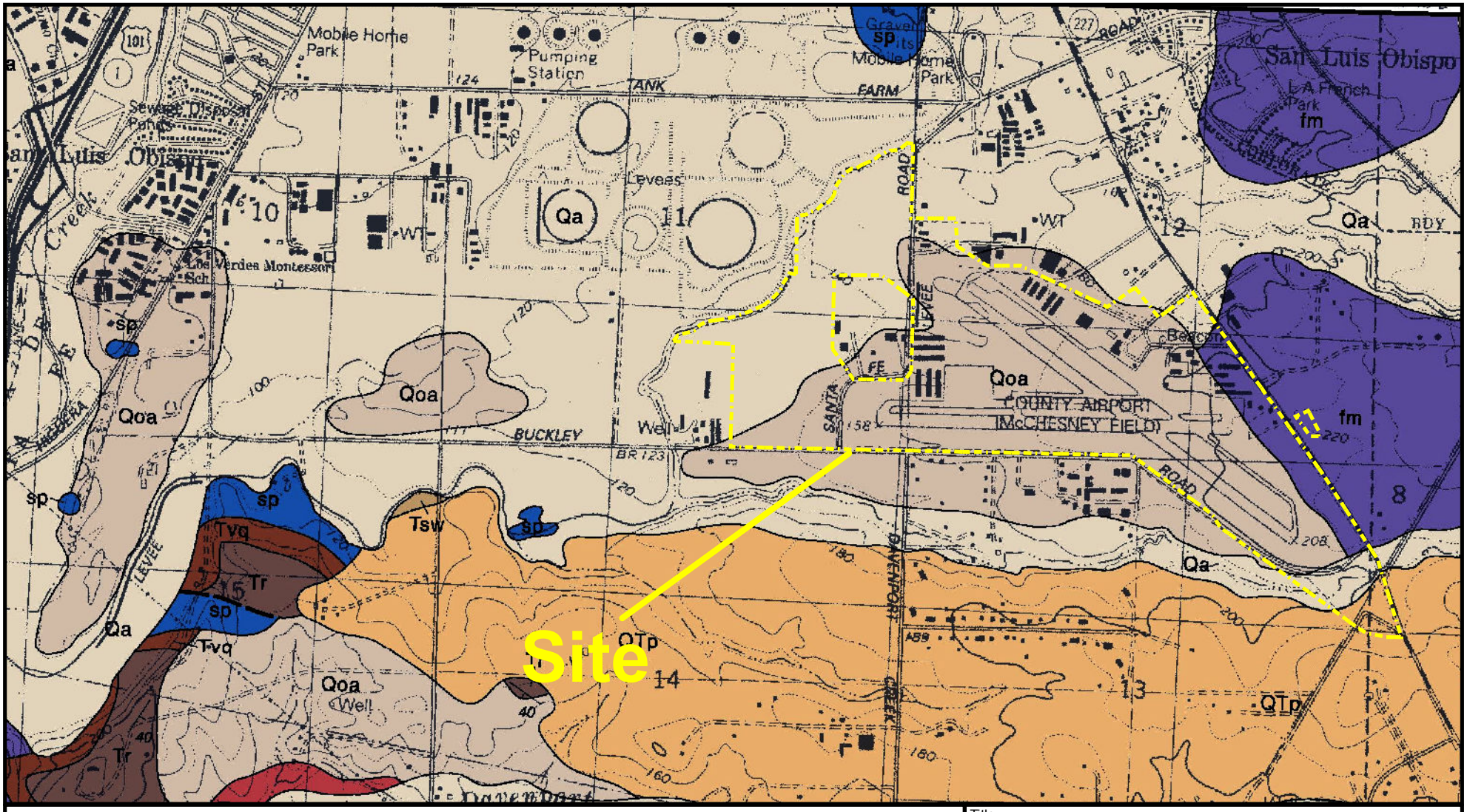

Image Source: Dibblee Pismo Beach Map (DF-212) 2006

Legend

- Site Boundary
- Qa: Surficial sediments
- QTp: Paso Robles Formation
- Qoa: Older Alluvium
- fm: Fransiscan Rocks

N

0.25 0 0.25 0.5 Miles

Title:

REGIONAL GEOLOGY

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: PDF	Date: 4/14/2016	FIGURE 3
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File No: F(AL)	Project: 2744.0001L001	

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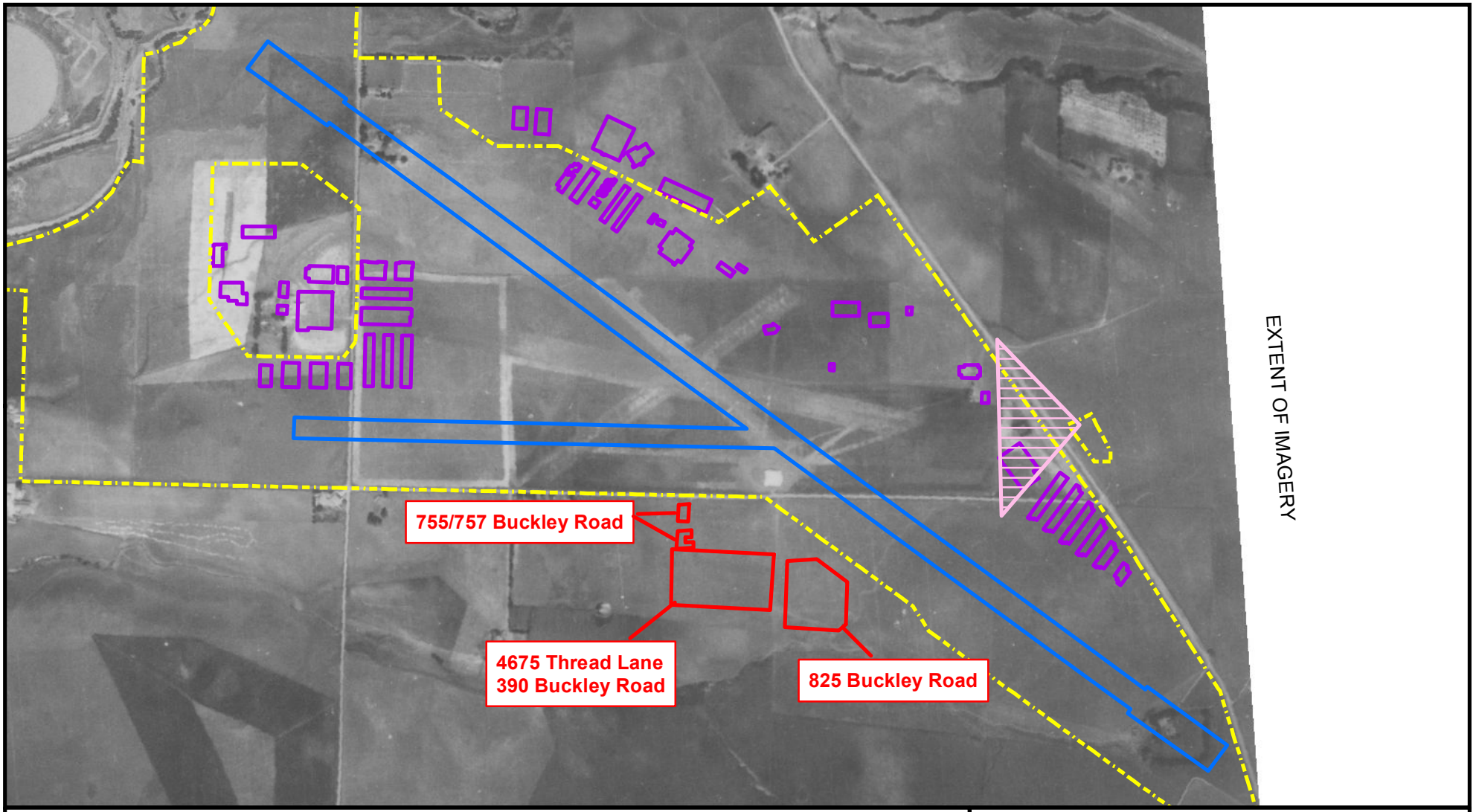

Image Source: http://gis.slocounty.ca.gov/arcgis/rest/services/Aerials

Legend

- Site Boundary
- Present Extent of Runway
- Present Building Footprints
- Approximate Location of Former Leach Field (Cleath, 1987)

N

0.1 0 0.1 0.2 Miles

Title:

1939 AERIAL IMAGERY

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: PDF	Date: 4/14/2016	FIGURE
Prepared by: PDF	Scale: 1:10,542	**4A**
Project Mgr: KJ	Office: LA	
File No: F(AL)	Project: 2744.0001L001	

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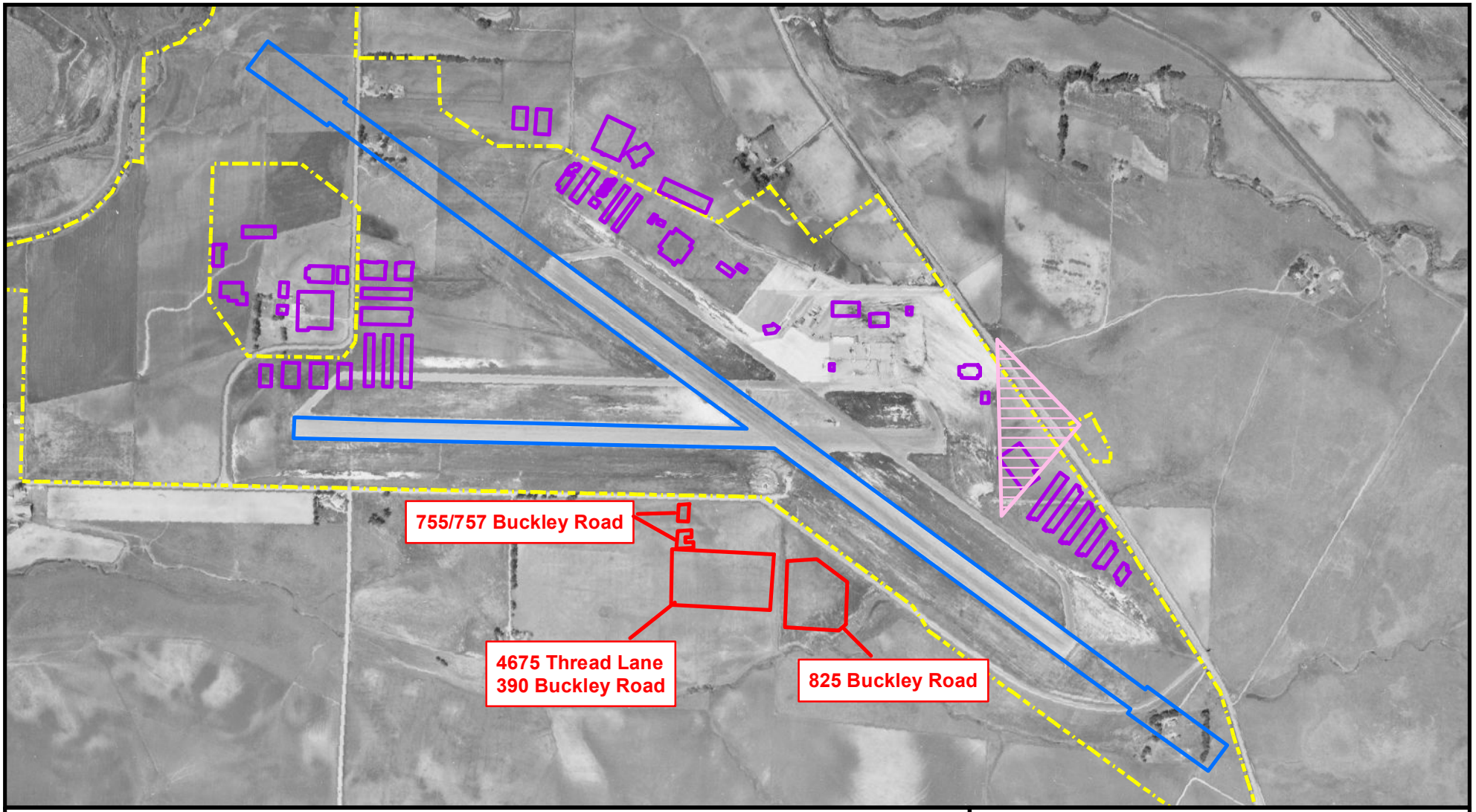

Image Source: http://gis.slocounty.ca.gov/arcgis/rest/services/Aerials

Legend

- Site Boundary
- Present Extent of Runway
- Present Building Footprints
- Approximate Location of Former Leach Field (Cleath, 1987)

N

0.1 0 0.1 0.2 Miles

Title:

1949 AERIAL IMAGERY

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

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Environmental Consulting & Management

Compiled by: PDF	Date: 4/14/2016	FIGURE
Prepared by: PDF	Scale: 1:10,542	**4B**
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File No: F(AL)	Project: 2744.0001L001	

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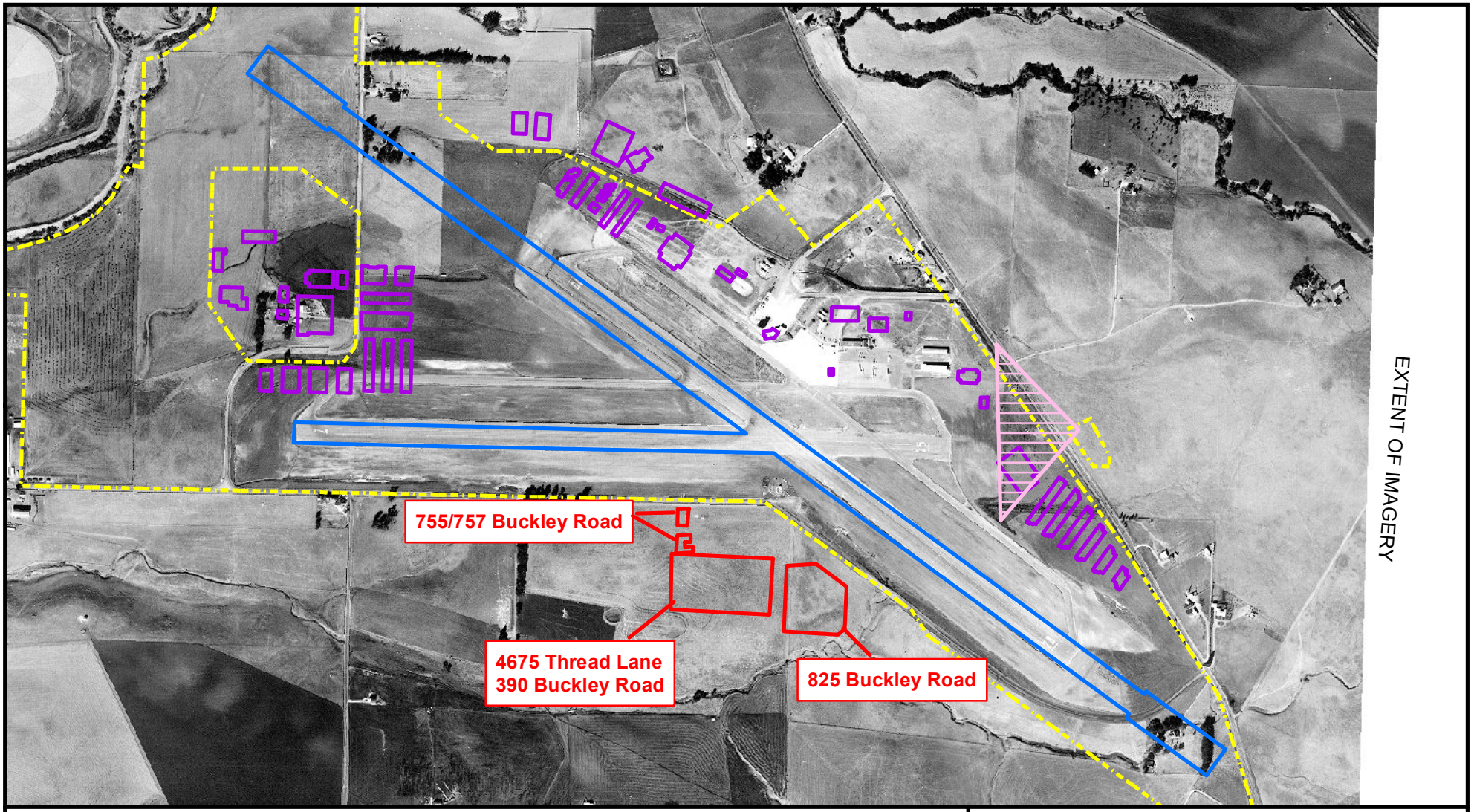

Image Source: Environmental Data Resources-Requested March 21, 2016

Legend

- Site Boundary
- Present Extent of Runway
- Present Building Footprints
- Approximate Location of Former Leach Field (Cleath, 1987)

N

0.1 0 0.1 0.2 Miles

Title:

1959 AERIAL IMAGERY

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: PDF	Date: 4/14/2016	FIGURE
Prepared by: PDF	Scale: 1:10,542	**4C**
Project Mgr: KJ	Office: LA	
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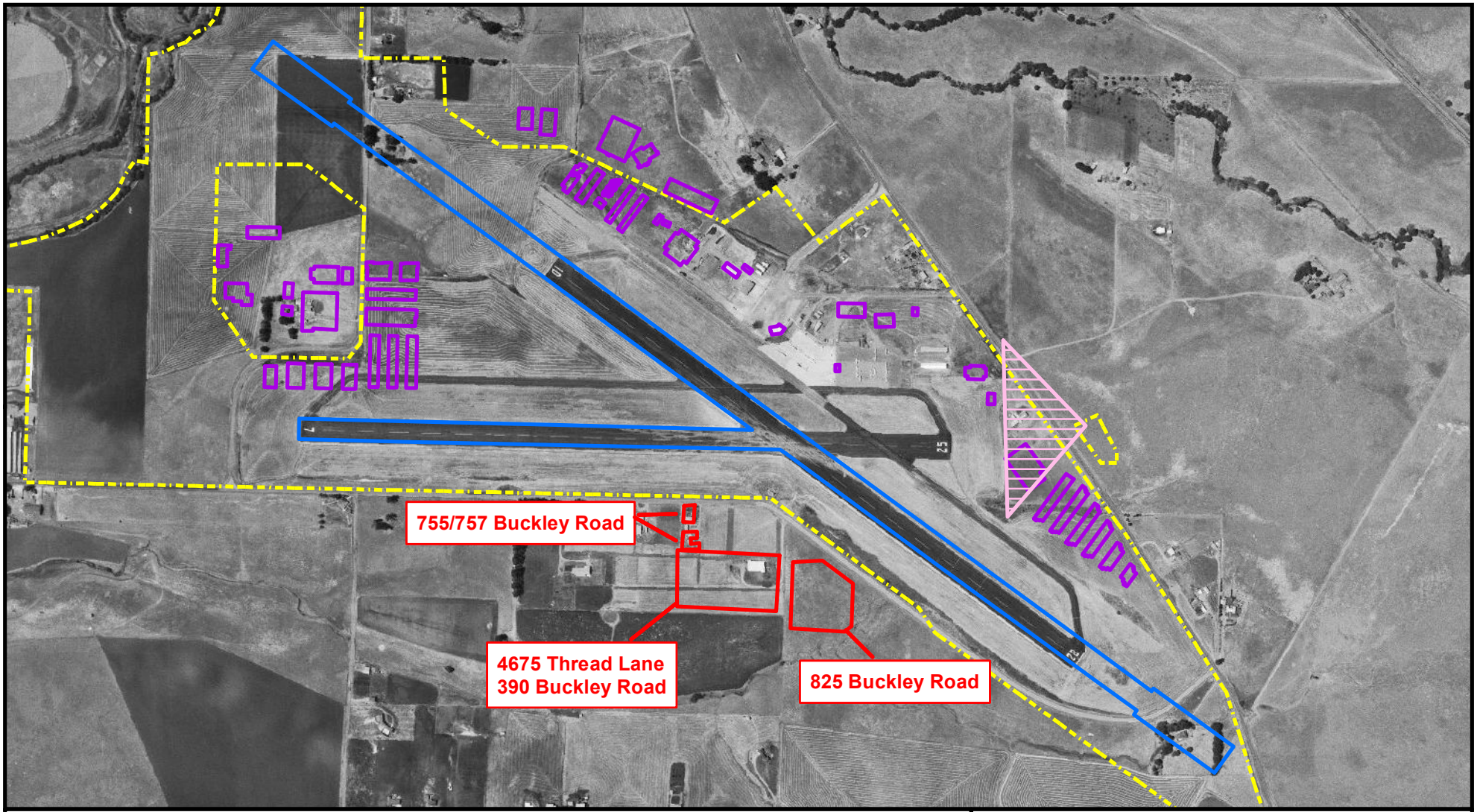

Image Source: United States Geological Survey

Legend

- Site Boundary
- Present Extent of Runway
- Present Building Footprints
- Approximate Location of Former Leach Field (Cleath, 1987)

N

0.1 0 0.1 0.2 Miles

Title:

1963 AERIAL IMAGERY

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

ROUX

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: PDF	Date: 4/14/2016	FIGURE
Prepared by: PDF	Scale: 1:10,542	**4D**
Project Mgr: KJ	Office: LA	
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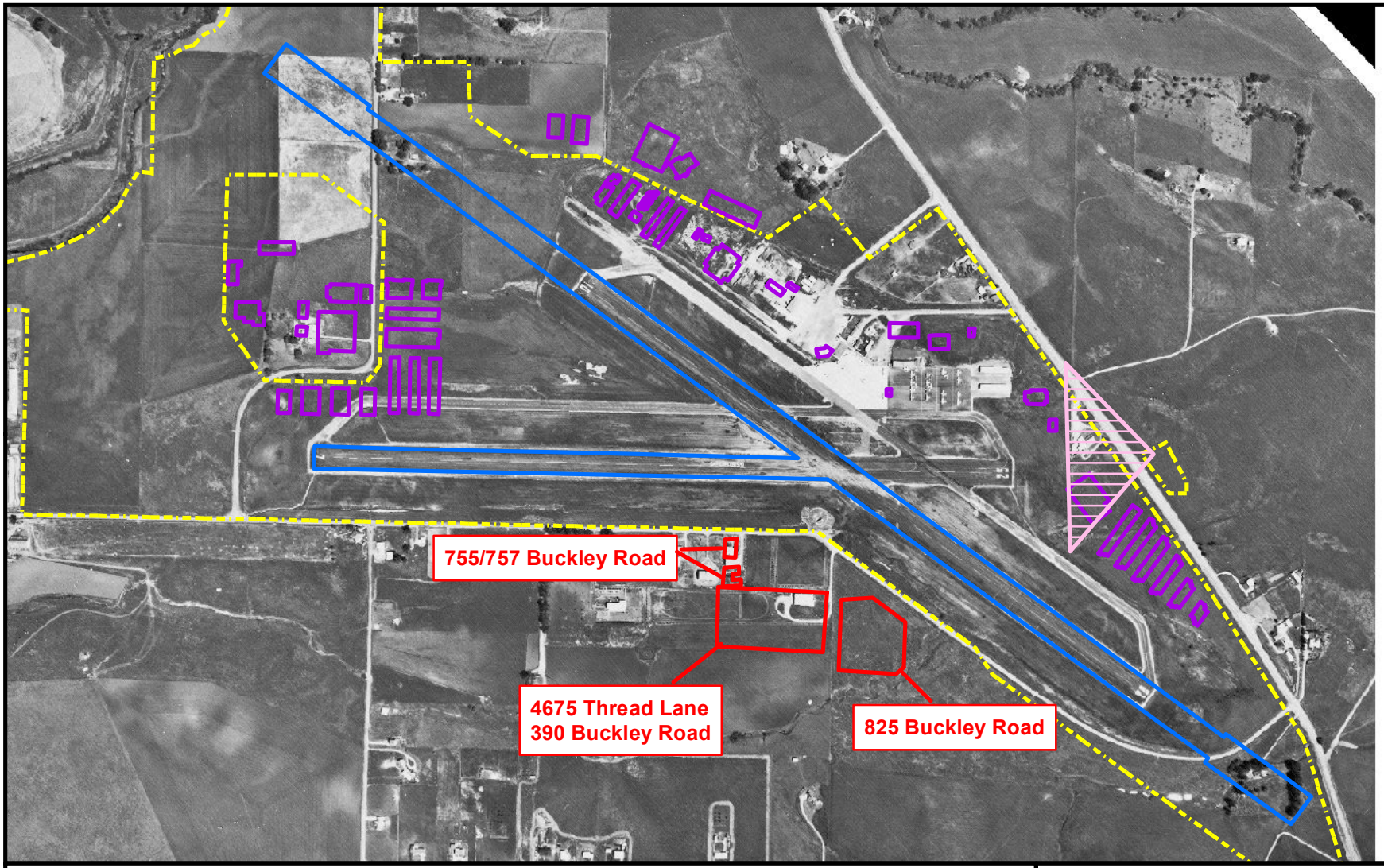

Image Source: Environmental Data Resources-Requested March 21, 2016

Legend

- Site Boundary
- Present Extent of Runway
- Present Building Footprints
- Approximate Location of Former Leach Field (Cleath, 1987)

N

0.1 0 0.1 0.2 Miles

Title:

1965 AERIAL IMAGERY

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: PDF	Date: 4/14/2016	FIGURE
Prepared by: PDF	Scale: 1:10,542	4E
Project Mgr: KJ	Office: LA	
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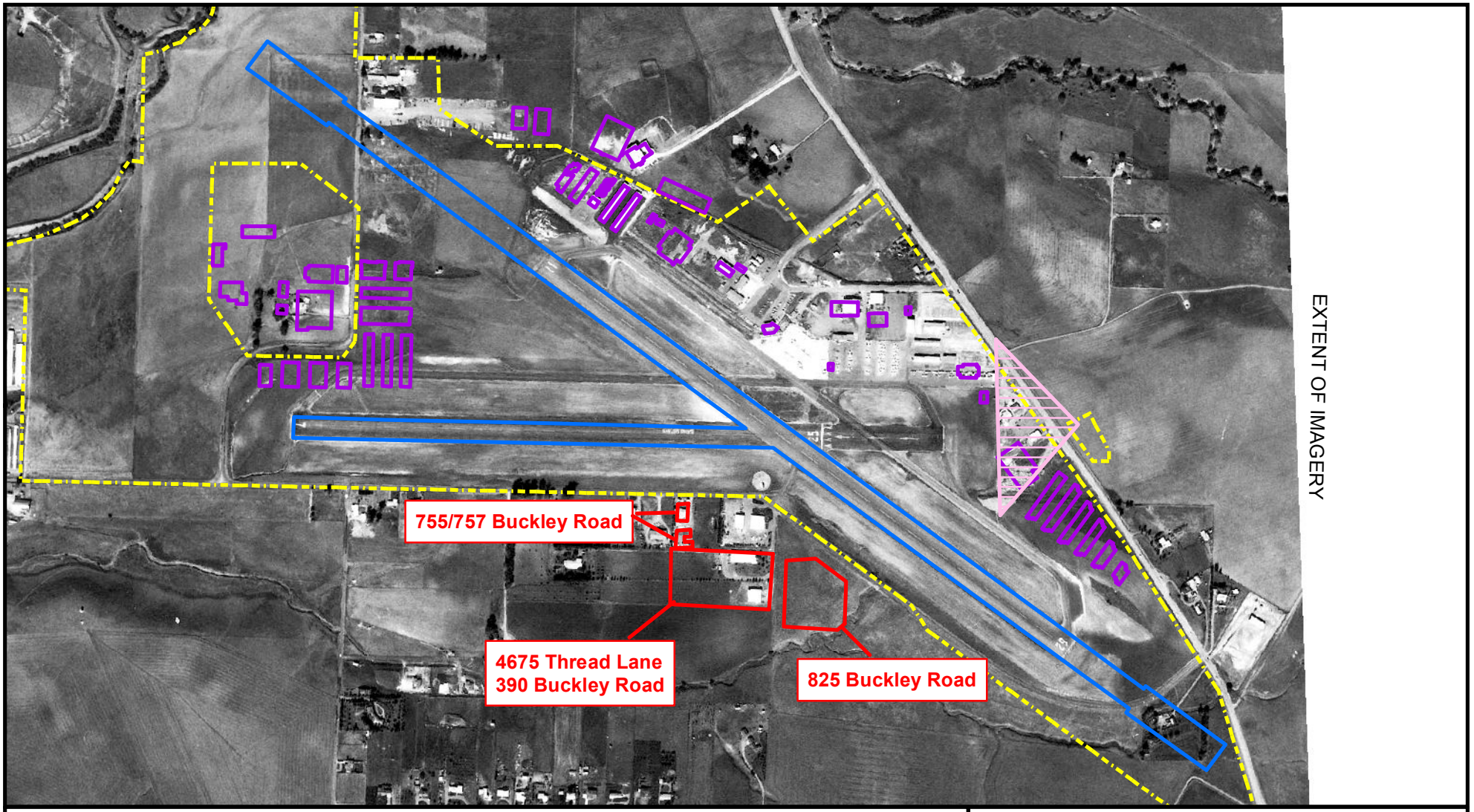

Image Source: Environmental Data Resources-Requested March 21, 2016

Legend

- Site Boundary
- Present Extent of Runway
- Present Building Footprints
- Approximate Location of Former Leach Field (Cleath, 1987)

N

0.1 0 0.1 0.2 Miles

Title:

1972 AERIAL IMAGERY

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: PDF	Date: 4/14/2016	FIGURE
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Project Mgr: KJ	Office: LA	
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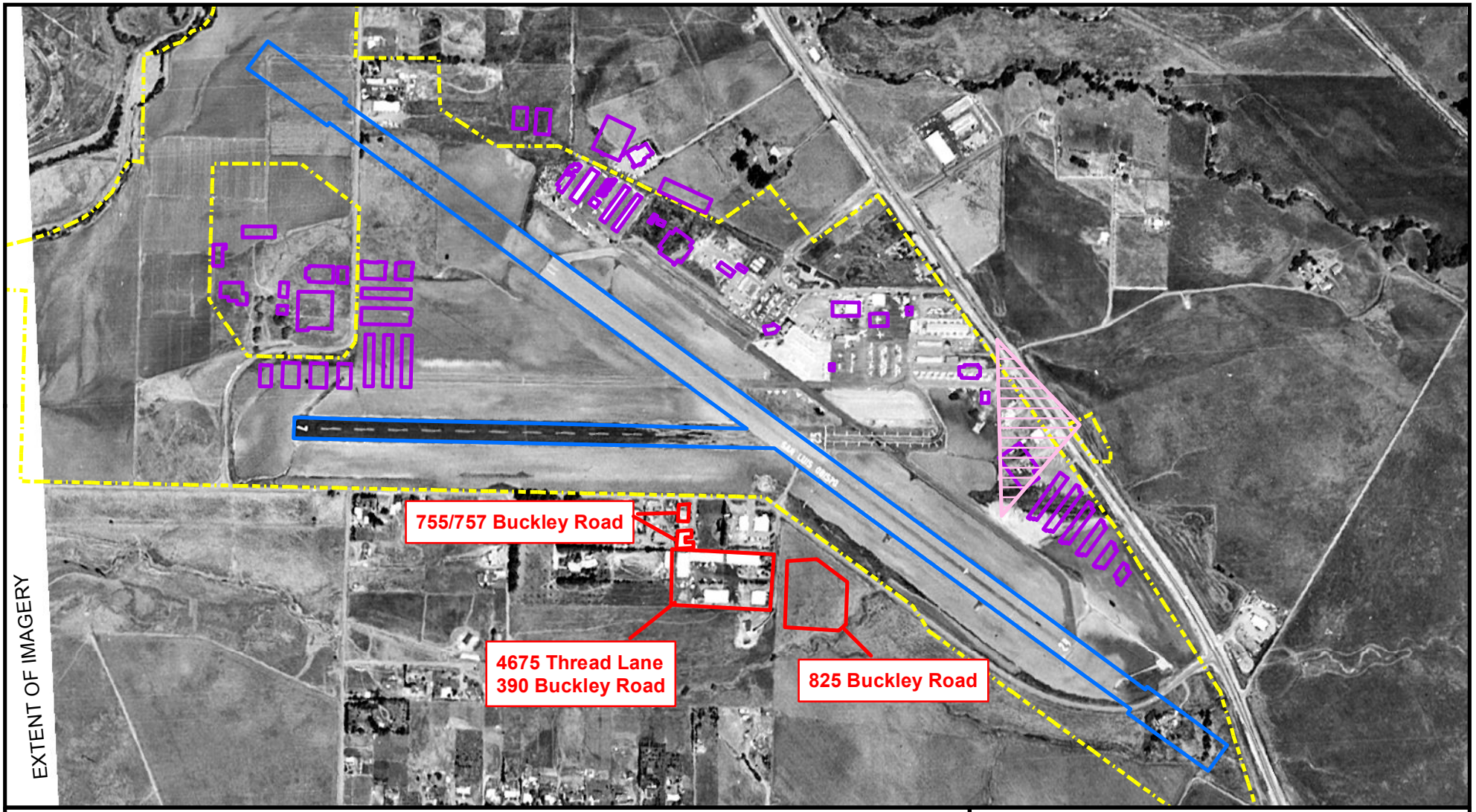

Image Source: Environmental Data Resources-Requested March 21, 2016

Legend

- Site Boundary
- Present Extent of Runway
- Present Building Footprints
- Approximate Location of Former Leach Field (Cleath, 1987)

N

0.1 0 0.1 0.2 Miles

Title:

1978 AERIAL IMAGERY

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

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ROUX ASSOCIATES, INC.
Environmental Consulting & Management

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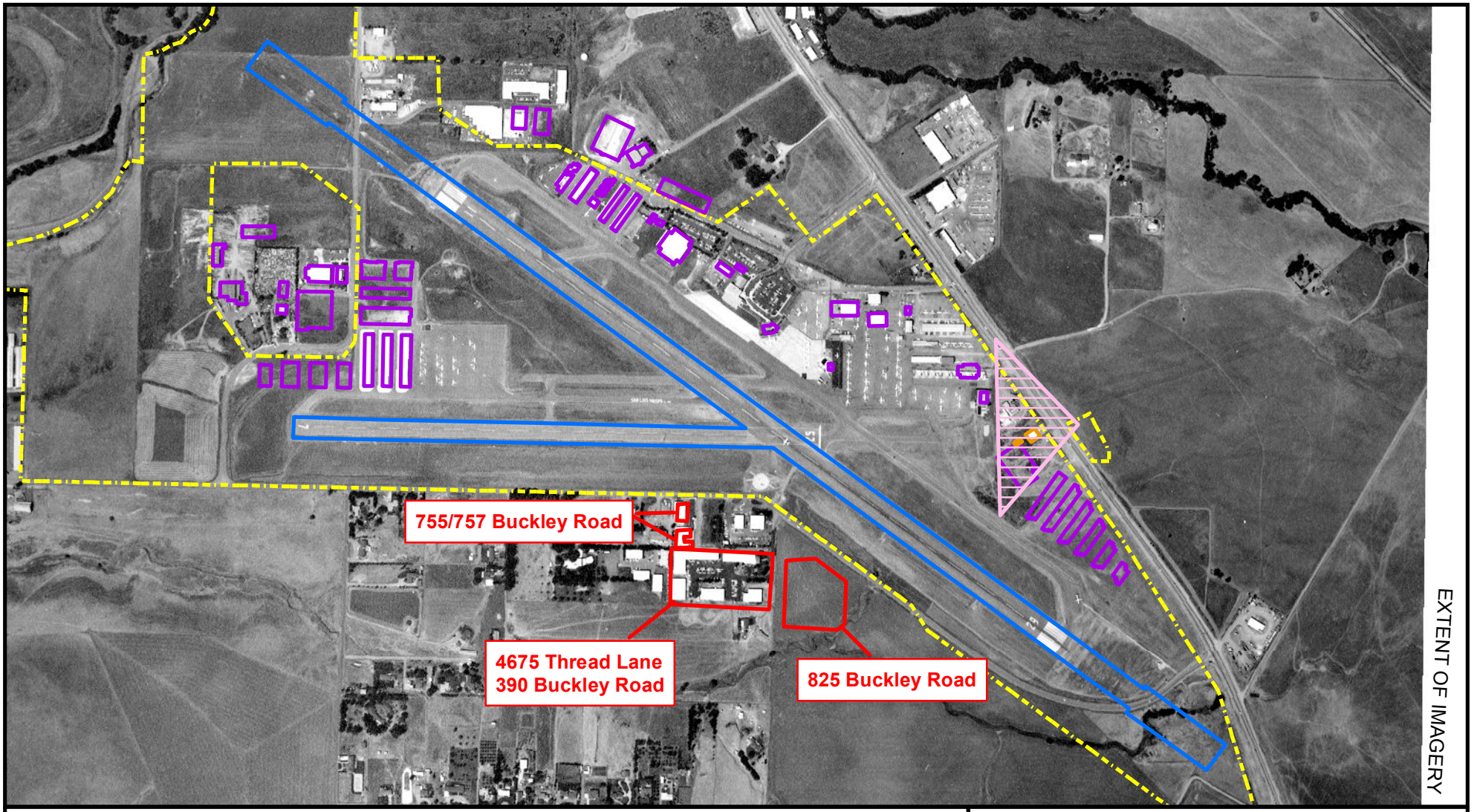

Image Source: Environmental Data Resources-Requested March 21, 2016

Legend

- Site Boundary
- Present Extent of Runway
- Present Building Footprints
- Approximate Location of Former Leach Field (Cleath, 1987)

N

0.1 0 0.1 0.2 Miles

Title:

1987 AERIAL IMAGERY

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: PDF	Date: 4/14/2016	FIGURE
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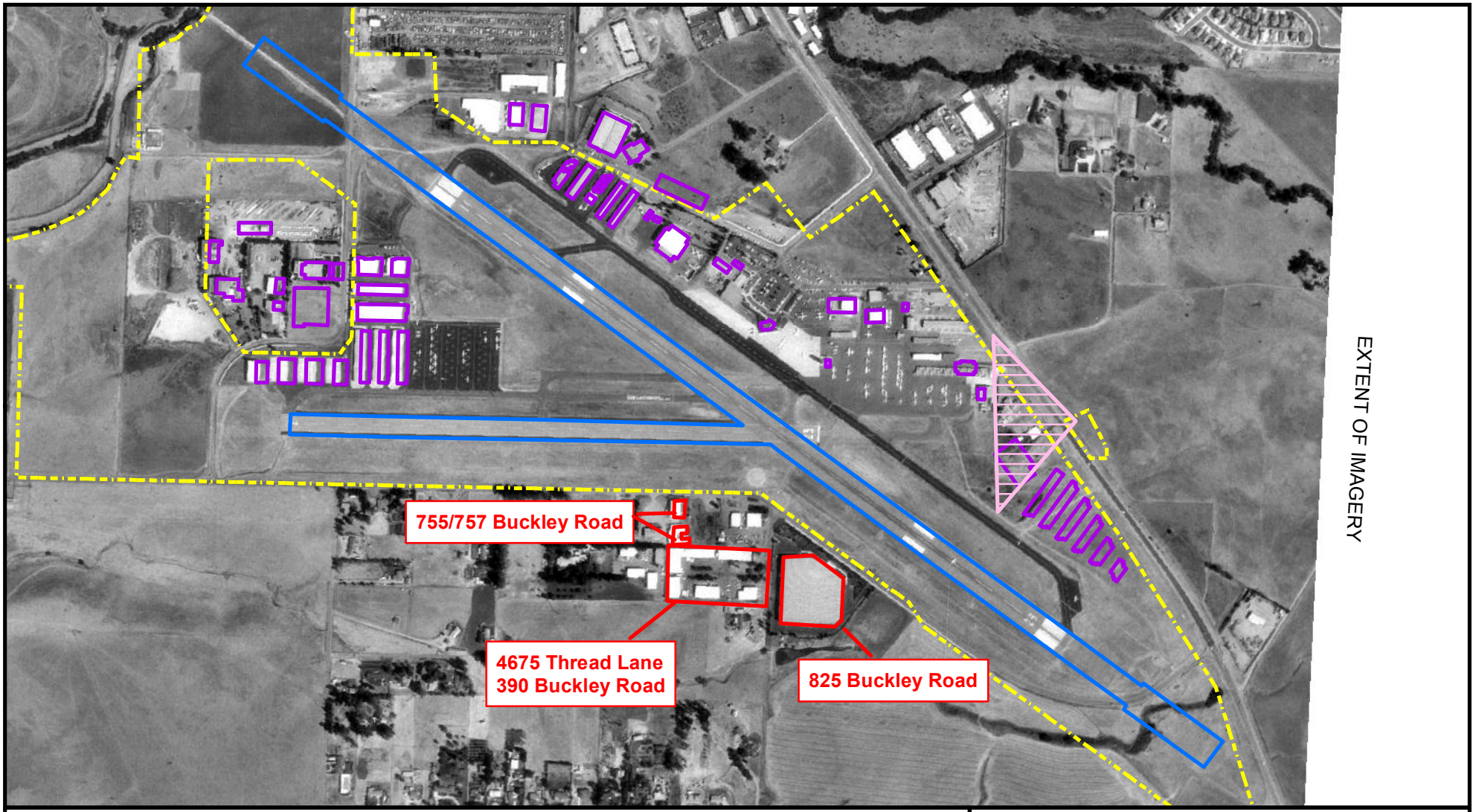

Image Source: Environmental Data Resources-Requested March 21, 2016

Legend

- Site Boundary
- Present Extent of Runway
- Present Building Footprints
- Approximate Location of Former Leach Field (Cleath, 1987)

N

0.1 0 0.1 0.2 Miles

Title:

1994 AERIAL IMAGERY

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: PDF	Date: 4/14/2016	FIGURE
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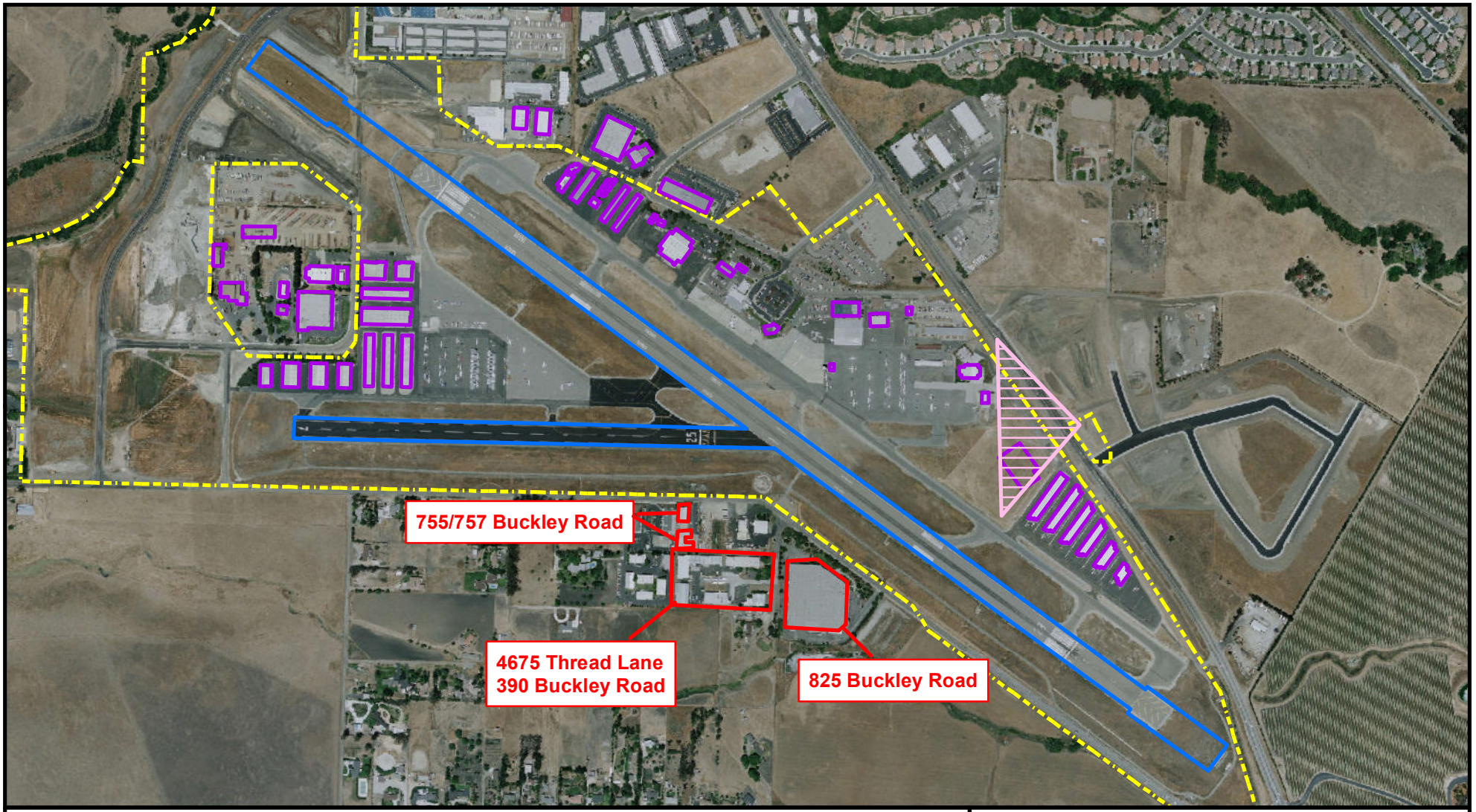

Image Source: http://gis.slocounty.ca.gov/arcgis/rest/services/Aerials

Legend

- Site Boundary
- Present Extent of Runway
- Present Building Footprints
- Approximate Location of Former Leach Field (Cleath, 1987)

N

0.1 0 0.1 0.2 Miles

Title:

2007 AERIAL IMAGERY

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: PDF	Date: 4/14/2016	FIGURE
Prepared by: PDF	Scale: 1:10,542	4J
Project Mgr: KJ	Office: LA	
File No: F(AL)	Project: 2744.0001L001	

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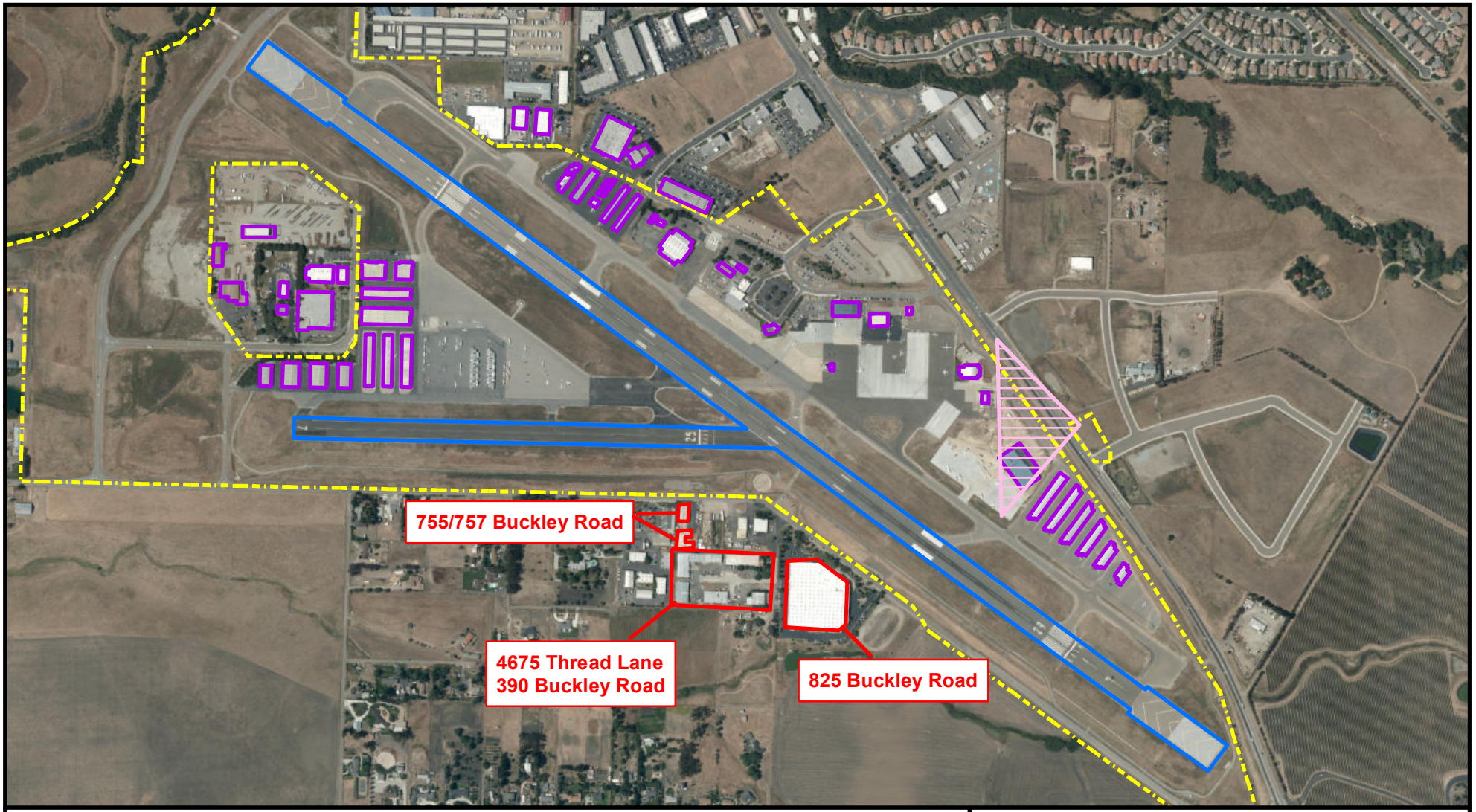

Image Source: http://gis.slocounty.ca.gov/arcgis/rest/services/Aerials

Legend

- Site Boundary
- Present Extent of Runway
- Present Building Footprints
- Approximate Location of Former Leach Field (Cleath, 1987)

N

0.1 0 0.1 0.2 Miles

Title:

2011 AERIAL IMAGERY

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: PDF	Date: 4/14/2016	FIGURE
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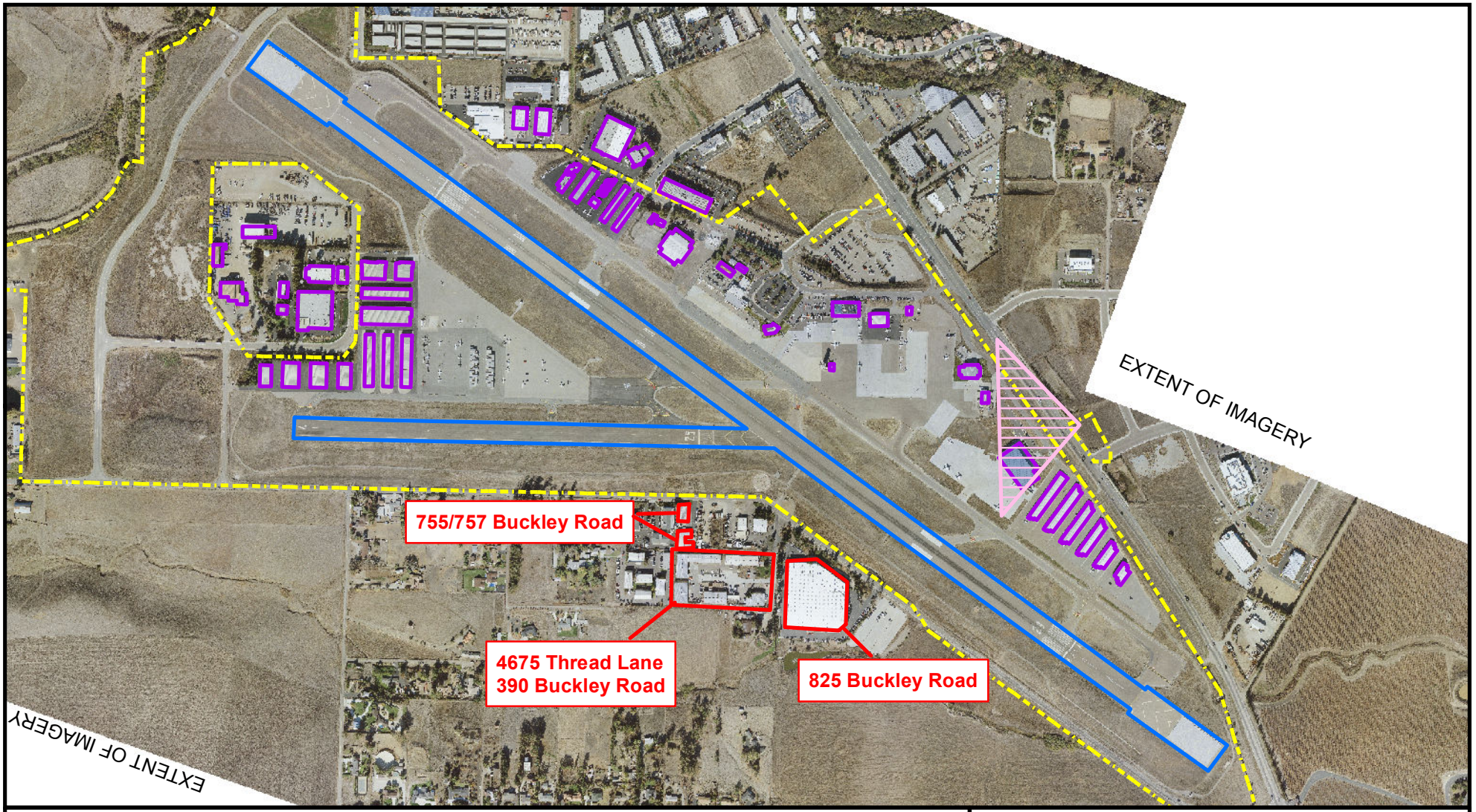

Image Source: http://gis.slocounty.ca.gov/arcgis/rest/services/Aerials

Legend

- Site Boundary
- Present Extent of Runway
- Present Building Footprints
- Approximate Location of Former Leach Field (Cleath, 1987)

N

0.1 0 0.1 0.2 Miles

Title:

2014 AERIAL IMAGERY

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: PDF	Date: 4/14/2016	FIGURE
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File No: F(AL)	Project: 2744.0001L001	

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Image Source: ESRI World Imagery 2016

Legend

- Proposed Soil Gas Sample Locations
- Buckley Road Drainage Outlet
- Site Boundary
- Present Extent of Runway

N

100 0 100 200 Feet

Title:

PROPOSED PHASE I SOIL GAS SAMPLE LOCATIONS

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

ROUX

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: PDF	Date: 4/15/2016	FIGURE
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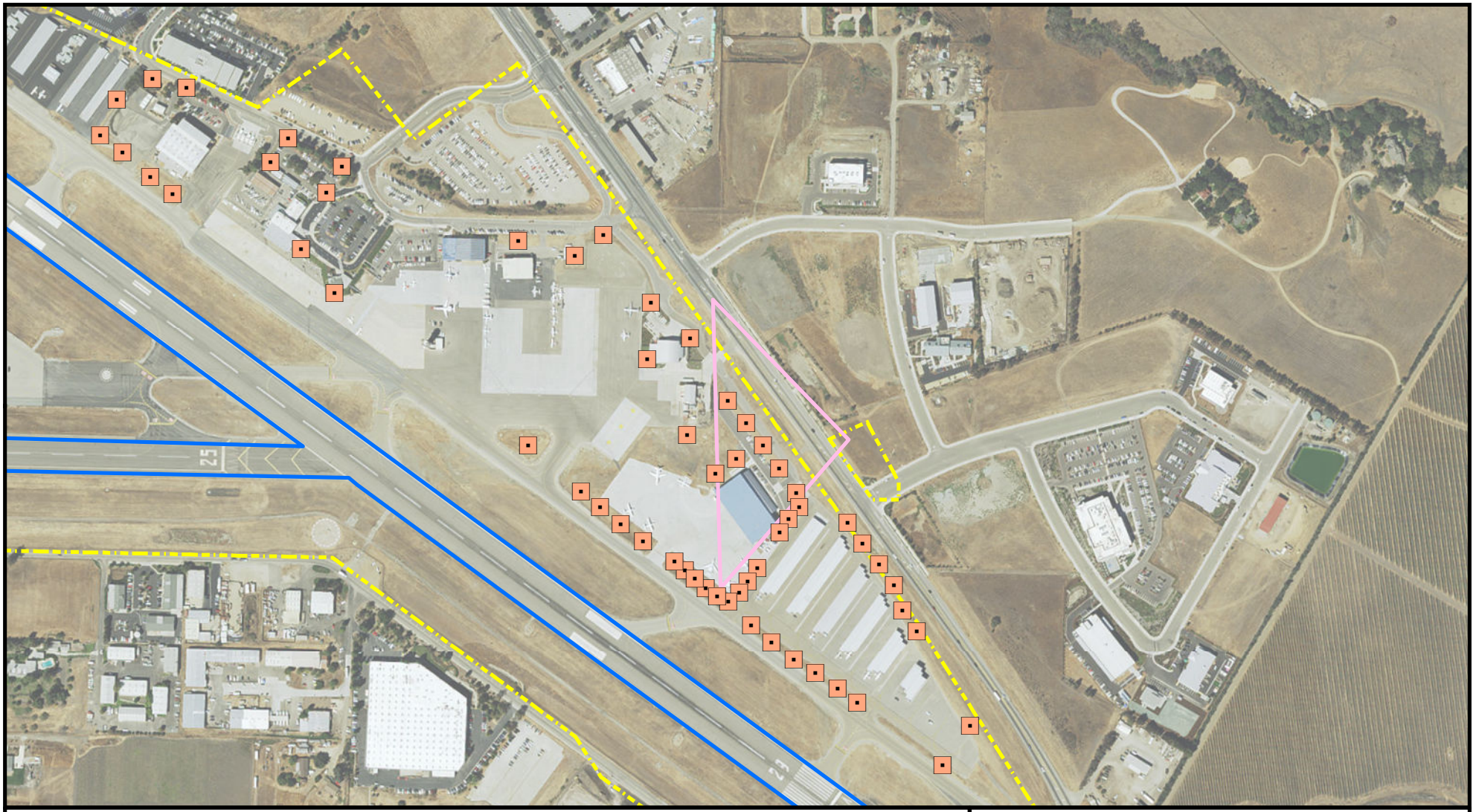

Image Source: ESRI World Imagery 2016

Legend

- Proposed Soil Gas Sample Locations
- Site Boundary
- Present Extent of Runway
- Approximate Location of Former Leach Field (Cleath, 1987)

N

250 0 250 500 Feet

Title:

PROPOSED
PHASE II SOIL GAS SAMPLE LOCATIONS

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

ROUX

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: PDF	Date: 4/14/2016	FIGURE
Prepared by: PDF	Scale: 1:6,437	**6A**
Project Mgr: KJ	Office: LA	
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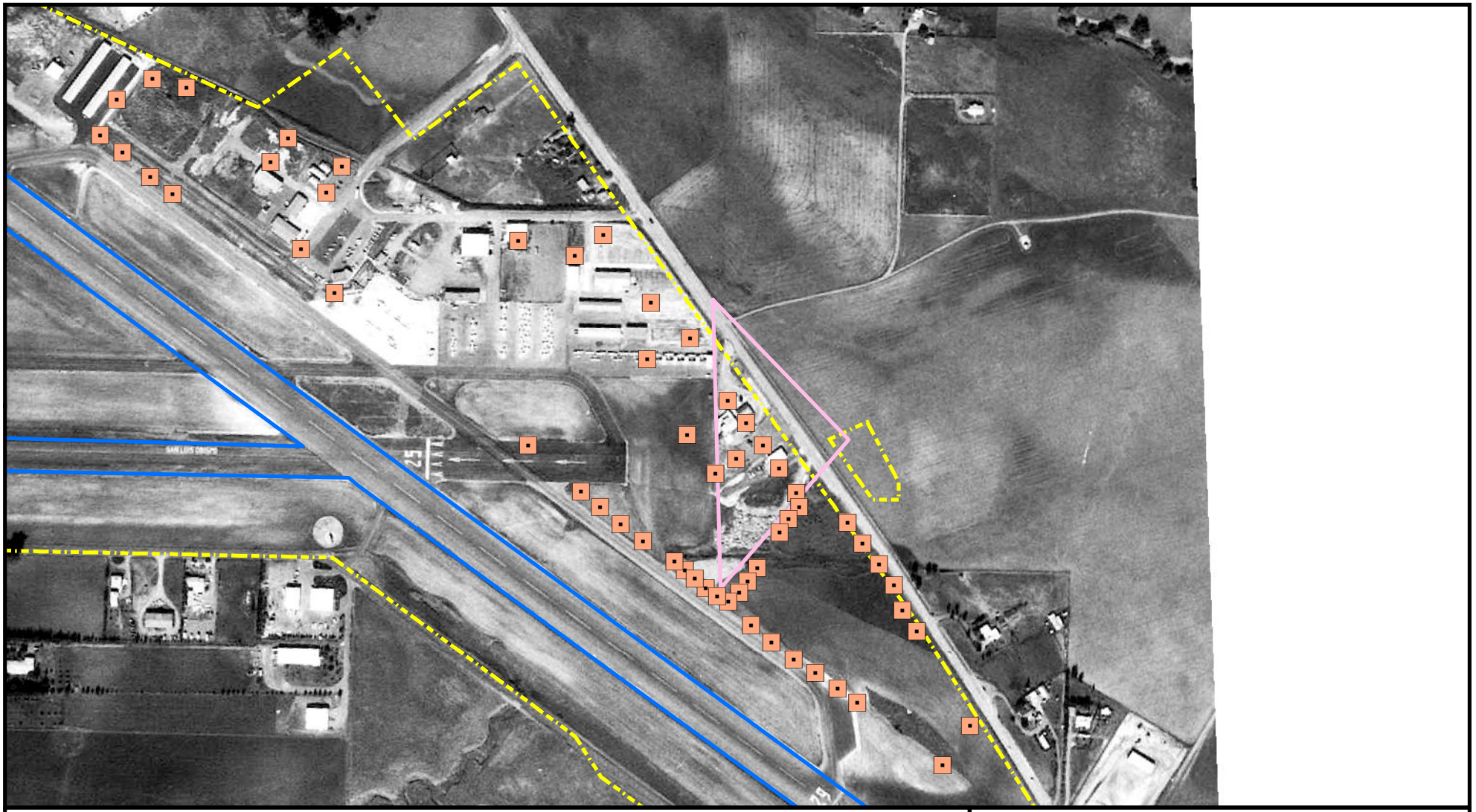


Image Source: Environmental Data Resources-Requested March 21, 2016

Legend

- Proposed Soil Gas Sample Locations
- Site Boundary
- Present Extent of Runway
- Approximate Location of Former Leach Field (Cleath, 1987)

N

250 0 250 500 Feet

Title:

PROPOSED
PHASE II SOIL GAS SAMPLE LOCATIONS (1972)

SAN LUIS OBISPO, CALIFORNIA

Prepared For:

COUNTY OF SAN LUIS OBISPO

ROUX

ROUX ASSOCIATES, INC.
Environmental Consulting & Management

Compiled by: PDF	Date: 4/14/2016	FIGURE
Prepared by: PDF	Scale: 1:6,437	**6B**
Project Mgr: KJ	Office: LA	
File No: F(AL)	Project: 2744.0001L001	

APPENDICES

A. Topographic Maps

B. Surface Drainage Maps

C: Geotechnical Boring Log for 390 Buckley Road

D: Aerial Photographs: Will be Provided Only In Raw Electronic Format

E: Airport FUDS Documentation

- **E.1: 1999 DOD/USACE Findings of Fact**
- **E.2: 1997 SAIC Site Inspection Memorandum**
- **E.3: 1997 SAIC Site Inspection Photographs**
- **E.4: 2012, Doherty Paper, RE: Solvent Use During World War II**

APPENDIX A

Topographic Maps

Buckley Road

Buckley Road

San Luis Obispo, CA 93401

Inquiry Number: 4555954.4

March 04, 2016

EDR Historical Topo Map Report

with QuadMatch™

6 Armstrong Road, 4th floor
Shelton, CT 06484
Toll Free: 800.352.0050
www.edrnet.com

EDR Historical Topo Map Report

03/04/16

Site Name:
Buckley Road
Buckley Road
San Luis Obispo, CA 93401
EDR Inquiry # 4555954.4

Client Name:
Roux Associates
5150 E Pacific Coast Highway
Long Beach, CA 90804
Contact: Paola Gomez-Birenbau

EDR Topographic Map Library has been searched by EDR and maps covering the target property location as provided by Roux Associates were identified for the years listed below. EDR's Historical Topo Map Report is designed to assist professionals in evaluating potential liability on a target property resulting from past activities. EDRs Historical Topo Map Report includes a search of a collection of public and private color historical topographic maps, dating back to the late 1800s.

Search Results:

Site Name: Buckley Road
Address: Buckley Road
City,State,Zip: San Luis Obispo, CA 93401
P.O.# SLO - Jon Rohrer
Project: SLO - Buckley Road

Coordinates:

Latitude: 35.234959 35° 14' 6" North
Longitude: -120.641883 -120° 38' 31" West
UTM Zone: Zone 10 North
UTM X Meters: 714585.59
UTM Y Meters: 3901648.11
Elevation: 187.00' above sea level

Maps Provided:

2012
1995, 1998
1993, 1994
1976, 1978
1965
1952
1942
1900
1897

Topo Sheet Thumbnails

This EDR Topo Map Report is based upon the following USGS topographic map sheets.

2012 Source Sheets

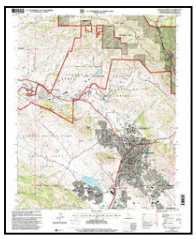
San Luis Obispo
2012
7.5-minute, 24000

Pismo Beach
2012
7.5-minute, 24000

Lopez Mountain
2012
7.5-minute, 24000

Arroyo Grande NE
2012
7.5-minute, 24000

1995, 1998 Source Sheets



San Luis Obispo
1995
7.5-minute, 24000
Edited 1995

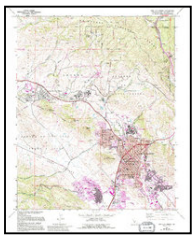
Lopez Mountain
1995
7.5-minute, 24000
Aerial Photo Revised 1994

Pismo Beach
1998
7.5-minute, 24000
Photo Inspected 1998
Aerial Photo Revised 1998

1993, 1994 Source Sheets

Lopez Mountain
1993
7.5-minute, 24000
Aerial Photo Revised 1987
Edited 1993

Arroyo Grande NE
1993
7.5-minute, 24000
Photo Revised 1993
Aerial Photo Revised 1990



San Luis Obispo
1994
7.5-minute, 24000
Aerial Photo Revised 1988
Edited 1994

Pismo Beach
1994
7.5-minute, 24000
Aerial Photo Revised 1988
Edited 1994

1976, 1978 Source Sheets

Lopez Mountain
1976
7.5-minute, 24000
Photo Inspected 1976
Aerial Photo Revised 1963

Arroyo Grande NE
1978
7.5-minute, 24000
Photo Revised 1978
Aerial Photo Revised 1976

Pismo Beach
1978
7.5-minute, 24000
Photo Revised 1978
Aerial Photo Revised 1976

Topo Sheet Thumbnails

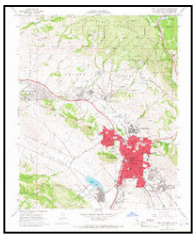
This EDR Topo Map Report is based upon the following USGS topographic map sheets.

1965 Source Sheets

Pismo Beach
1965
7.5-minute, 24000
Aerial Photo Revised 1963

Arroyo Grande NE
1965
7.5-minute, 24000
Aerial Photo Revised 1963

Lopez Mountain
1965
7.5-minute, 24000
Aerial Photo Revised 1963



San Luis Obispo
1965
7.5-minute, 24000
Aerial Photo Revised 1963

1952 Source Sheets

Arroyo Grande
1952
15-minute, 62500

San Luis Obispo
1952
15-minute, 62500

1942 Source Sheets

Arroyo Grande
1942
15-minute, 62500

San Luis Obispo
1942
15-minute, 62500

1900 Source Sheets

San Luis
1900
30-minute, 125000

Topo Sheet Thumbnails

This EDR Topo Map Report is based upon the following USGS topographic map sheets.

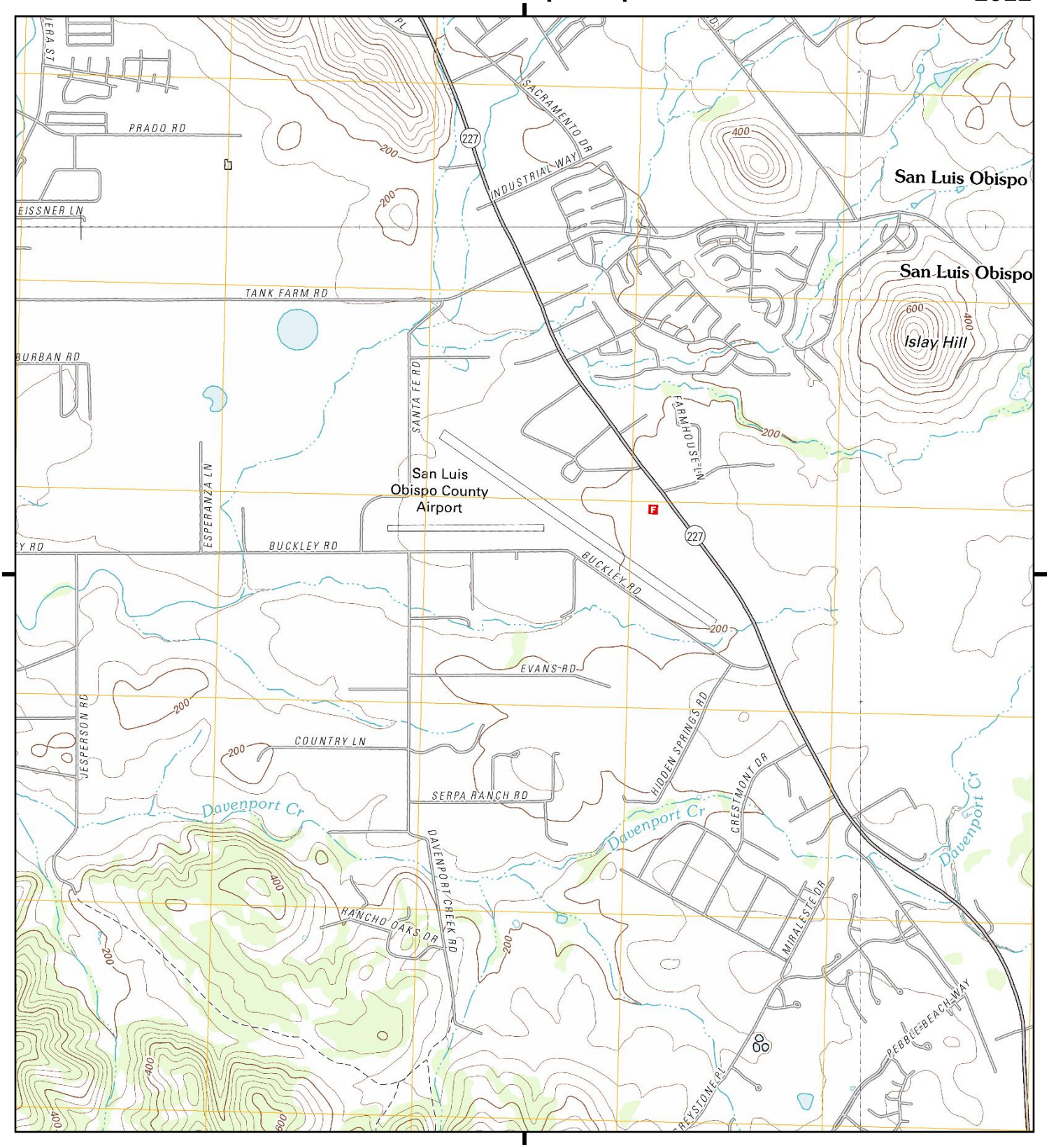
1897 Source Sheets

Arroyo Grande
1897
15-minute, 62500

San Luis Obispo
1897
15-minute, 62500

Historical Topo Map

2012



This report includes information from the following map sheet(s).

Miles 0.25 0.5 1 1.5

NW N NE
W E
SW S SE

TP, Pismo Beach, 2012, 7.5-minute

NE, Lopez Mountain, 2012, 7.5-minute

SE, Arroyo Grande NE, 2012, 7.5-minute

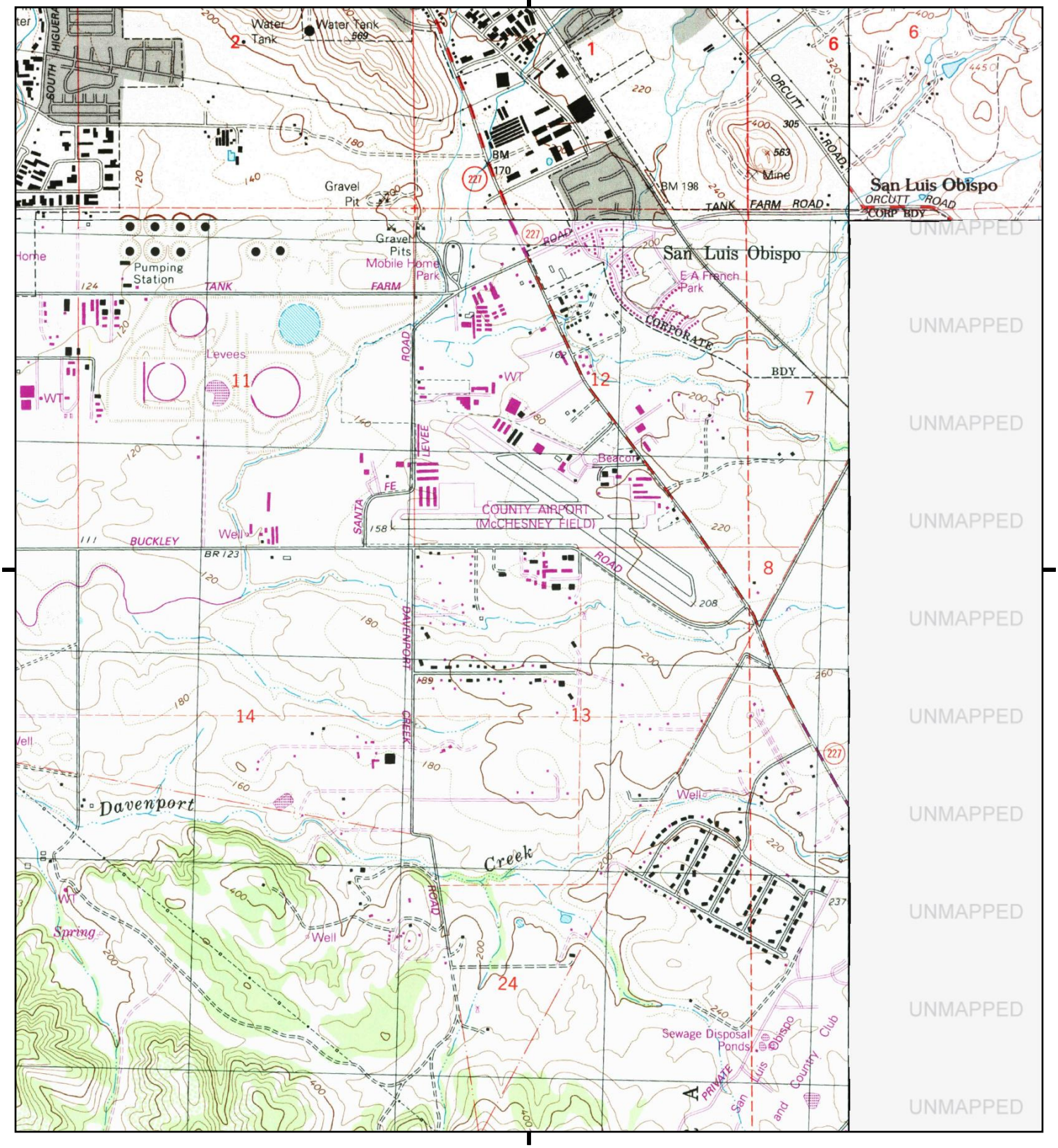
NW, San Luis Obispo, 2012, 7.5-minute

SITE NAME: Buckley Road
ADDRESS: Buckley Road
San Luis Obispo, CA 93401
CLIENT: Roux Associates

N

Historical Topo Map

1995, 1998



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NW N NE
W E
SW S SE

TP, Pismo Beach, 1998, 7.5-minute

NE, Lopez Mountain, 1995, 7.5-minute

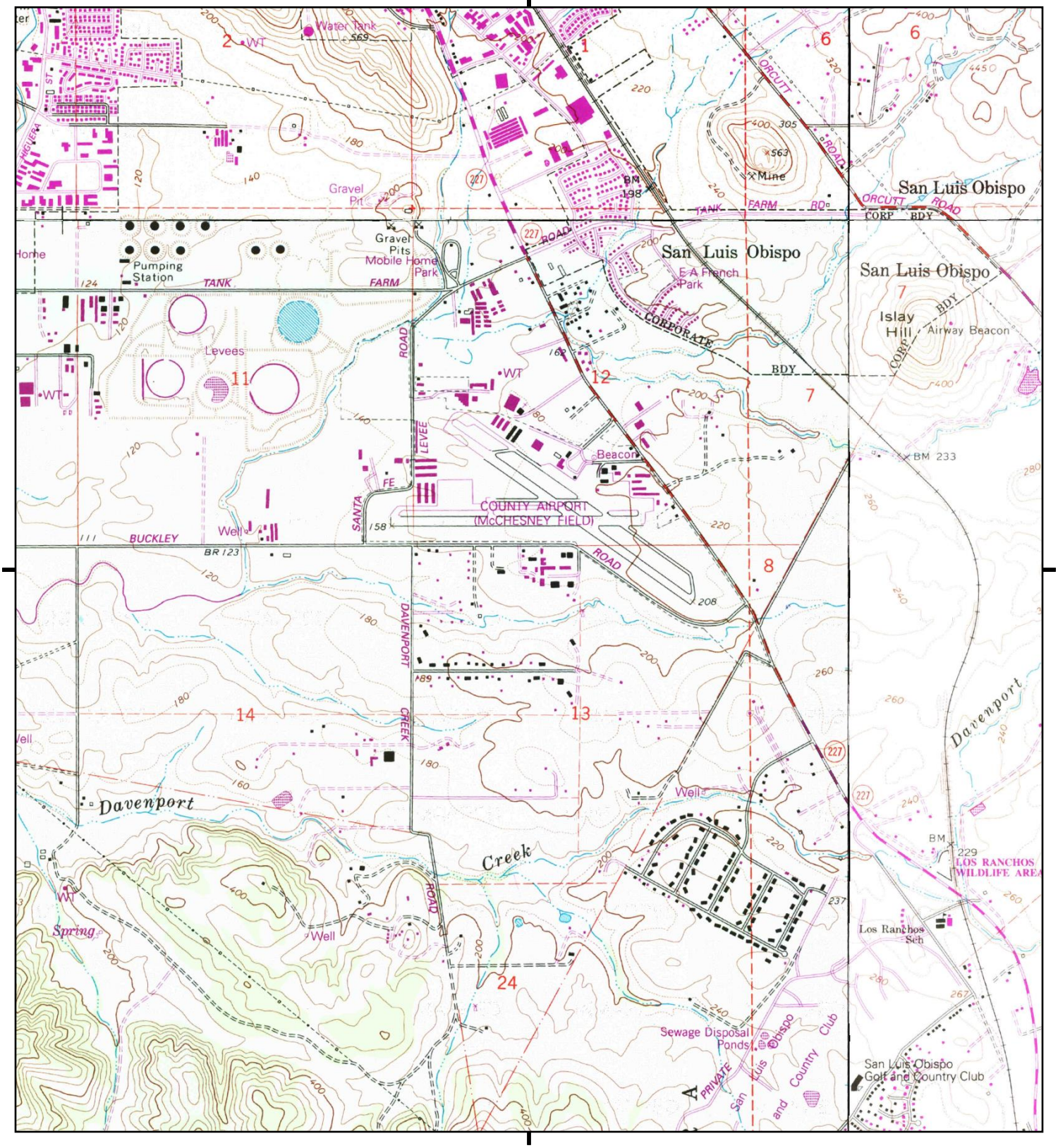
NW, San Luis Obispo, 1995, 7.5-minute

SITE NAME: Buckley Road
ADDRESS: Buckley Road
San Luis Obispo, CA 93401
CLIENT: Roux Associates

N

Historical Topo Map

1993, 1994



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W E
SW S SE

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NE, Lopez Mountain, 1993, 7.5-minute

SE, Arroyo Grande NE, 1993, 7.5-minute

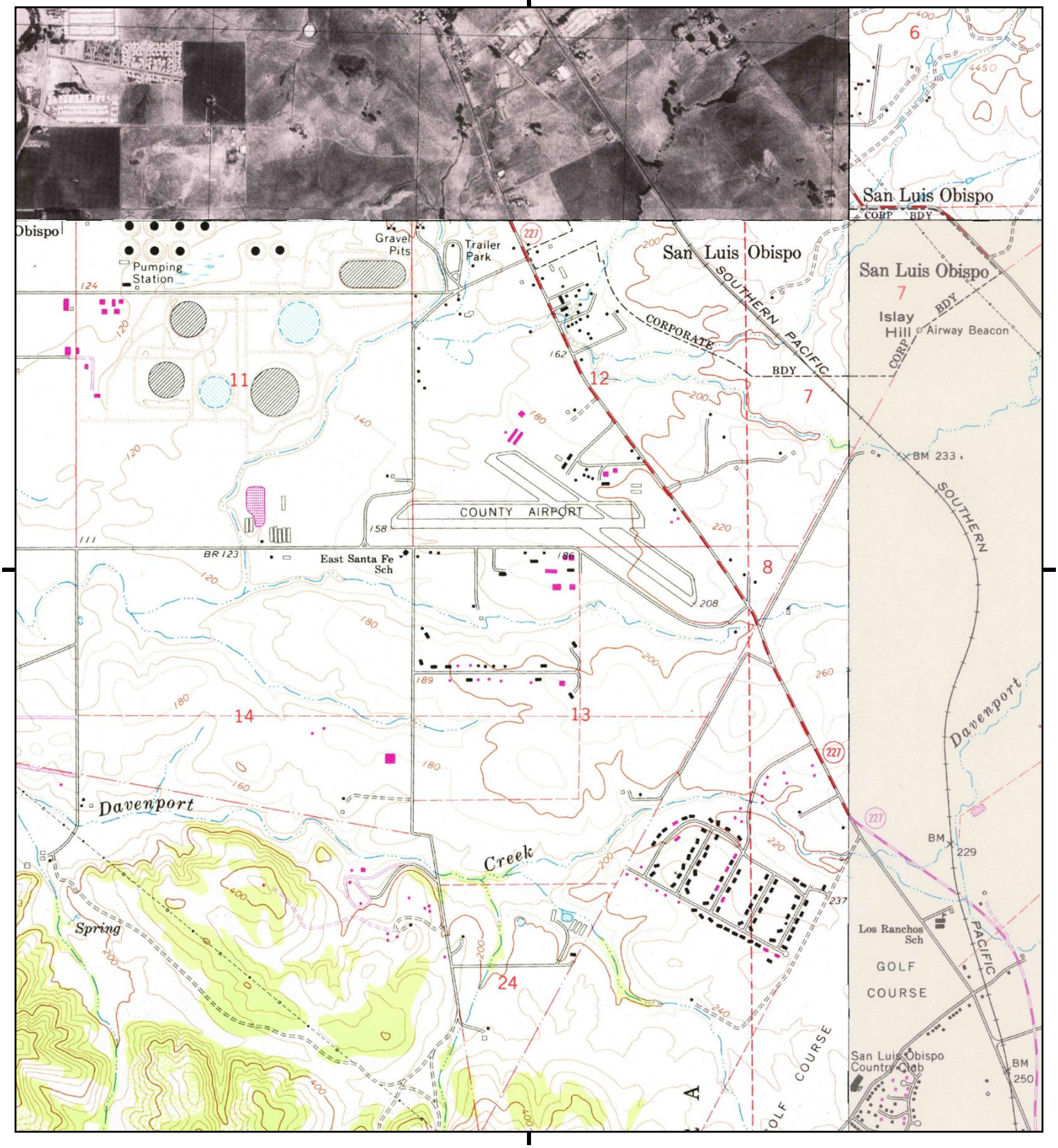
NW, San Luis Obispo, 1994, 7.5-minute

SITE NAME: Buckley Road
ADDRESS: Buckley Road
San Luis Obispo, CA 93401
CLIENT: Roux Associates

N

Historical Topo Map

1976, 1978



This report includes information from the following map sheet(s).

Miles 0.25 0.5 1 1.5

NW N NE
W E
SW S SE

TP, Pismo Beach, 1978, 7.5-minute

NE, Lopez Mountain, 1976, 7.5-minute

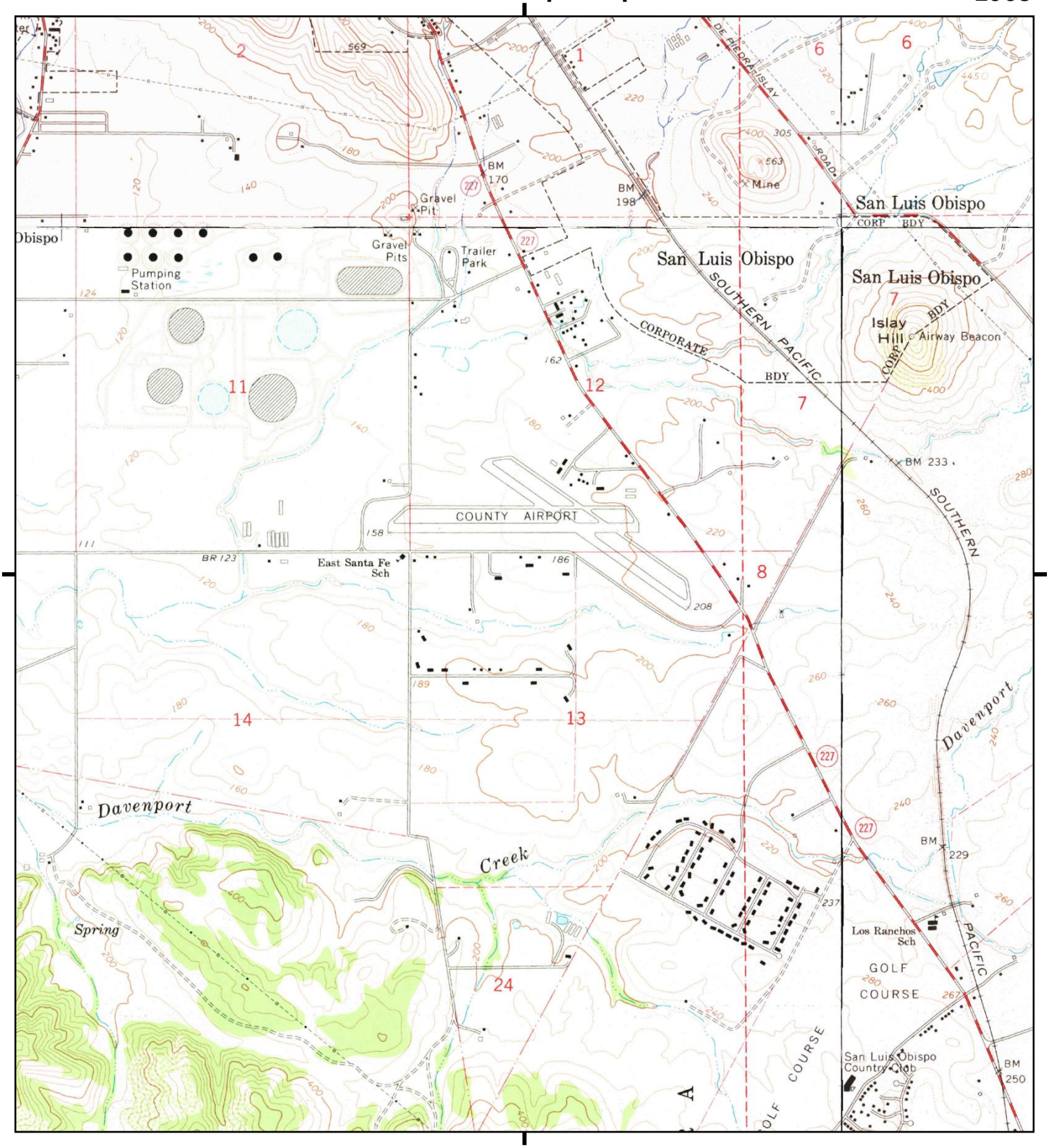
SE, Arroyo Grande NE, 1978, 7.5-minute

SITE NAME: Buckley Road
ADDRESS: Buckley Road
San Luis Obispo, CA 93401
CLIENT: Roux Associates

N

Historical Topo Map

1965



This report includes information from the following map sheet(s).

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NW N NE
W E
SW S SE

TP, Pismo Beach, 1965, 7.5-minute

NE, Lopez Mountain, 1965, 7.5-minute

SE, Arroyo Grande NE, 1965, 7.5-minute

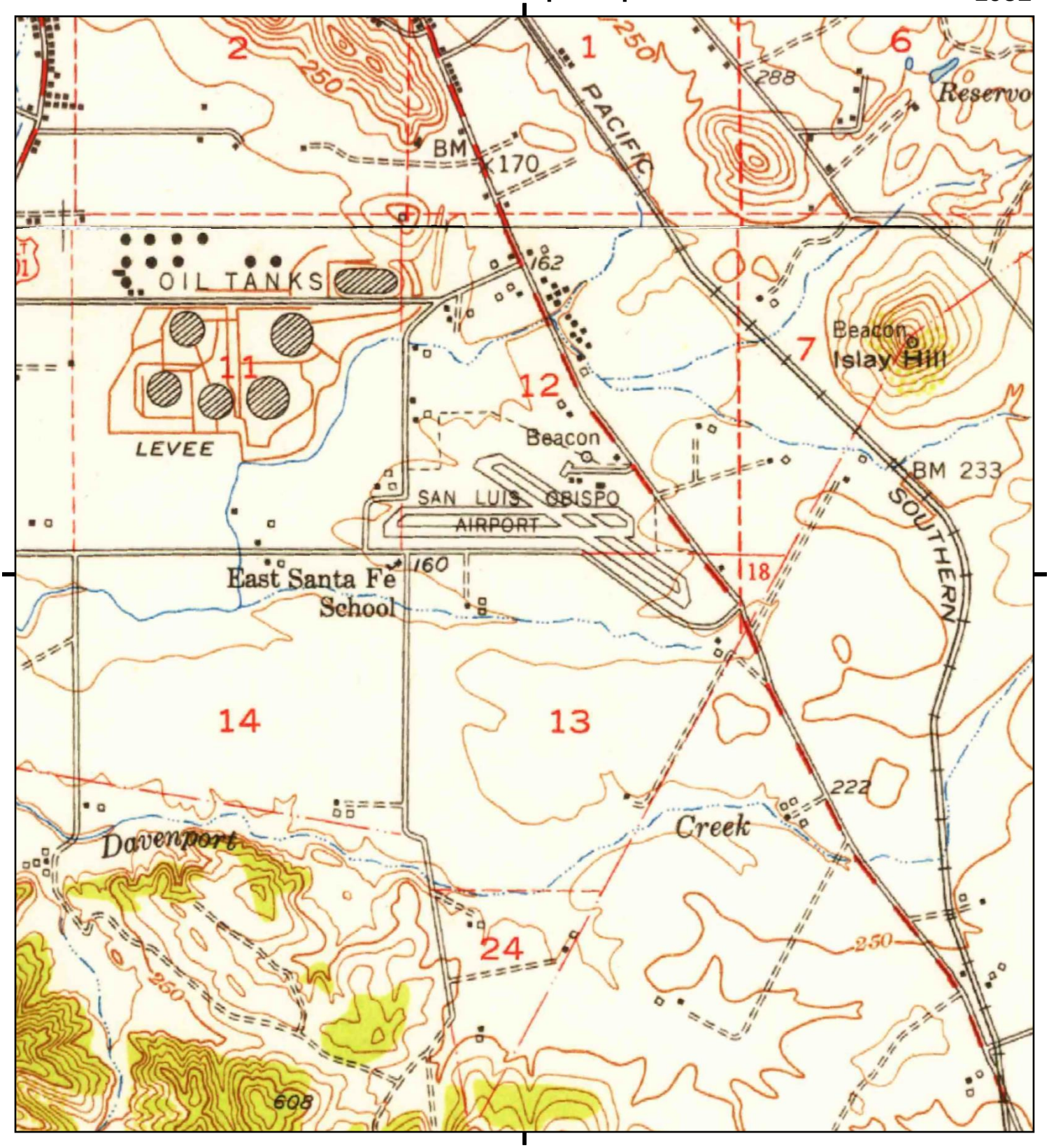
NW, San Luis Obispo, 1965, 7.5-minute

SITE NAME: Buckley Road
ADDRESS: Buckley Road
San Luis Obispo, CA 93401
CLIENT: Roux Associates

N

Historical Topo Map

1952



This report includes information from the following map sheet(s).

Miles 0.25 0.5 1 1.5

NW N NE
W E
SW S SE

TP, Arroyo Grande, 1952, 15-minute

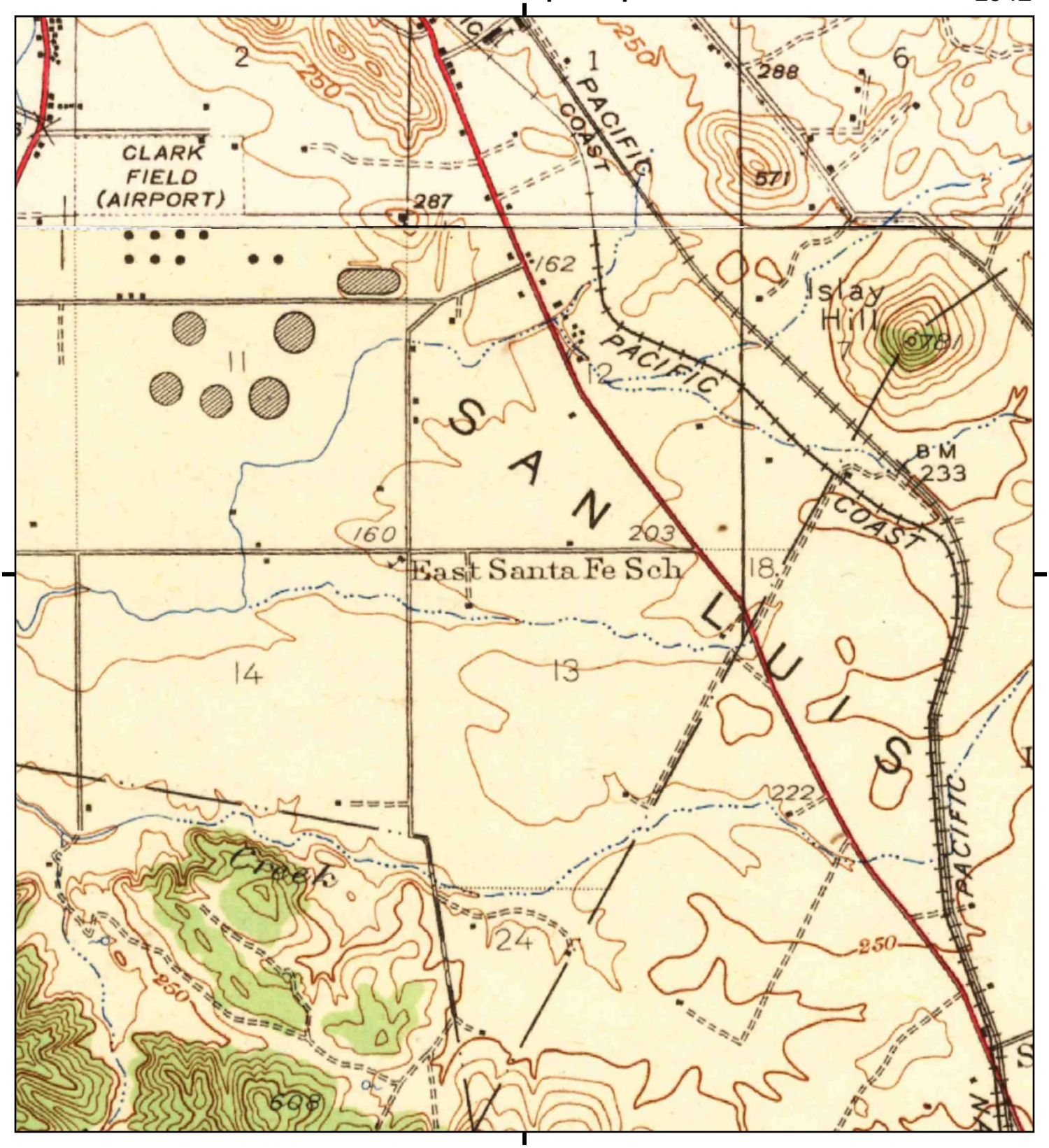
N, San Luis Obispo, 1952, 15-minute

SITE NAME: Buckley Road
ADDRESS: Buckley Road
San Luis Obispo, CA 93401
CLIENT: Roux Associates

N

Historical Topo Map

1942



This report includes information from the following map sheet(s).

Miles 0.25 0.5 1 1.5

NW N NE
W E
SW S SE

TP, Arroyo Grande, 1942, 15-minute

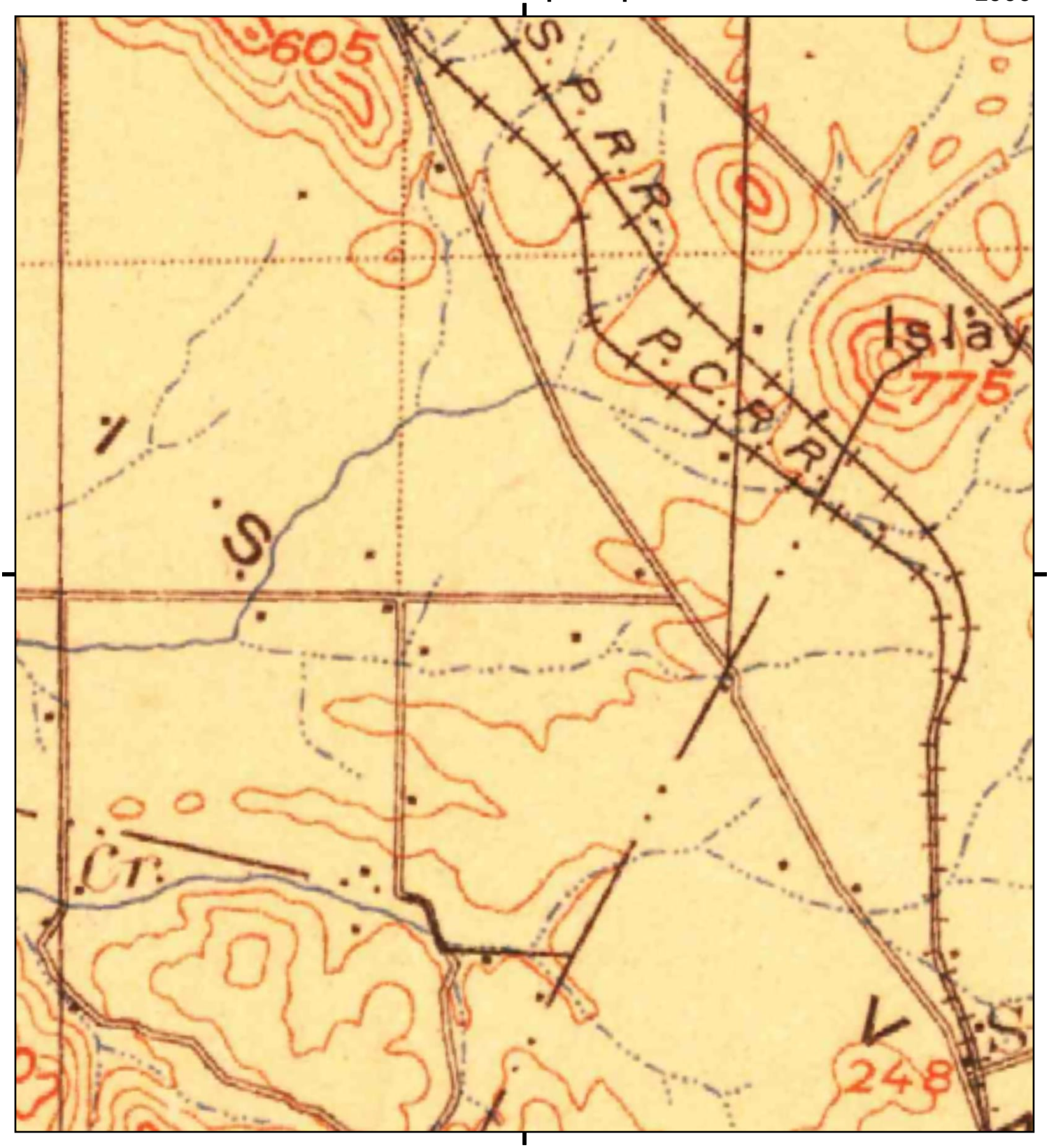
N, San Luis Obispo, 1942, 15-minute

SITE NAME: Buckley Road
ADDRESS: Buckley Road
San Luis Obispo, CA 93401
CLIENT: Roux Associates

N

Historical Topo Map

1900



This report includes information from the following map sheet(s).

Miles 0.25 0.5 1 1.5

NW N NE
W E
SW S SE

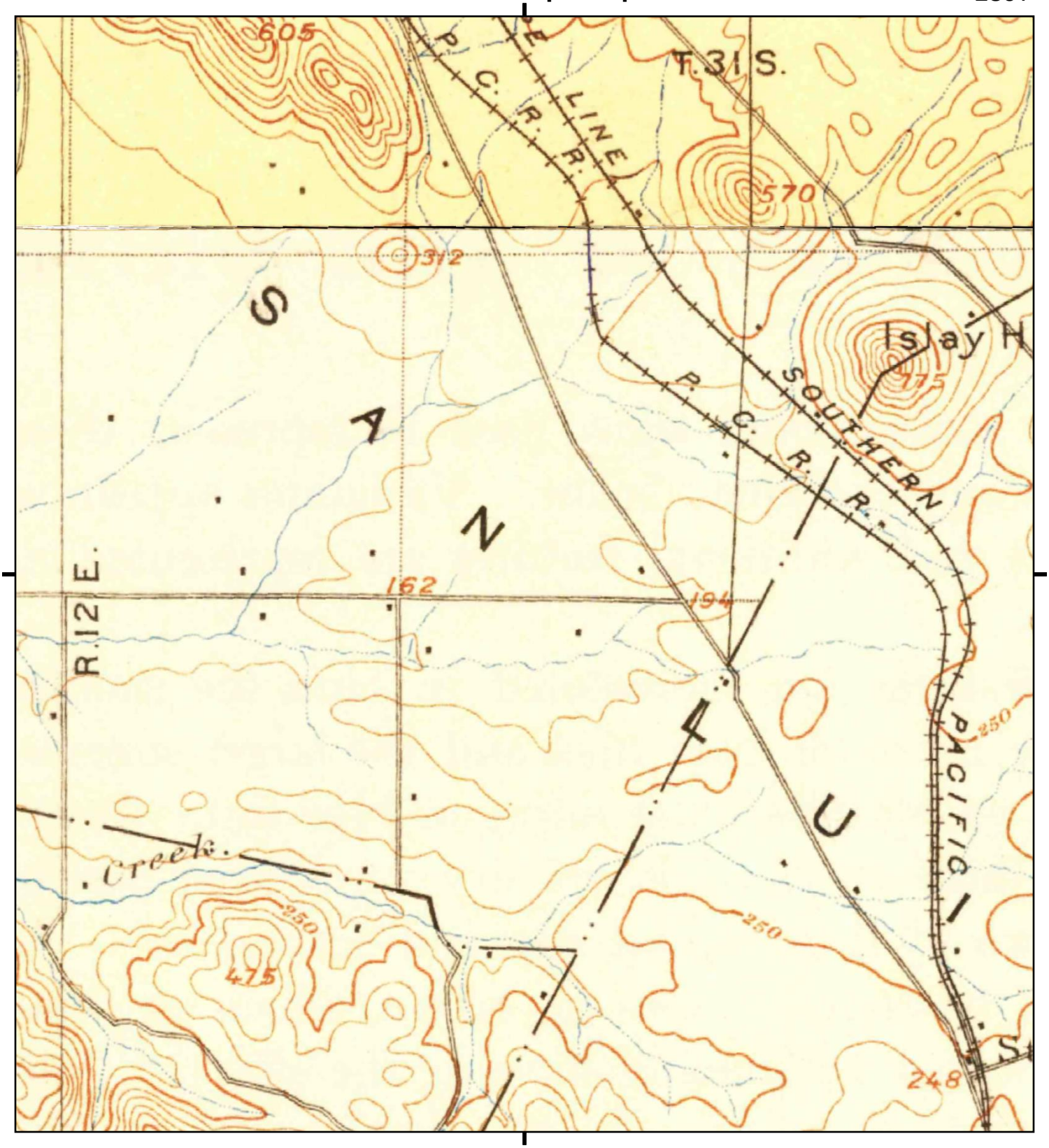
TP, San Luis, 1900, 30-minute

SITE NAME: Buckley Road
ADDRESS: Buckley Road
San Luis Obispo, CA 93401
CLIENT: Roux Associates

N

Historical Topo Map

1897



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Miles 0.25 0.5 1 1.5

NW N NE
W E
SW S SE

TP, Arroyo Grande, 1897, 15-minute

N, San Luis Obispo, 1897, 15-minute

SITE NAME: Buckley Road
ADDRESS: Buckley Road
San Luis Obispo, CA 93401
CLIENT: Roux Associates

N

APPENDIX B

Surface Drainage Maps

Final Report

Drainage Study

San Luis Obispo County Regional Airport Runway 11 Extension

Prepared for:

ESA Environmental Science Associates

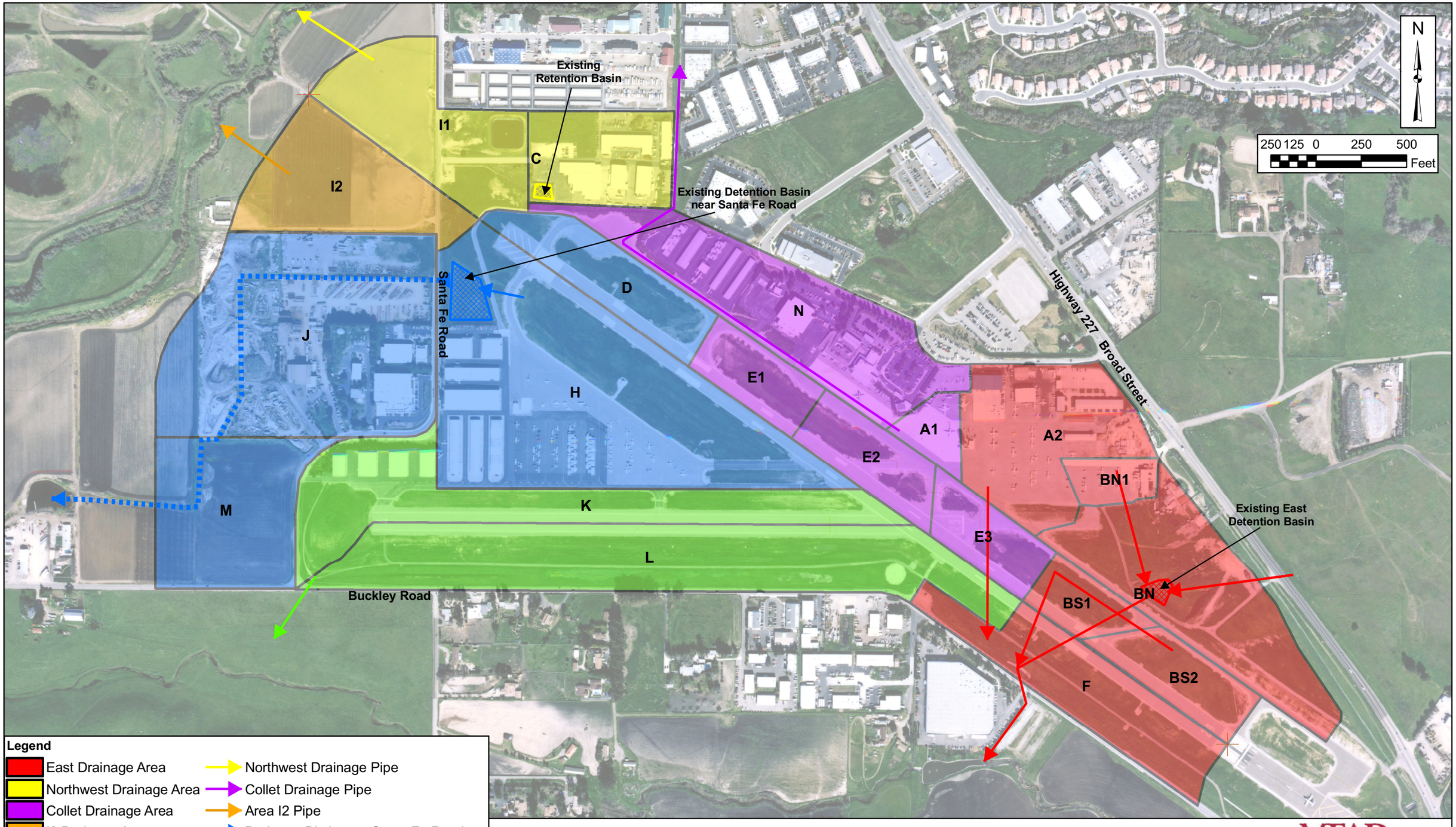
Environmental Science Associates
San Francisco, California

San Luis Obispo County
San Luis Obispo, California

Prepared by:

MEAD & HUNT

Offices Nationwide
www.meadhunt.com
March 2005



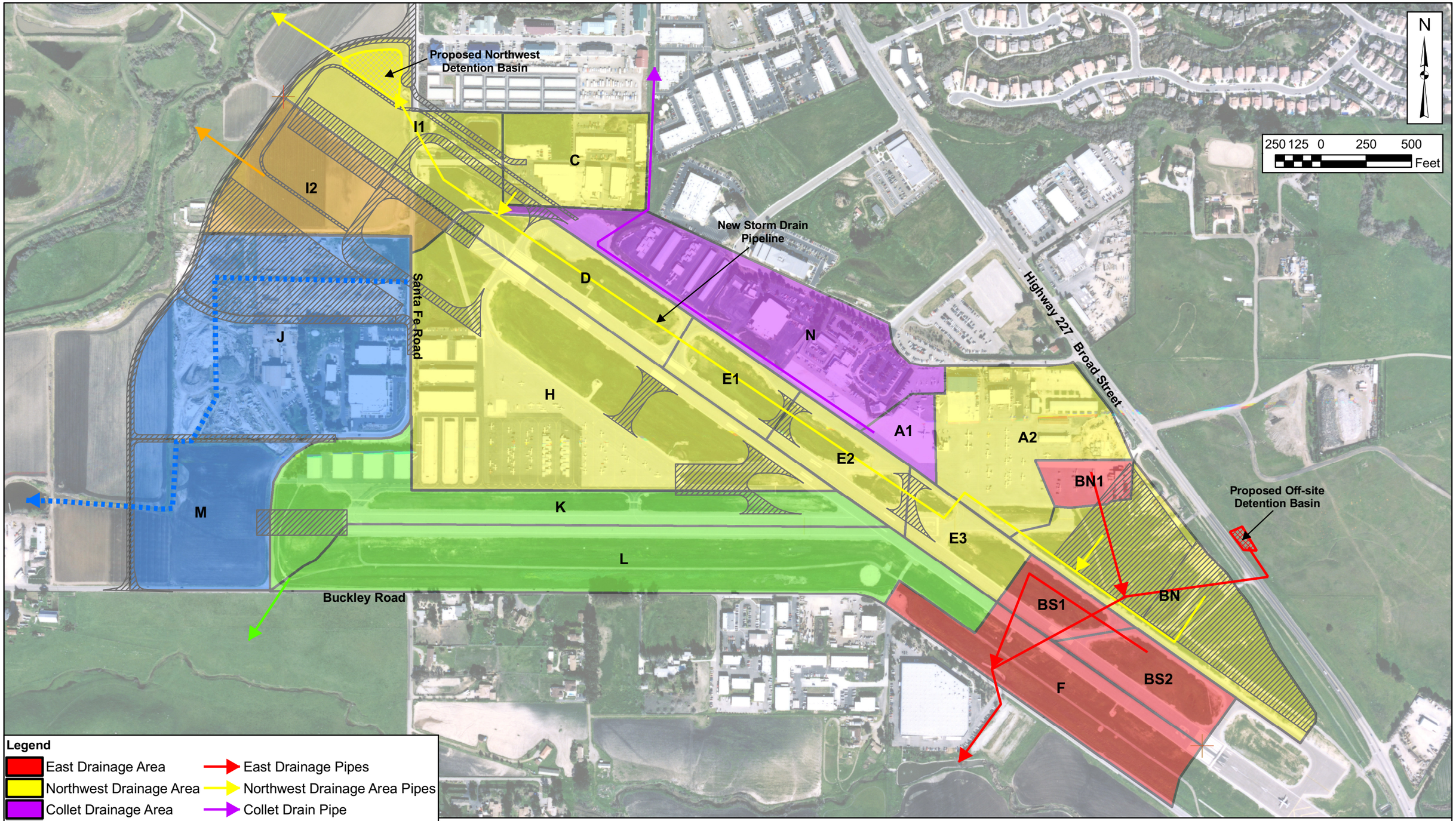
SAN LUIS OBISPO COUNTY AIRPORT

DRAINAGE - EXISTING
FIGURE 11

MEAD & HUNT

February 2006

X:\19430\05001\Tech\GIS\Existing.mxd



SAN LUIS OBISPO COUNTY AIRPORT

DRAINAGE - FUTURE
FIGURE 12

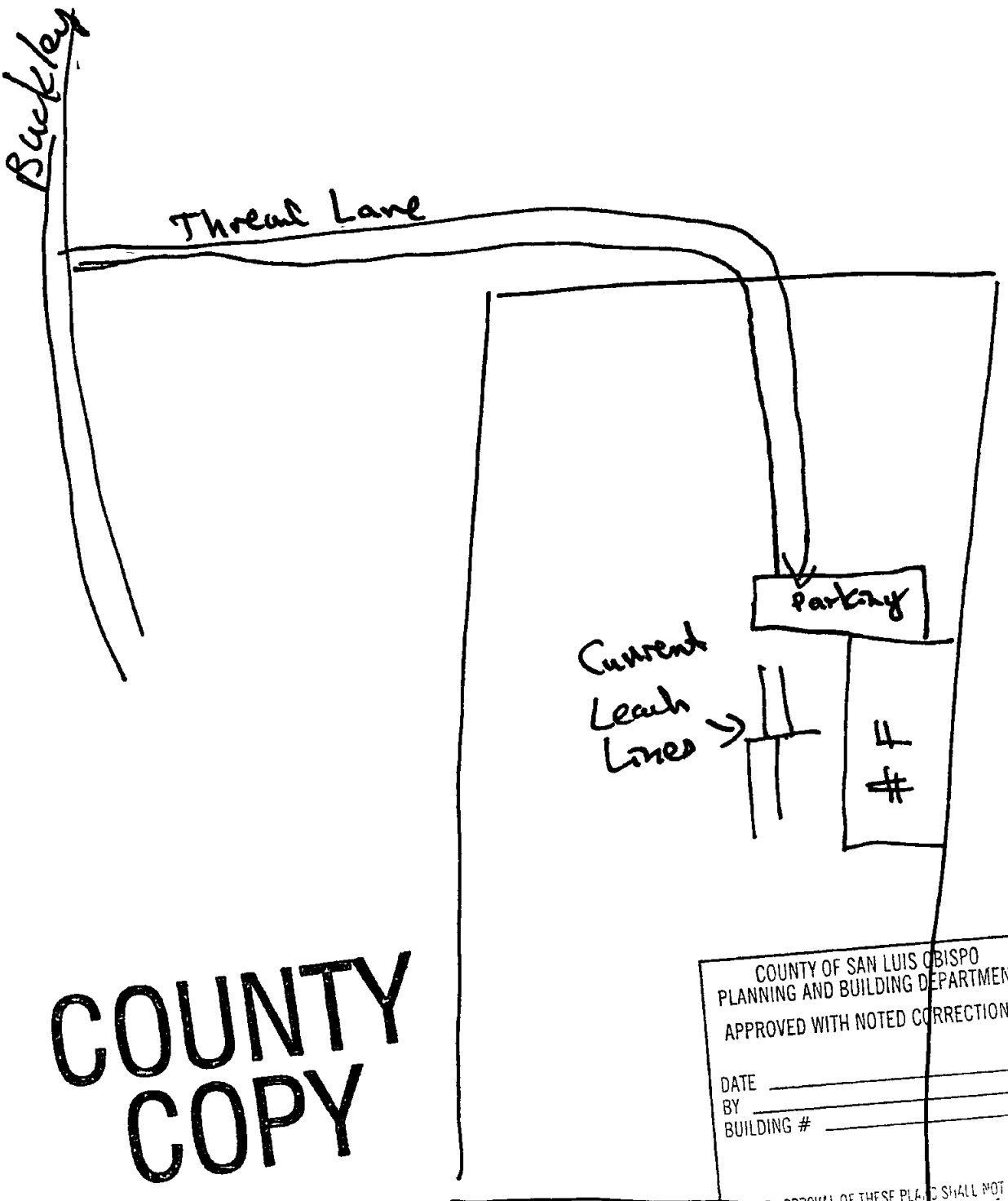
MEAD & HUNT

February 2006

X:\19430\05001\Tech\GIS\Future.mxd

APPENDIX C

Geotechnical Boring Log for 390 Buckley Road



COUNTY COPY

COUNTY OF SAN LUIS OBISPO
PLANNING AND BUILDING DEPARTMENT
APPROVED WITH NOTED CORRECTIONS

DATE _____
BY _____
BUILDING # _____

THE APPROVAL OF THESE PLANS SHALL NOT BE CONSTRUED TO PERMIT VIOLATIONS OF ANY COUNTY ORDINANCE OR STATE LAW AND SHALL NOT PREVENT THE COUNTY OF SAN LUIS OBISPO FROM REQUIRING CORRECTION OF ERROR OR OMISSIONS IN PLANS SPECIFICATIONS OR CONSTRUCTION. A SET OF THESE APPROVED PLANS SHALL BE KEPT ON THE SITE AT ALL TIMES. SUCH APPROVED PLANS SHALL NOT BE CHANGED MODIFIED OR ALTERED WITHOUT AUTHORIZATION

Case: PMT2009-00933

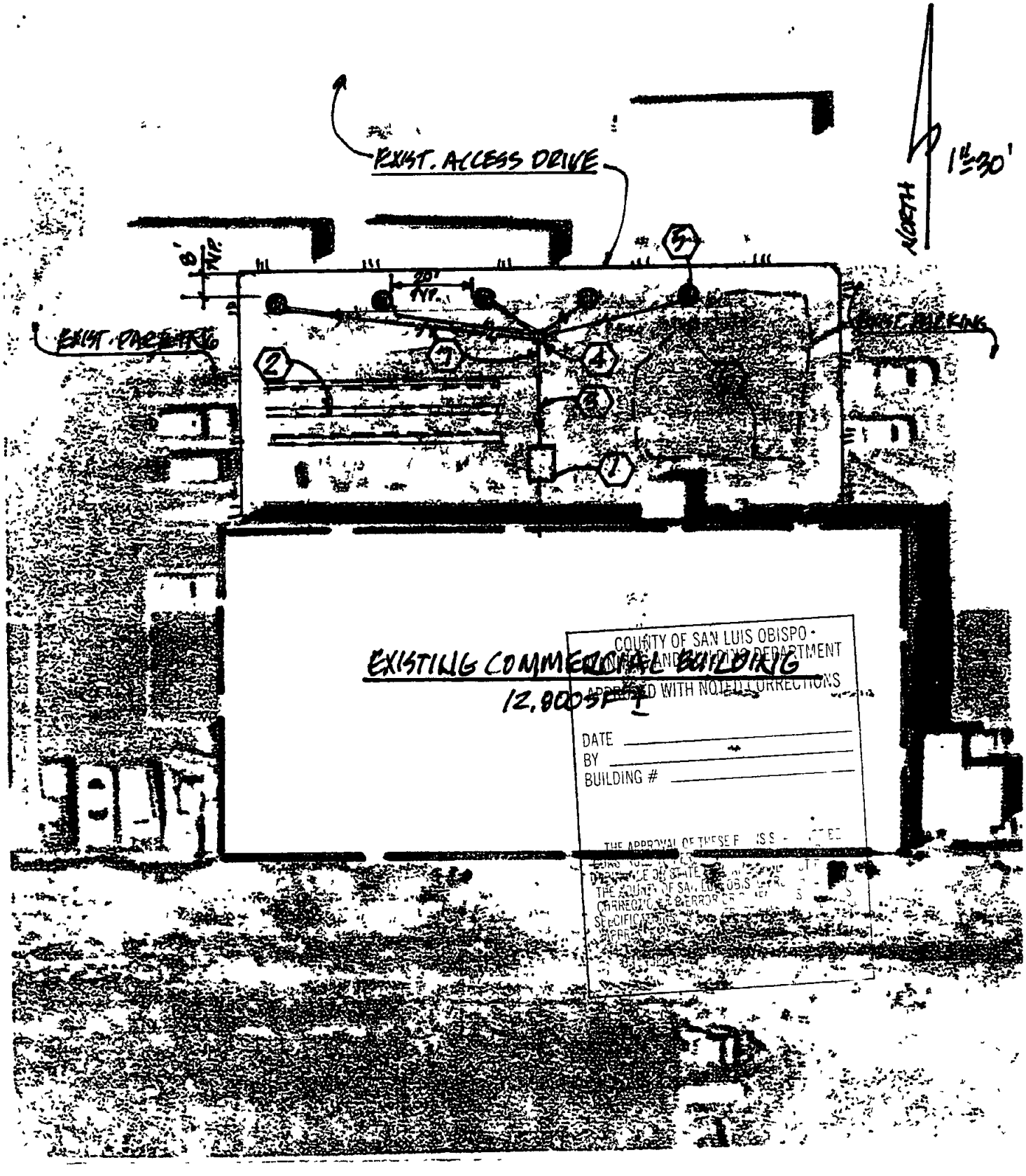
NOLL JANICE A

Project APN 076-062-033

Septic Repair-Commercial

LEACH LINE REPAIR

00390 BUCKLEY RD RSLO



Construction Notes

1. Approx. location of existing 1000 gal. septic tank. Acceptable for reuse
2. Approx. location of existing leach field. Abandon in place
3. Tie into existing septic discharge pipe. Verify size = 4"
4. Install distribution box
5. Install 5 seepage pits, 4' dia. x 36' effective depth typ. See design report for specs and details
6. 100% expansion area
7. Install new 4" PVC sewer pipe @ S= 2% min. typ.

Replacement Septic System Plan

Korte Commercial Building
390 Buckley Road, Building F
San Luis Obispo, CA 93401

12-12-2009 Scale: 1" = 30'

Al's Septic Pumping Service, Inc.

Septic Tank Locating-Inspection Service-Maintenance Service & Repairs
P O BOX 6996 Los Osos, CA 93412
528-0432, 541-8288, 773-0123, 927-1722, 466-4689

Report of Inspection-Individual Sewage Disposal System

Date: 12/15/09 Escrow # _____ Owner/Seller Edna's Bakery-Phil Korte

Property Address. 390 Buckley San Luis Obispo, CA.

Agent:
Realtor/Finance Company: _____ Title Company _____

Septic Tank

Type of Tank: ☒ Concrete ☐ Fiberglass ☐ Plastic ☐ Other _____

Tank Capacity ☒ 1000 gal. ☐ 1200 gal. ☐ 1500 gal. ☐ Other _____

Tank Components: ☒ Access Lids ☒ Baffle ☒ San-Tees ☐ Pump Station ☐ Diversion Valve ☐ Zabel Filter

Tank was pumped completely on day of inspection ☒ Yes ☐ No

Notes: TANK IN WORKING CONDITION AT THIS TIME

Leach System

☐ Operating at proper level and shows no signs of failure at time of inspection.

☒ Operating at above normal operating level Will require upgrade or replacement to maintain sanitary conditions

Notes: LEACH SYSTEM IS FAILED COMPLETELY.

Conclusions

☐ The system is functioning properly and is in good / fair condition at this time for its age.

☒ The entire system is NOT functioning properly at this time and will require upgrade in order to maintain sanitary conditions

Problem area ☐ Tank ☒ Leach Field (see details above)

Notes: LEACH SYSTEM NEEDS UPGRADE.

COUNTY OF SAN LUIS OBISPO
PLANNING AND BUILDING DEPARTMENT
APPROVED WITH NOTED CORRECTIONS
DATE
BY
BUILDING #
THE APPROVAL OF THESE PLANS SHALL NOT BE CONSTRUED TO PERMIT VIOLATIONS OF ANY COUNTY ORDINANCE OR STATE LAW, AND SHALL NOT PREVENT COUNTY OF SAN LUIS OBISPO FROM REQUIRING CORRECTION OF ERRORS OR DIMENSIONS IN PLANS OR CONSTRUCTION. A SET OF THESE APPROVED PLANS SHALL BE KEPT ON JOB SITE AT ALL TIMES. SUCH APPROVED PLANS SHALL NOT BE CHANGED, ADDED TO OR ALTERED WITHOUT AUTHORIZATION

Recommendations

☐ The tank should be checked and pumped every 2-3 years to ensure proper operation

☒ If the system is equipped with a pump station or diversion valve it should be checked annually.

Notes: _____

NOTICE TO BUYER/OWNER: This inspection is an expert disclosure of the condition of this waste disposal system. It is not a guarantee of continued performance, or condition, past inspection date. The sewer pipe from the building to the tank is not included in this inspection. Leach systems are not designed to last indefinitely. Failures can occur at any time without notice. Trees can cause premature leach failure if located near leach system. Gray water diversions of any kind are not part of this report.

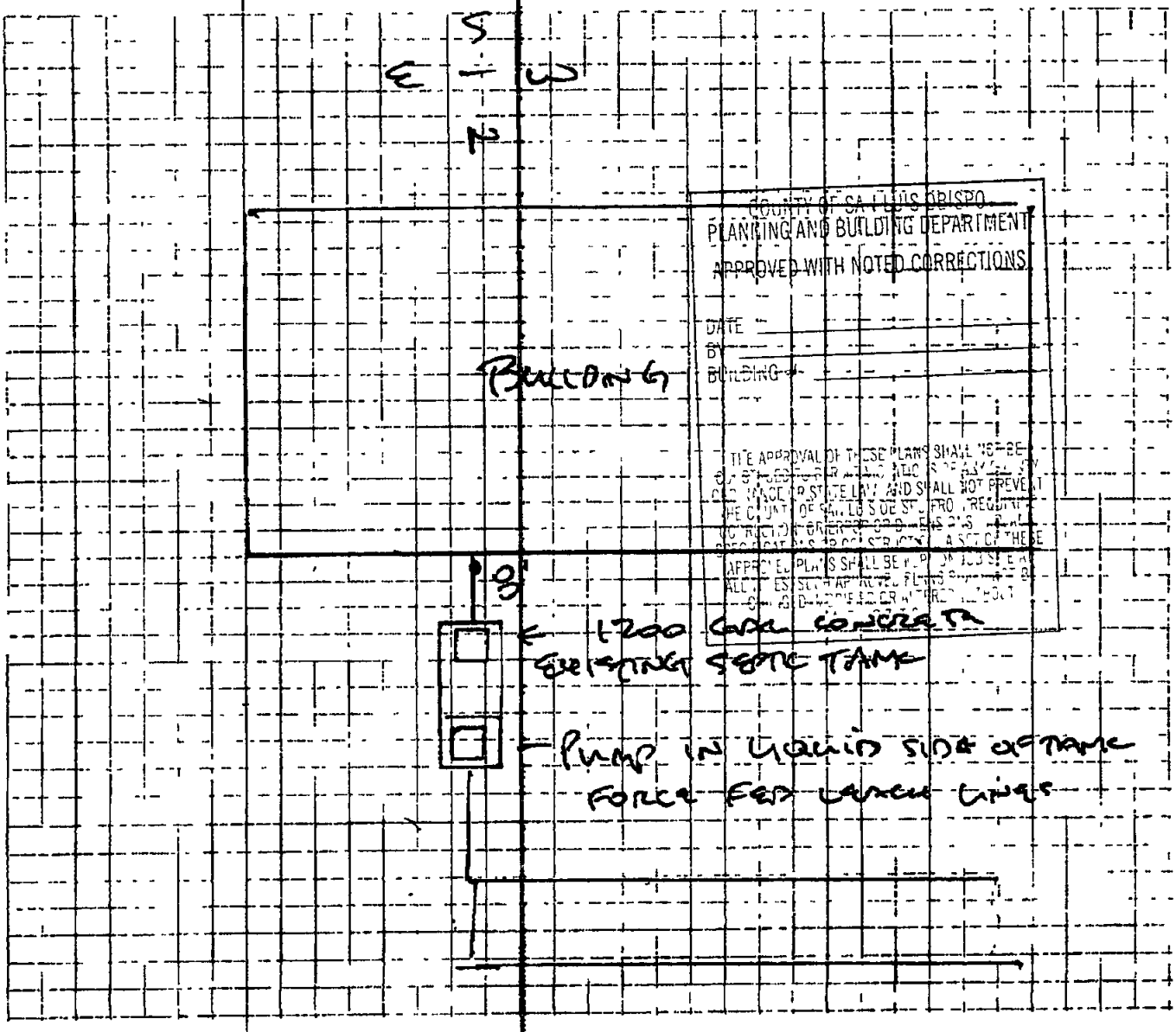
R. Alan Beavers
Owner/Operator
Bus. Lic #0603464
Contractor. Lic # 883281

Al's Septic Pumping Service Inc.-Inspection Report

Job address: 390 Buckley San Luis Obispo, CA.

Notes:

System Location & Site Sketch



Locations of the septic tank and leach field above are approximate only. The exact location or dimensioning is not within the scope of this inspection. Drawing is not to scale

BEACON GEOTECHNICAL, INC.

May 29, 2009 F-90036

Phil Korte
390 Buckley Road - F
San Luis Obispo, CA 93401

Project: 390 Buckley Road – Building F
San Luis Obispo County, California

Subject: Percolation Testing

Dear Mr. Korte:

On May 26, 2009 two (2) six (6) inch diameter borings were drilled on the above property. The locations of the holes are shown on the attached site plan.

The boring was presaturated for 24 hours and then refilled. The boring was tested/refilled every half hour for a period of five (5) hours, and then allowed to drain and tested for the noted depths below.

Total Depth	Tested Depth	Percolation Rate (min./inch)
40.0'	3'5"-10'2"	1
40.0'	3'9"-10'1"	1
40.0'	3'5"-10'3"	1
40.0'	3'4"-10'1"	1
40.0'	3'8"-9'9"	1
40.0'	3'8"-10'2"	1
40.0'	3'10"-10'0"	1
40.0'	3'6"-9'9"	1
40.0'	3'8"-9'10"	1
40.0'	3'5"-9'8"	1
40.0'	3'6"-9'10"	1
40.0'	9'10"-14'5"	5
40.0'	14'5"-18'3"	14
40.0'	18'3"-23'7"	20
40.0'	23'7"-29'5"	24
40.0'	29'5"-34'2"	40

COUNTY OF SAN LUIS OBISPO
PLANNING AND BUILDING DEPARTMENT
APPROVED WITH NOTED CORRECTIONS
DATE _____
BY _____
BUILDING # _____

THE APPROVAL OF THESE PLANS SHALL NOT BE CONSTRUED TO PERMIT VIOLATIONS OF ANY COUNTY ORDINANCE OR STATE LAW AND SHALL NOT PREVENT THE COUNTY OF SAN LUIS OBISPO FROM REQUIRING CORRECTION OF ERROR OR DIMENSIONS IN PLANS SPECIFICATIONS OR CONSTRUCTION A SET OF THESE APPROVED PLANS SHALL BE KEPT ON JOB SITE AT ALL TIMES SUCH APPROVED PLANS SHALL NOT BE CHANGED MODIFIED OR ALTERED WITHOUT AUTHORIZATION

- P.O. Box 4814, Paso Robles, CA 93447 - 3850 Ramada Drive, #A2, Paso Robles, CA 93446
- Phone - (805) 434-9490 / Fax (805) 434 -9098 Email: Beacongeotechnical@gmail.com

May 29, 2009 F-90036

We recommend that this septic system be designed by a Civil Engineer with adequate experience in and knowledge of this type of system.

If you have any questions concerning this report, please do not hesitate to contact the undersigned.

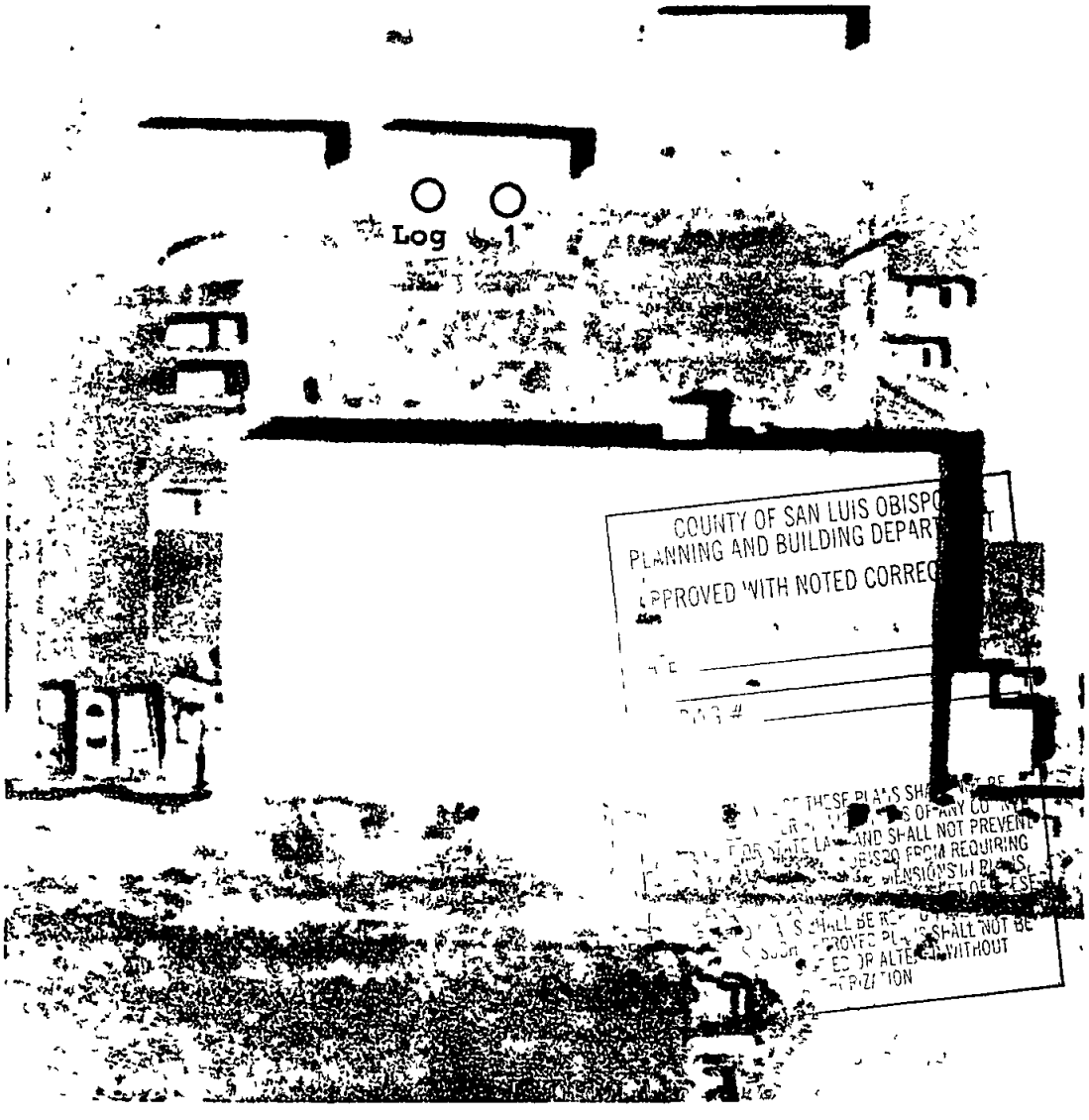
Respectfully submitted,

Greg McKay
Project Manager

Nicholas A. McClure
Civil Engineer

Attachments: Site Plan
Boring Log

Key: ⓟ = Approximate Percolation Boring Location



PROJECT No. F-90036	SITE MAP
BEACON GEOTECHNICAL INC.	

LOG OF BORING

for:

Site Location: San Luis Obispo County, California 390 Buckley Road - F F-90036

Driller/Helper:

Rig Type: Giddings #35 SCS BORING NO. 1

Auger Diameter: 4"

Date: May 26, 2009

Depth (ft.)	Bag Sample	Blows per ft.	Drilling comments	Voids	Moisture	Description	USCS	Beacon Soil ID
0						Dark brown sandy silty clay		
5						Light brown clayey silty sand		
10								
15								
20								
25						Brown silty clayey sand with gravel		
30								
40								
50						Total Depth @ 50'		

COUNTY OF SAN LUIS OBISPO
PLANNING AND BUILDING DEPARTMENT
APPROVED WITH NOTED CORRECTIONS
DATE
BY
BUILDING #
THE APPROVAL OF THESE PLANS SHALL NOT BE CONSTRUED TO BE A PERMIT FOR OR AN APPROVAL OF ANY VIOLATION OF ANY PROVISIONS OF ANY COUNTY ORDINANCE OR STATE LAW AND SHALL NOT PREVENT THE COUNTY OF SAN LUIS OBISPO FROM REQUIRING CORRECTION OF ERRORS OR OMISSIONS IN PLANS
A SET OF THESE APPROVED PLANS SHALL BE KEPT ON THE JOB SITE AT ALL TIMES DURING CONSTRUCTION. APPROVED PLANS SHALL NOT BE CHANGED, MODIFIED OR ALTERED WITHOUT AUTHORIZATION

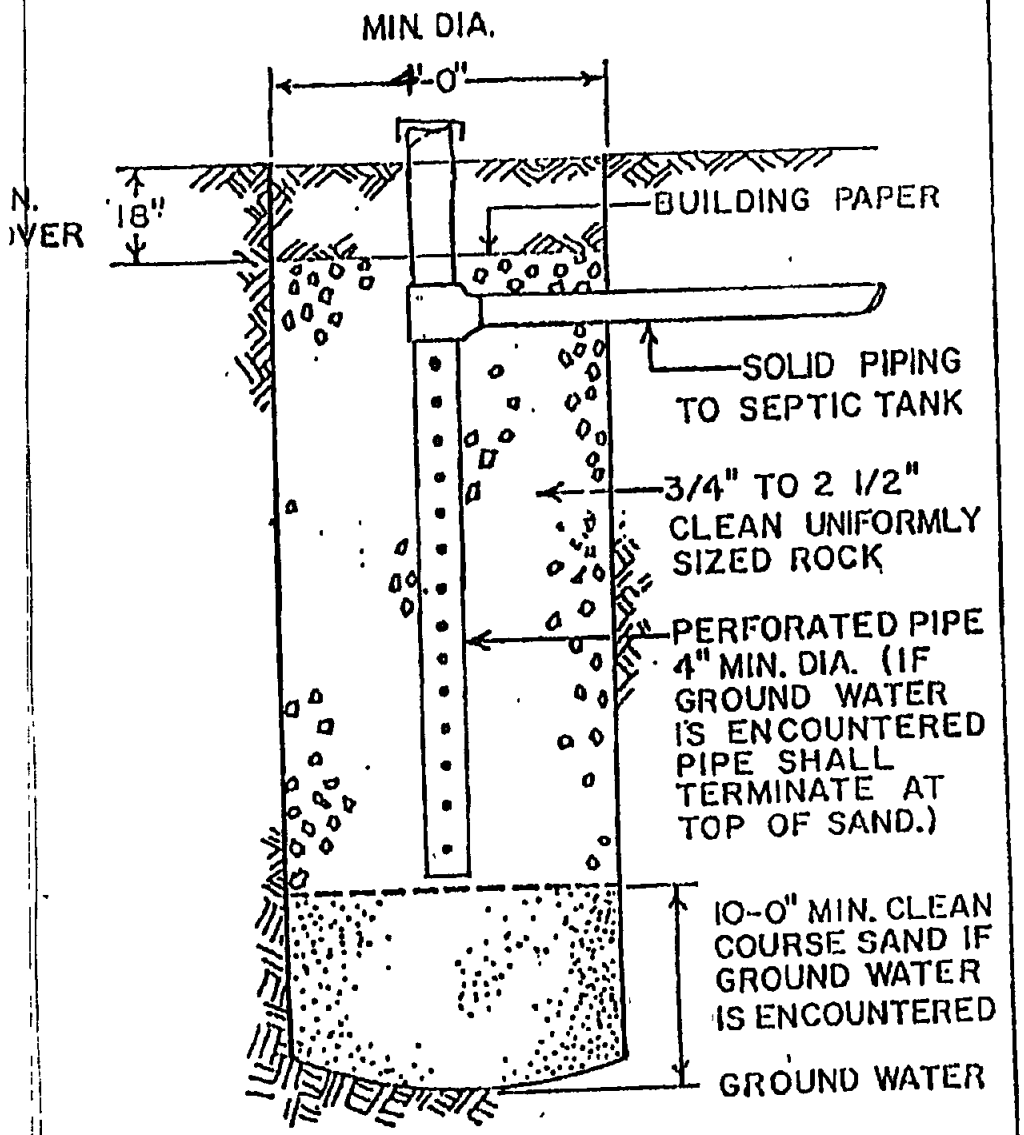
GROUNDWATER
Time Depth
NE

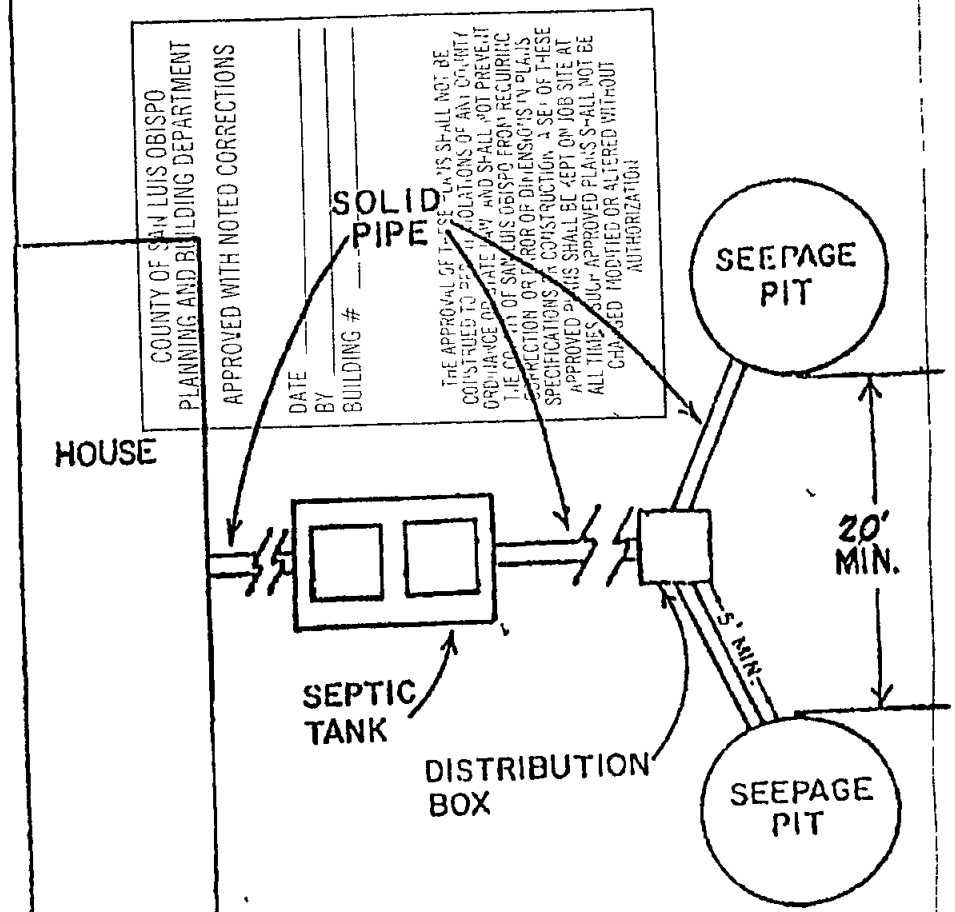
SAMPLE TYPE
U=Undisturbed ring sample
S=Standard penetration tube
T=Shelby tube
SPT=Standard Penetration Test

[ ] 3" [ ] Other:

11

SEEPAGE PIT DESIGN





UPC Table I-1

LOCATION OF SEWAGE DISPOSAL SYSTEMS IN FEET

MINIMUM HORIZONTAL DISTANCE FROM:	BUILDING SEWER	SEPTIC TANK	DISPOSAL FIELD	SEEPAGE PIT
Building structures (1)	2	5	8	8
Property line adjoining private property	—	5	5	8
Water well or suction line	50 (2)	50	100	150
Streams, lakes, ocean tidal waters or ocean waters	50	50	100	100
Large trees	—	10	—	10
Seepage pits	—	5	5	12
Disposal fields	—	5	4 (3)	5
Domestic water line	1 (4)	5	5	5
Distribution box	—	—	5	5

COUNTY OF SAN LUIS OBISPO PLANNING AND BUILDING DEPARTMENT APPROVED WITH NOTED CORRECTIONS DATE BUILDING

NOTE: When disposal fields and/or seepage pits are installed in sloping ground the minimum horizontal distance between any part of the leaching system and ground surface shall be fifteen (15) feet.

When facilities are located near the ocean tidal waters or ocean waters, the horizontal distance shall be measured from the historically most landward location of the beach at the mean high tidal water elevation. Structures of facilities shall be constructed in accordance with all Federal, State, and local laws to prevent erosion of the beaches and movement of the mean high tidal water line closer than the horizontal distances specified above.

1. Including porches and steps whether covered or uncovered, breezeways, roofed port-cocheres, roofed patios, carports, covered walls, covered or uncovered driveways and similar structures or appurtenances.
2. The distance may be reduced to not less than twenty-five (25) feet when approved type metallic piping is installed. Where special hazards are involved, the distance required shall be increased, as may be directed by the County Health Officer or the Administrative Authority.
3. Plus two (2) feet for each additional foot of depth in excess of one (1) foot below the bottom of the drain line (See Sec. UPC 1.6)
4. See Sec. UPC 1108.

RECOMMENEDED INSTALLATION TECHNEQUES AND MAINTENANCE OF SEWAGE DISPOSAL SYSTEMS

A. Problems Associated with Leachfield/Seepage Pit Construction

1. Smearing of sidewall and bottom surfaces during construction reduces absorption rate.

2. Bottom surface compaction by workers or equipment reduces absorption rate.

3. Silting of open excavation by rain, by crumbling of walls, or by windblown soil, reduces absorption rate.

Recommended leachfield/seepage pit construction to minimize damage to soil.

1. Work should be scheduled only when infiltrative surfaces can be covered in one day because windblown silt or rain can clog the soil.

2. In clayey soils, work should be done when soil moisture content is low

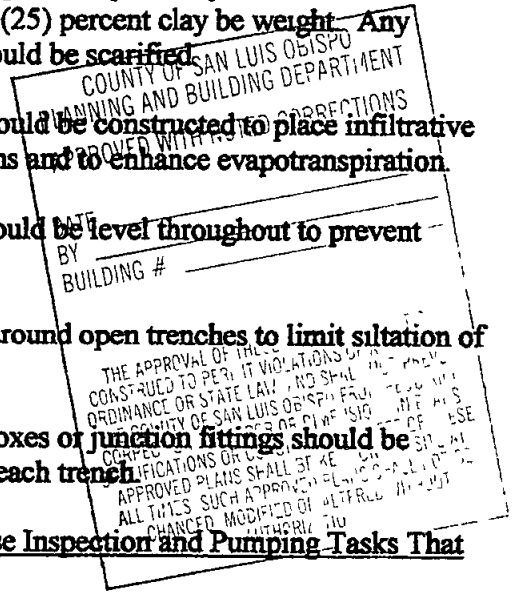
3. Bottom and sidewall areas should be left with a rough, open surface. Compaction, smearing and puddling occurs primarily in moist soils containing greater that twenty-five (25) percent clay be weight. Any smeared or compacted surfaces should be scarified.

4. In clayey soils, shallow systems should be constructed to place infiltrative surfaces in more permeable horizons and to enhance evapotranspiration.

5. Bottoms of the trenches or beds should be level throughout to prevent localized effluent overloading.

6. Surface runoff should be diverted around open trenches to limit siltation of bottom area.

7. Properly constructed distribution boxes or junction fittings should be installed to maintain equal flow to each trench.



B. Recommended During Construction to Ease Inspection and Pumping Tasks That Must Occur Later

1. Risers to the ground surface and manholes should be installed over the septic tank inspection ports and access ports.

2. Risers should be large enough to allow one person to stand over the access port and stir the tank contents as it is pumped to assure sludge and scum accumulations are removed.

3 Leachfield/seepage pits should include an inspection pipe to check the water level.

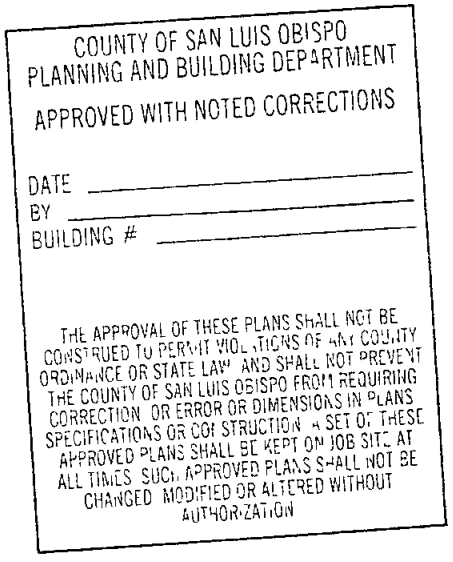
C Conventional On-Site System Maintenance

1 Septic tanks for single family dwellings or commercial discharges should be inspected at a frequency of every two (2) to five (5) years to determine sludge and scum depths. Septic tanks should be pumped every two (2) years if garbage grinders or dishwashers discharge into the septic tank.

2. Conservation and reduction of solids generated are recommended. Solids generation can be reduced by putting food scraps and non-biodegradable items in the garbage and avoiding pouring grease and inorganic salts, such as detergents and drain cleaners into the sink.

3. If on-site water softener regeneration is necessary, minimum salt use in water softener is recommended. This can be accomplished by minimizing regeneration time or limiting the number of regeneration cycles.

4. Caution should be exercised in the use of certain detergents which, over a period of time, will clog the soil.



APPENDIX D

Aerial Photographs: Will be Provided Only In Raw Electronic Format

APPENDIX E

Airport FUDS Documentation

APPENDIX E.1

1999 DOD/USACE Findings of Fact

DEFENSE ENVIRONMENTAL RESTORATION PROGRAM
FORMERLY USED DEFENSE SITES
FINDINGS AND DETERMINATION OF ELIGIBILITY

SAN LUIS OBISPO COUNTY AIRPORT
SAN LUIS OBISPO, CALIFORNIA
SITE NO. J09CA708800

FINDINGS OF FACT

1. Use of 218 acres of the San Luis Obispo County Airport by the U.S. Army Air Corps and the California National Guard was initiated in November 1938. Acquisition records were neither specific nor complete. On 4 January 1943 the Navy leased 208 acres of the San Luis Obispo County Airport from the County of San Luis Obispo. With the exception of an unspecified 10 acres, the portion of the airport used by the Army appears to be identical to that portion used subsequently by the Navy.

2. The Army Air Corps and the National Guard used the airport as an aerial observation training center, associated with Camp Merriam. Improvements constructed by the Army Air Corps and National Guard consisted of three runways, hangars, mechanic shops, mess halls, barracks, and a photography studio. The airport was used simultaneously as a commercial airport. The Navy used the airport as an air training center, in support of Amphibious Forces in the Pacific Fleet during World War II. Navy improvements consisted primarily of construction of wooden, prefabricated buildings and surficial improvements to the runways and taxiways.

3. The use of 218 acres of airport property by the Army Air Corps and the National Guard continued until at least November 1941. In May 1946, the Navy disposed of the 208 leased acres and abandoned the airport facilities, leaving all improvements to the County of San Luis Obispo. Disposal records were neither complete nor specific. Use of the airport by the County of San Luis Obispo has continued to the present. With the exception of the runways, it does not appear that any of the existing improvements were in use during Army, Navy, or National Guard occupation.

DETERMINATION

Based on the foregoing Findings of Fact, this site has been determined to be formerly used by the Department of Defense. It is therefore eligible for the Defense Environmental Restoration Program - Formerly Used Defense Sites, established under 10 USC 2701, et seq.

28 Sep 99
DATE

FOR PETER T. MADSEN
Colonel (P), U.S. Army
Commanding

APPENDIX E.2

1997 SAIC Site Inspection Memorandum

SAN LUIS OBISPO AIRPORT
DERP-FUDS SITE INSPECTION
MEMORANDUM

DATE: October 2, 1997

TO: File

FROM: Perry Russell of Science Applications International Corporation, Santa Barbara, CA

SUBJECT: DERP-FUDS Inventory Project Report Site Inspection J09CA708800 San Luis Obispo County Airport

REFERENCE: SAIC Project No. 01-0255-04-7381-102
COE Contract No. DACA63-95-D-0020

SITE LOCATION: The site is located at 903-5 Airport Drive, San Luis Obispo County, California. To access the airport from downtown San Luis Obispo, proceed approximately three miles south on Broad Street (Highway 227) and turn right on Aero Drive or Airport Drive, directly into the airport.

The site is located in Township 31 south, Range 12 east, sections 12 and 13, of the U.S. Geological Survey Pismo Beach, California 7.5 minute quadrangle.

SITE SURVEY: The site survey was completed on foot and by car, with the aid of Ms. Jacquelyn Hulsey, Airport Operations Supervisor. The airport currently consists of 320 acres, which are currently in use as a private and commercial airport. The property is occupied by typical airport facilities, including commercial and private hangars, plane service facilities (e.g. a propellar service company), an airport terminal, a restaurant, parking lots, and an aircraft control tower.

The area surrounding the airport consists of open space and commercial, industrial, and residential uses. The area west of the airport property is a former Unocal petroleum bulk storage facility. The tanks have been removed but the containment berms remain. These berms have created wetland areas. Santa Fe Levee Road traverses the western portion of the airport property, in a north-south direction. An island of private commercial development, surrounded by airport property, is located along the western side of this road. Buckley Road lies along the southern property boundary. Commercial, industrial, and residential properties are located along this road, adjacent to the airport. Broad Street lies along the eastern property boundary. Commercial and residential properties are also present along this

road, east of the airport. A portion of airport-owned property, in the northern part of the airport, is occupied by a commercial/industrial park. Similar properties are also present in the surrounding area, north of the airport property.

Most of the airport improvements appear to have been completed subsequent to DOD occupation of the airport. Plot plans of the airport, dated 1947 and 1952, illustrate two buildings in the location of the existing terminal. These buildings were reportedly remodeled into the existing terminal building. The 1947 plans of the airport show two hangars, of similar size, shape, and orientation, located in the eastern portion of the airport. These drawings suggest the hangars were either already present or constructed immediately subsequent to Navy occupation of the airport (through 1946). One of these hangars, which appears to have been unaltered in the past 20 to 50 years, is present at the airport today. No other possible evidence of DOD occupation was observed at the airport.

A fuel underground storage tank (UST) was reportedly present at either the western or eastern end of the latter older hangar (as described above) in 1960, although it is unclear when the tank was installed or whether the tank was removed. This tank was leased to Coastal Air, which sold fuel for private planes. This was the only UST present at the airport in 1960. A rectangular saw cut is present in the asphalt at the western end of one of the hangars (suggesting possible removal of the tank), however, the airport supervisor indicated the saw cut was created simply to repair damaged asphalt. A 1965 aerial photograph of the airport shows an unpaved, cleared area adjacent to the eastern end of the two old hangars, which could potentially be a UST location. No other evidence of possible existing or former USTs was observed in the vicinity of these hangars. No documentation is available regarding this UST in files from the airport, the County of San Luis Obispo Environmental Health Department (SLOEHD), or the California Regional Water Quality Control Board (RWQCB).

Coastal Air operated two other USTs adjacent to the existing Golden State Propellar facility. These tanks, consisting of one 12,000 gallon jet fuel tank and one 550 gallon waste oil tank, were installed in the 1970s and removed in July 1988. Petroleum hydrocarbon-contaminated soil was removed from the jet fuel tank excavation, to a maximum depth of 10 feet, and aerated on site. Contaminated soil was not detected in the waste oil tank excavation. A closure letter was never issued for the site (which would have indicated no additional site assessment or remediation is required), however, the site is considered closed at the SLOEHD.

Six other USTs, reportedly owned and operated by Standard Oil, were removed from the location of one of the existing public

parking lots, adjacent to an existing navigational beacon. Two 12,000 gallon jet fuel tanks, three 12,000 gallon aviation gas tanks, and one 1,000 gallon regular (leaded) gasoline tank, which were installed in the 1950s, were removed in July 1988. Similarly, contaminated soil was excavated to a maximum depth of 20 feet, and aerated on site. A closure letter was never issued for the site, however, the site is considered closed at the SLOEHD.

Several existing USTs, and associated fueling areas, were observed at the airport. At the Pilot Services, Inc. hangar, one 8,500 gallon aviation gasoline UST, and associated fuel pump, is present. This fueling station has not been used in three or four years. Pilot Services is currently in permit violation with respect to this tank. This tank will be removed during 1998. No fuel spills have been documented associated with this tank. The SLOEHD currently maintains an active file for this tank site (address: 995 Airport).

Wings West, Inc. owns three USTs at the airport. These tanks are operated by International Fuels Corporation, which supplies fuel for American Eagle Airlines. These tanks consist of one 20,000 gallon jet fuel tank, one 550 gallon gasoline tank, and one 250 gallon waste oil tank. A hazardous materials/waste storage area was observed adjacent to this fueling area. No surface spills were observed in the vicinity of the fueling and storage areas. The USTs are scheduled to be replaced by above ground storage tanks by December 1998. No fuel spills have been documented associated with these tanks. The SLOEHD currently maintains an active file for this tank site (address: 835 Airport).

Several contaminated sites are present in the immediate vicinity of the airport. Petroleum hydrocarbons are present in surface water, groundwater, and soils of the property located immediately to the west of the airport, as a result of a Unocal bulk petroleum storage tank fire in the 1920s. Based on the results of subsurface investigations at the tank farm site, the petroleum hydrocarbon plume does not extend onto the airport property. A creek, which separates the two properties, acts as a hydraulic barrier to prevent the hydrocarbon plume from extending onto the airport property. In addition, the average groundwater gradient in the vicinity of the site is to the west-southwest, which is unfavorable for the migration of the hydrocarbons beneath the airport. Soil and water remediation will occur incrementally at the tank farm site over the next several years.

Solvent concentrations have been detected locally in groundwater wells in the vicinity of the airport, however, the contamination does not appear to be widespread throughout the airport area. A business located south of Buckley Road, between Santa Fe Road and Broad Street, has a water supply well with a groundwater trichloroethylene (TCE) concentration of 60 parts per billion

(ppb). The maximum contaminant level (for drinking water purposes) established by the State is 5 ppb. However, a water sample collected from another well located on the same property contained a TCE concentration of only 2.3 ppb. A business located immediately north of the airport, on Fiero Lane, contains a well with low levels of freon and a dichloroethylene (DCE) concentration of 3 to 6 ppb. However, other wells in the vicinity of the airport, including a business on Santa Fe Road, located within an island of private companies surrounded by airport property, contains no solvent concentrations, suggesting the solvent concentrations in groundwater are localized.

Subsurface contamination resulting from a leaking diesel UST is present at a Laidlaw bus repair facility, located on Santa Fe Road, however, the groundwater gradient is generally to the west-southwest (away from the direction of the airport).

CONTACTS:

1. U.S. Army Center for Military History, Washington D.C. Mr. Demma, (202) 761-5420. No information available.

2. Office of History, U.S. Army Corps of Engineers 7701, Alexandria, Virginia. Dr. Martin Gordon, Ms. Lisa Wagner, (703) 428-6558. No information available.

3. National Archives, Printed Archives Branch, Washington D.C. Derral Bottoms, (301) 713-7029. No information available.

4. National Archives - College Park Military Reference Branch, College Park, Maryland. Rich Boylan, FAX (301) 713-7482. No information available.

5. U.S. Army Military History Institute, Carlisle Barracks, Pennsylvania. John Sloanaker, (717) 245-3611. No information available.

6. Command Office Naval Construction Battalion, Code 10H NAVFAC-Historian, Port Hueneme, California. Dr. Vince Transano, (805) 982-5563. No information available.

7. Command Office Naval Construction Battalion, Code 1564-Civil Engineering Support Office, Port Hueneme, California. Clifford Lederer, (805) 982-5537. No information available.

8. U.S. Navy-Surveying, Southwest Engineering Command, San Diego, California. Tom Phelps (619) 532-1169. This site is not within the footprint of Southwest Division. Referred to EFA West, Mike Mahoney @ (415) 244-3859.

9. U.S. Navy-EFA West, San Francisco, California. Mike Mahoney (415) 244-3859. No information available.

10. TACOM Historical Office, Joseph Avesian, (313) 574-6583. Information pertaining to Michigan sites only.

11. Air Force History Office 1, Washington D.C. Lt. Col. Miller, Sgt. Robert Crawford, (202) 767-5088. No information available.

12. Engineering Field Activities, West (Environmental Restoration Branch), San Francisco, California. Jim Brown, (415) 244-2521. No information available.

13. Port Hueneme Construction Battalion Naval Facilities Service Center. Wanda Edwards, (805) 982-2637. No information available.

14. Harth, S., Krieger, L., and Krieger, D. (eds.), "War Comes to the Middle Kingdom", Vol. 1 - 1939-1942. No information available in this historical account of the Central Coast of California during the initial years of World War II. Volume II was unavailable.

15. San Luis Obispo County Historical Society, San Luis Obispo County, California. Dorie Bentley, (805) 543-0638. Provided chronological index of newspaper articles from the Telegram Tribune. Several articles were reviewed for content, including an article dated November 1, 1938, which indicates the County Board of Supervisors signed a five year lease with I. Giumini for 116 acres of airport property and that the 40th Division Aviation of the California National Guard approved use of the airport for training purposes. Both the aforementioned article and an article dated June 12, 1939 indicated the airport was to consist of a 4,000 foot main runway, an administration building, hangars, a photographic unit, barracks, mess halls, mechanic shops, two O-47s reconnaissance/photograph planes, and five Douglas 38s. An article dated November 5, 1941 indicates the Air Corps Station was still in existence at that time. Articles from 1946 indicate the airport was utilized by the Navy during the first part of that year. However, a 1946 photograph illustrates one of the former Navy barracks was used for the first Southwest Airline Office, suggesting the Navy vacated the airport during the latter part of that year.

16. U.S. EPA Superfund Program, CERCLIS List 8: Site/Event Listing, dated September 23, 1997. The airport is not included on this list.

17. California EPA Hazardous Materials Data Management Program, State of California Hazardous Waste and Substances Sites List, dated December 1994. The airport is not included on this list.

18. California Regional Water Quality Control Board Active Local and Regional Underground Tank Cases, dated August 13, 1996. The

airport is not included on this list.

19. County of San Luis Obispo, Department of General Services, County Airports, San Luis Obispo, California. Ms. Jacquelyn Hulsey, Airport Operations Supervisor, (805) 781-5205. Ms. Hulsey has worked at the airport for 9 years. She provided a tour of the airport, including all existing and former UST locations. At the American Eagle/Wings West hangar, one 20,000 gallon jet-A fuel tank and one 500 gallon automobile gasoline tank is present. At the Pilot Services hangar, an abandoned 8,500 gallon av-gas UST is present. This tank was last used three to four years ago. Ms. Hulsey indicated an old Standard Oil UST, used in the 1960s, was removed 10 to 12 years ago from beneath one of the existing public parking lots, located near a navigational beacon. Another 10,000 gallon UST was removed approximately 12 years ago, by Coastal Air, adjacent to the existing Golden State Propellar facility. She had no knowledge of an old UST adjacent to two old hangars, located in the eastern end of the airport, as referenced by Mr. Walter Fell, airport manager from 1960 to 1979. The airport maintains no files regarding USTs or removal of USTs. The airport consists of 320 acres. She supplied copies of a 1965 aerial photograph of the airport. This photograph shows an unpaved, cleared area at the east end of the two old hangars, which may correspond with the UST location described by Mr. Fell, and an unpaved, cleared area which may correspond with the former Standard Oil UST location beneath the existing public parking lot.

20. Mr. Walter Fell, (805) 544-3232. Mr. Fell was manager of the airport from 1960 to 1979. He indicated the County built the airport in the 1930s, and the Army Air Corps and the Navy (reserve unit, non-air) occupied it during World War II. When he arrived in 1960, one UST was present at the west end of an old (approximately four plane) hangar, located in the eastern portion of the airport, next to a little office in the hangar. This tank was leased to Coastal Air, which sold fuel for private planes. No commercial aircraft were present at that time. He was unsure when the UST was installed or removed. Swift Air (commercial airline), which was established at the airport in the 1970s, installed and later removed several USTs. A parking lot currently exists over this former UST location. Other steel USTs were installed at a private hangar owned by Robert Cook. These tanks were still in use upon his termination in 1979. He indicated the County General Services Department has information on all these tanks. The military completed many improvements at the airport and then sold these improvements at the end of the war. The Navy remained at the airport for a few years following the war.

21. San Luis Obispo County General Services. Mr. Ralph Cass, (805) 781-5200. Mr. Cass provided construction plans and plot plans of the airport. Lighting plans dated January 1944 indicate

the airport was owned by the County. No information was available suggesting the DOD occupied the airport. No structures were illustrated on the plans. A plot plan, dated October 1947, shows two old hangars in the eastern portion of the airport, similar to those present today. No USTs are shown. Plans dated August 1952 indicate the airport was leased by the Navy, but no USTs are shown. The plans show the Administration building to be the existing Spirit of San Louis Restaurant and two buildings in the vicinity of the existing terminal building, which were reportedly converted into the existing terminal. Plans dated February 1955 also show the two older hangars in the eastern part of the airport. As shown in the plans, the southern hangar was existing and the northern hangar was proposed. There were no indications of USTs adjacent to these hangars.

Plans dated March 1970 illustrated two proposed USTs located north of a former beacon tower, and west of an existing beacon tower, in the location of an existing public parking lot, at the intersection of Aero Drive and Airport Drive. Construction plans dated May 1974 illustrate the addition of two new 12,000 gallon jet fuel tanks adjacent to three existing 12,000 gallon tanks (of unknown type), one smaller leaded gasoline tank (for automobiles), and possibly one waste oil tank. These tanks corresponded with with the aforementioned tanks located at the intersection of Aero Drive and Airport Drive. Drawings dated January 1977 illustrate two proposed 12,000 gallon tanks located adjacent to three existing tanks of unknown size. The location of these tanks, which were operated by Swift Air, were unknown. Plans dated October 1978 illustrated proposed Coastal Air jet fueling facilities located immediately south of Airport Drive, adjacent to the existing propellar company. The facilities consisted on one main UST, of unknown quantity, and one 550 gallon slop tank.

22. San Luis Obispo County Environmental Health Department. Mr. Manual Negrete, (805) 781-5595, Mr. John Scholtes, (805) 781-5544, and Mr. Brad Seek (805) 781-5548. Mr. Negrete and Mr. Scholtes provided information regarding USTs at the airport. A review of Environmental Health Department files provided more detail regarding these USTs. This information is included above in the Site Inspection Memorandum. In addition, Mr. Scholtes indicated that a Unocal tank farm was formerly present west of the airport and that contamination is present in this area. Reportedly there was a fire in the 1930s at the farm. The RWQCB is the lead agency on the site. The file name is "276 Tank Farm Road". Existing levees at the site are old tank containment berms. Mr. Seek is with the Domestic Drinking Water Department. He provided information regarding solvents in domestic supply wells in the vicinity of the airport. The details are provided above in the Site Inspection Memorandum.

23. California Regional Water Quality Control Board - Central

Coast. Mr. Frank De Marco (805) 549-3147, Mr. Richard Aleshire (805) 542-4631. Mr. De Marco handles general groundwater contaminated sites and Mr. Aleshire was formerly involved with the Well Investigation Program, approximately six years ago, which specifically targeted solvent contamination in groundwater. They have no file pertaining to the airport. County Environmental Health would refer the site to the RWQCB only in the event of documented groundwater contamination. However, several contaminated sites are located in the immediate vicinity of the airport. Details regarding these sites is provided above in the Site Inspection Memorandum. Mr. De Marco also provided maps which delineate the hydrocarbon plume at the adjacent former Unocal tank farm site.

24. Arroyo Grande Library. Mr. Harold Yeo, (805) 473-7161. With regard to historical information for the area, Mr. Yeo referred to "War Comes to the Middle Kingdom", by Dan Krieger, and historians Margaret Price (489-4079) and Jean Hubbard, at the County Historical Society. Also recommended contacting Dan Krieger.

25. Dan and Elizabeth Krieger, (805) 543-9611. Authors of "War Comes to the Middle Kingdom". They were unavailable for comment.

26. San Luis Obispo County Planning Department. (805) 781-5600. The Planning Department maintains no UST files or drawings of the airport. Referred to the County Environmental Health Department and the Airport Manager in the General Services Department.

27. San Luis Obispo County Recorders Office. (805) 781-5080. No information available. Referred to County Clerks Office.

28. San Luis Obispo County Clerks Office. (805) 781-5088. Copied Board of Supervisor Resolutions and lease agreements regarding Navy occupation at the airport. No information was available regarding Army Air Corps or National Guard use of the airport. See details in Site Survey.

29. San Luis Obispo County Assessors Office. (805) 781-5643. Copied Assessors Parcel Map of airport (APN 076-401-04, 231 acres total).

30. San Luis Obispo County, Department of General Services, Property Division. Sandy Duff, (805) 781-5200. Referred to Caryn Stumpenhaus, Property Manager, regarding property transfer records and general County Airport records.

31. San Luis Obispo County, Department of General Services, Property Division. Caryn Stumpenhaus, (805) 781-5200. Referred to County Clerks Office.

32. San Luis Obispo County, Department of General Services,

County Airports. Paul Gimer (805) 781-5200. Mr. Gimer is the airport manager. He authorized a request for a site walk and referred me to Jacquelyn Hulsey, Airport Operations Supervisor. He was manager during removal of USTs during 1989. He indicated all six tanks were removed beneath the existing parking lot adjacent to the beacon tower. He also indicated the two smaller tanks in this area consisted of one leaded fuel tank, used for automobiles, and one waste oil tank. He indicated all these tanks were installed by private firms subsequent to DOD use of the airport. He thought that San Luis Air used these tanks.

33. San Luis Obispo County, Department of General Services. Mr. Gene Johnson, Architectural Supervisor. He indicated the existing airport terminal originally consisted of two agricultural buildings, which were converted into the existing terminal building. He also thought the original buildings were formerly used by the Navy.

34. Mr. Joe Adamski, (805) 543-3377. He was stationed at the airport with the Navy Air Corps unit in 1944-1945. Approximately 5 people were stationed at the airport. The airport was to be used for support of land-sea operations, but not much activity occurred at the airport. The airport was also available for emergency landings. Navy improvements consisted of two wooden barracks. These remained for a while after the war and were later removed. These barracks were not used for any other reason after Navy use. No military planes were stationed at the airport. No commercial or private planes were located there. No fueling tanks were present. Fuel was supplied by trucks which used fuel tanks at the Paso Robles airport as their source. Paso Robles airport was a much larger military airport, which possibly had several large USTs. The airport was considered the Carrier Aircraft Unit 5.

APPENDIX E.3

1997 SAIC Site Inspection Photographs

PHOTO NO. 1 — Existing UST at Pilot Services hangar. View southeast.

PHOTO NO. 2 — Existing UST at Pilot Services hangar. View northeast.

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SAN LUIS OBISPO AIRPORT
J09CA708800
San Luis Obispo, CA

PHOTO NO. 3 — Old 4-plane hangar. View southeast.

PHOTO NO. 4 — Plane inside of old 4-plane hanger. View southeast.

PHOTO NO. 5 — West end of old 4-plane hangar. Possible UST location.

PHOTO NO. 6 — Former UST location adjacent to Golden State Propeller. View east.

PHOTO NO. 7 — Jet fuel UST and fueling area at American Eagle/Wings West hangar. View north.

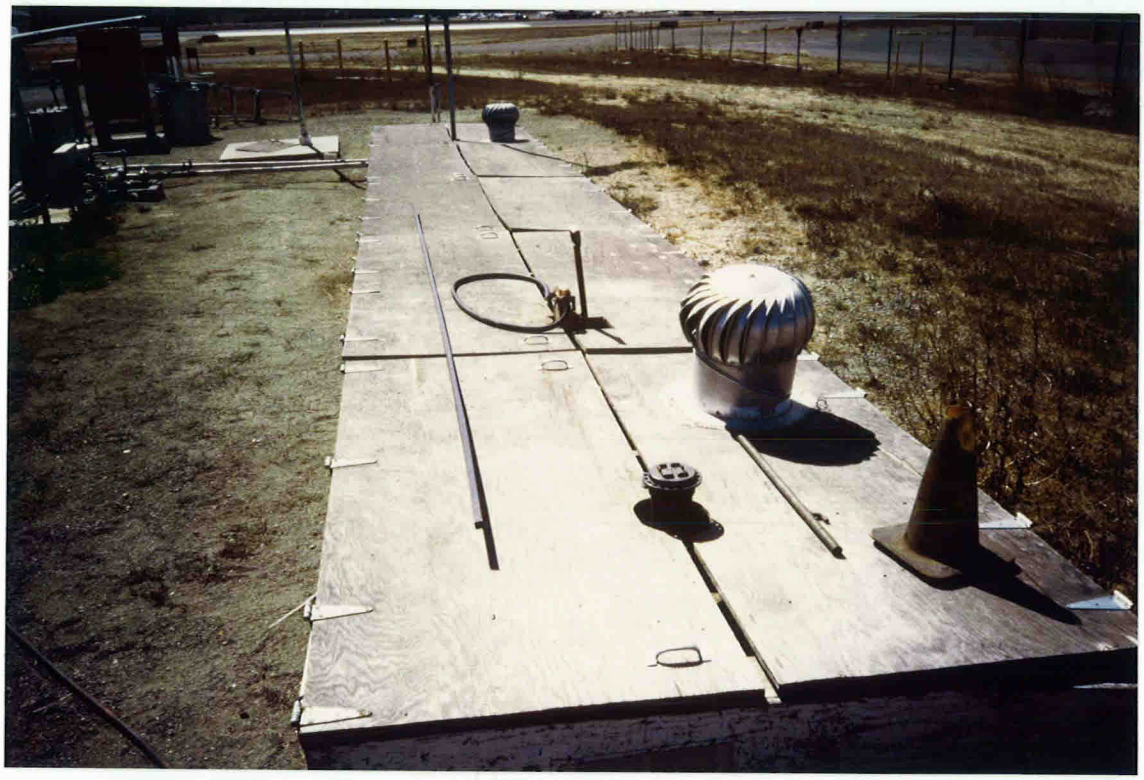

PHOTO NO. 8 — UST at American Eagle/Wings West hangar. View southwest.

PHOTO NO. 9 — Hazardous materials storage area, American Eagle/Wings West hangar. View northeast.

PHOTO NO. 10 — Hazardous materials storage area, American Eagle/Wings West hangar. View northeast.

PHOTO NO. 11 — Former Standard Oil UST location at existing parking lot.

PHOTO NO. 12 — East end of old 4-plane hangar. View southwest.

APPENDIX E.4

2012, Doherty Paper, RE: Solvent Use During World War II

Environmental Forensics, 13:7–26, 2012

ISSN: 1527-5922 print / 1527-5930 online
DOI: 10.1080/15275922.2011.643341

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Review Articles

The Manufacture, Use, and Supply of Chlorinated Solvents in the United States During World War II

Richard E. Doherty

Engineering and Consulting Resources, Inc., Acton, MA, USA

The history of the manufacture, use, and supply of carbon tetrachloride, tetrachloroethylene, and trichloroethylene in the United States during World War II is discussed against the background of war events, particularly the extraordinary level of government control over the economy that evolved during this period. The manufacture and use of these chlorinated solvents (and other materials needed as part of the war effort) was regulated under a succession of government agencies and programs. Despite the general shortage, military demands for these chemicals were successfully met, although amounts available for civilian use varied. During the war, supply levels fluctuated significantly due to changes in production, demand, and policy.

Keywords: chlorinated solvents, carbon tetrachloride, trichloroethylene, tetrachloroethylene, perchloroethylene

Carbon tetrachloride (CT), trichloroethylene (TCE), and tetrachloroethylene (PCE) were three of the most widely used cleaning and degreasing solvents in the United States (US). These chlorinated solvents were useful to industry and the military due to their rapid evaporation rates, low flammability and reactivity, and their ability to quickly and efficiently dissolve a wide range of organic substances. Although the manufacture and use of these solvents in the United States during the 20th century has been discussed previously (Doherty, 2000a; 2000b), a more detailed discussion pertaining to the World War II period (circa 1940 to mid-1945) is presented here. Following a summary of wartime uses and major producers of each chemical, the discussion is presented in a chronological format, together with information on the war's progress and the evolution of government controls, in order to provide a historical context for the changes that took place.

During the World War II (WWII) period, a succession of US government agencies assumed an increasing level of control on supplies of essential materials, including chemicals. In the war's later stages, the government was responsible for controlling the supply of more than 3,000 chemicals and chemically-related products, of which approximately 300 (including CT, TCE and PCE) were controlled through a system of priorities, often followed by a more rigorous system of allocation (War Production Board [WPB], 1946). The evolution of these systems is discussed as they related to CT, TCE, and PCE, but also as they related to chlorine (a raw material in the production of all three chemicals) and other essential materials.

Review of historical documents indicates that, in general, government regulators took steps to both control demand and increase supply prior to development of the most severe shortages. For CT, supplies were generally adequate early in the war, but became more scarce in later years due to its increased use in the production of chlorofluorocarbons (CFCs). TCE and PCE supplies, which were closely interrelated due to shared production facilities, were especially tight in the later stages of the war, although stockpiles were created in the early years in anticipation of increased demands. TCE supplies reached their most critical stage from mid-1944 until near the end of the war. The increased demand for TCE during the war was primarily due to its increased use in vapor degreasing, while PCE demand increased due to its use in the production of hexachloroethane. During the most severe shortages, civilian supply for all but the most essential uses (e.g., use in food production) was eliminated so that defense requirements could be met. Table 1 provides a chronological summary of the implementation of government controls, and the supply and demand status for CT, TCE, and PCE throughout the war years.

Principal Wartime Uses and Manufacturers

Carbon Tetrachloride

As of the end of the war, the major use of CT was in the manufacture of CFC refrigerants (identified by the trade name Freon). This use consumed approximately 40% of the total CT supply. Other applications included direct military use for degreasing

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Table 1. *Chronologic summary of chlorinated solvent supply and demand, 1941–1945*

DATE	Carbon Tetrachloride (CT)	Trichlorothylene (TCE)	Tetrachloroethylene (PCE)
		1941	
10/15/1941	**M-41 Order issued to preserve supply and direct distribution. Priority ratings assigned to essential uses (Federal Register 1941).**	**M-41 Order issued to preserve supply and direct distribution. Priority ratings assigned to essential uses (Federal Register 1941).**	**M-41 Order issued to preserve supply and direct distribution. Priority ratings assigned to essential uses (Federal Register 1941).**
December 1941	Efforts underway to find substitutes, reduce demand,and quantify supplies and demands (Baxter 1941).	Efforts underway to find substitutes, reduce demand,and quantify supplies and demands (Baxter 1941).	Efforts underway to find substitutes, reduce demand,and quantify supplies and demands (Baxter 1941).
		1942	
3/02/1942	WPB warns metal fabricators to investigate all possible alternatives to chlorinated solvents for cleaning (WPB 1942b).	WPB warns metal fabricators to investigate all possible alternatives to chlorinated solvents for cleaning (WPB 1942b).	WPB warns metal fabricators to investigate all possible alternatives to chlorinated solvents for cleaning (WPB 1942b).
03/21/42	Adequate supplies reported, production increases anticipated (Chem. Branch 1942a).	Surplus reported due to increased production capacity, stockpiling to begin (Chem. Branch 1942a).	
05/02/42	**Amendment to M-41 Order issued; adds new ratings and places new limits on civilian uses (WPB 1942c).**	**Amendment to M-41 Order issued; adds new ratings and places new limits on civilian uses (WPB 1942c).**	**Amendment to M-41 Order issued; adds new ratings and places new limits on civilian uses (WPB 1942c).**
05/30/42	Stockpiling underway; proceeding satisfactorily (WPB 1942d).	DuPont stockpiling TCE; proceeding satisfactorily (WPB 1942d).	
06/27/42		Memo notes that nearly 4 million pounds of TCE being procured by AAF for FY 1943 (Cook 1942).	
06/27/42	Four of five producers report surpluses, and seek to increase shipments to civilians (WPB 1942e).	Stockpiling continues ahead of anticipated increased demands. New DuPont plant producing 3 million pounds per month. Goal of 20 million pound stockpile appears attainable (WPB 1942e).	
07/01/42	Four of five producers report surpluses and seek to increase shipments to civilians (WPB 1942e).	Stockpiling continues ahead of anticipated increased demands. New DuPont plant producing 3 million pounds per month. Goal of 20 million pound stockpile appears attainable (WPB 1942e).	
07/18/42		AAF Chief reports no difficulty in obtaining adequate supplies (Carroll 1942b).	
08/22/42	Supplies considered adequate to fill B-2 and higher-rated orders (WPB 1942g).	Essential requirements being met; stockpiling continuing. However, a new AAF order for 6 million pounds and increased CWS demand for PCE are expected to tighten supplies and it is proposed to refuse B-rated orders (WPB 1942g).	CWS increases tetrachloroethane requirement, increasing demand for PCE. Proposal made to refuse B-rated orders (WPB 1942g).
08/29/42	Supplies remain adequate; B-rated orders to be filled until at least Jan. 1943 (WPB 1942h).	Navy orders 7.5 million pounds, critical supply situation foreseen, all B-rated orders to be refused (WPB 1942h).	All B-rated orders to be refused (WPB 1942h).
09/19/42	Supplies “plentiful”. Suppliers request approval to increase sales to B-2 rated users (WPB 1942k).	Sales to be restricted until year end due to short supply (WPB 1942j).	Sales to be restricted until year end due to short supply (WPB 1942j).
		1943	
1/30/1943		“Satisfactory” stockpile exists for emergency use (WPB 1943a).	DuPont to begin stockpiling to meet anticipated needs for hexachloroethane production (WPB 1943a).
September 1943	Use in dry cleaning is banned due to high military demand and limited production facilities (WPB 1944b).		
October 1943		Air Service Command said to have an excess of TCE in stock (Morgan 1943).	
11/20/43		TCE is “still in short supply”. Air Service Command to transfer excess TCE for use in fire extinguishers (WPB 1943b).	PCE is “still in short supply” (WPB 1943b).

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Table 1. *Chronologic summary of chlorinated solvent supply and demand, 1941–1945 (Continued)*

DATE	Carbon Tetrachloride (CT)	Trichlorothylene (TCE)	Tetrachloroethylene (PCE)
11/27/43	Tight supply situation, demand continues to increase. Allocation order being drafted (WPB 1943c).	Orders significantly exceed production capacity. DuPont instructed to cut quantities supplied to AA-1 orders. Allocation order being drafted (WPB 1943c).	Orders significantly exceed production capacity. DuPont instructed to cut quantities supplied to AA-1 orders. Allocation order being drafted (WPB 1943c).
12/25/43		Supplies still short. Orders subject to horizontal cuts. Allocation expected by February 1944 (WPB 1943d).	Supplies still short. Orders subject to horizontal cuts. Allocation expected by February 1944 (WPB 1943d).
		1944	
January 1944	**M-363 Order issued, placing CT under full allocation (WPB 1943d).**		
02/26/44	Demand "far greater than production", all civilian requests being denied. High demand is due to use in CFC production and 5.4 million pound Navy order for use in fire extinguishers (WPB 1944q).		
03/01/44		**M-371 Order in effect, placing TCE and PCE under full allocation (WPB 1944d, Federal Register 1944).**	**M-371 Order in effect, placing TCE and PCE under full allocation (WPB 1944d, Federal Register 1944).**
March 1944	Demand increases due to anticipated expansion of Chicago CFC production facility, 6.1 million pound Navy order, and pressure to supply rural dry cleaners. Monthly production capacity is roughly three quarters of anticipated demand (WPB 1944e).		
03/25/44		April allocation expected to meet all essential demands (WPB 1944r).	April allocation expected to meet all essential demands (WPB 1944r).
04/22/44	May requests are more than twice estimated production. New production capacity not expected until at least Fall 1944 (WPB 1944h).	Production and stocks considered sufficient to meet essential demands. Stockpiling recommended to address anticipated summer production drop (WPB 1944h).	Production and stocks considered sufficient to meet essential demands (WPB 1944h).
06/13/44	War Dept. issues directive restricting use and requiring recovery measures (War Dept. 1944b).		
06/21/44	WPB announcement cites "reduced military demands" (WPB 1944g).	WPB states that supply situation remained bad through the first half of 1944 due to urgent military demands, and that no solvent was made available for dry cleaning (WPB 1944g).	WPB states that supply situation remained bad through the first half of 1944 due to urgent military demands, and that no solvent was made available for dry cleaning (WPB 1944g).
07/01/44	Amount available for dry cleaning increased from 214 to 1086 drums per month (Hamill 1944).	WPB making 300,000 pounds per month available for dry cleaning beginning in July (Hamill 1944).	WPB making 200,000 pounds per month available for dry cleaning beginning in July (Hamill 1944).
10/07/44		Decreased production in third quarter tightens supply situation (WPB 1944i).	Cutback in hexachloroethane production eases supply situation, allows more TCE production (WPB 1944i).
10/14/44	Military and essential demands met for October, but insufficient supply for dry cleaning due to heavy military demand (WPB 1944j).	Stocks decreased and supplies tight due to production difficulties. 97% allocated to metal degreasing for war production; none for dry cleaning (WPB 1944j).	
10/28/44		None to be made available for dry cleaning in November due to increased military demand and production difficulties (WPB 1944k).	None to be made available for dry cleaning in November due to increased military demand and production difficulties (WPB 1944k).
11/18/44	Additional production capacity anticipated (WPB 1944l).	DuPont released material from stock to ease tight supply situation. Increased production anticipated in December is expected to meet all military demands (WPB 1944l).	A limited amount will be made available in December due to order cancellations and returns (WPB 1944l).
11/25/44	Supply situation appears under control (WPB 1944m).	Supply situation remains critical. December requests exceed increased production levels by 4 million pounds (WPB 1944m).	Supply situation appears under control (WPB 1944m).
12/02/44	December allocation will meet all military and essential civilian demands (WPB 1944n).	Supplies remain tight; stockpiles being depleted. CWS Marshall plant to produce TCE (WPB 1944n, WPB 1946).	December allocation will meet all military and essential civilian demands (WPB 1944n).

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Table 1. *Chronologic Summary of Chlorinated Solvent Supply and Demand, 1941–1945 (Continued)*

DATE	Carbon Tetrachloride (CT)	Trichlorothylene (TCE)	Tetrachloroethylene (PCE)
12/06/44		WPB recommends that TCE be added to Critical List due to lack of stock, and demands in excess of supply. (WPB 1944o)	
12/23/44	"Military and essential civilian needs" to be met for January 1945 (WPB 1944p).	"Essential war production needs" to be met for January 1945 (WPB 1944p).	"War production needs" to be met for January 1945 (WPB 1944p).
		1945	
01/06/1945		Production at CWS Marshall plant and imports from Canada improve supply situation, but winter storms delay shipments from Niagara Falls (WPB 1945a).	Efforts being made to convert TCE users to PCE (WPB 1945a).
02/10/45		Demand for TCE in degreasing continues to increase; large AAF order expected (WPB 1945b).	
02/24/45		1.9 million pounds not shipped in January 1945 due to transportation problems; similar or greater quantities expected to be delayed in February (WPB 1945c).	March production will just meet allocation. Tight supply situation due to large Army requirements (WPB 1945c).
03/03/45		**Due to increased military needs, M-371 Order revoked and replaced with tighter restrictions under Order M-300. Requests for use in commercial dry cleaning to be denied beginning in March (Federal Register 1945).**	**Due to increased military needs, M-371 Order revoked and replaced with tighter restrictions under Order M-300 (Federal Register 1945).**
07/21/45	Increase in allotment for dry cleaning in August (WPB 1945e).	Shortages abating, small amounts to be released for dry cleaning (WPB 1945e).	Shortages abating, small amounts to be released for dry cleaning (WPB 1945e).
07/28/45	Substantial surpluses starting to build up; increased quantities released for dry cleaning and other uses (WPB 1945f).	Substantial surpluses starting to build up; increased quantities released for dry cleaning and other uses (WPB 1945f).	Substantial surpluses starting to build up; increased quantities released for dry cleaning and other uses (WPB 1945f).
08/27/45	**WPB announces that dry cleaners will be free of controls as of August 31 (WPB 1945h).**	**WPB announces that dry cleaners will be free of controls as of August 31 (WPB 1945h).**	**WPB announces that dry cleaners will be free of controls as of August 31 (WPB 1945h).**

AAF, Army Air Force; CFC, chlorofluorocarbons; CWS, Chemical Warfare Service; DuPont, E.I. du Pont de Nemours; FY, fiscal year; WPB, War Production Board.

and in fire extinguishers (19% of total supply), indirect military use for degreasing (11%), civilian use for degreasing (8%), miscellaneous and industrial uses (6%), civilian use in fire extinguishers (5%), dry cleaning (4%), and agricultural uses such as grain fumigation (3%). Smaller amounts of CT were used for drugs, in synthetic rubber production, or were exported. The majority of exports went to Canada, which did not have CT production facilities (WPB, 1946). CT was also used to a limited extent in the production of hexachloroethane, which was used as a military smokescreen (WPB, 1944a); however, the primary hexachloroethane production process used during the war involved the chlorination of PCE.

In the Army Air Force (AAF), CT was used for "filling fire extinguishers, . . . for cleaning spark plugs; parachute harnesses; small radio, radar, bombsight, and gyro instrument parts; electrical accessories; aircraft cabins; small parts of engines; propellers; carburetors; ignition parts; hydraulic assembly parts; and office appliances" (Parrish and Byram, 1945, p. 195). CT was also found to be an excellent solvent for "dissolving waxes, degreasing spark plugs, cleaning oxygen equipment, photographic film, bombsights, and other precision instruments" (Parrish and Glass, 1945) Misuse inevitably occurred, including "personnel cleaning work clothes in 5 gal. pail*[s]* of fluid, wringing and airing garments; using the solvent to mop grease and oil from floors within relatively confined areas; wiping spilled oil from regulator in B-17 wing section; *[and]* working in *[a]* concentration of 155 ppm in air at *[a]* spark plug cleaning station" (Parrish and Glass, 1945).

During the war, CT was produced by five manufacturers: Dow Chemical Company (Dow Chemical), Westvaco Chlorine Production Corporation (Westvaco), Pennsylvania Salt Manufacturing Company (PennSalt), Stauffer Chemical Company (Stauffer), and the Diamond Alkali Company. Reported total US CT production during the war is shown on Table 2 (WPB, 1946, Ind. Eng. Chem., 1941b, Kirk and Othmer, 1949). The year-over-year production increases shown in Table 2 primarily resulted from the need to meet the demand for use in fire extinguishers, in metal degreasing and dry cleaning, and as a raw material for CFC production. The production increases were made possible by privately financed expansions

Table 2. *Reported US Production Volumes During WWII*

Year	1940	1941	1942	1943	1944	1945
CT	100.8	121.8	139.5	170.9	210.0	109.1[2]
TCE	NA	NA	80.5[1]	206.6	235.7	140.6[2]
PCE	NA	NA	15.0	53.0	75.1	NA

All quantities in millions of pounds. NA indicates data not available. [1]Past 6 months only; [2]First 6 months only.
Data from Leppart (1945); WPB (1946); Ind. Eng. Chem. (1941b); Kirk and Othmer (1949); United States Tariff Commission (1943–1944).

of Dow Chemical's plants in Pittsburg, California, and Freeport, Texas, in 1943, and Stauffer's Niagara Falls plant (WPB, 1946).

Trichloroethylene

TCE "was used in machines built especially for the purpose *[i.e., vapor degreasers]*, which were usually part of production lines in manufacturing plants making war equipment of all kinds, such as airplanes, tanks, guns, ammunition, etc. A large field use for the same purpose developed by the various military branches, particularly the Air Corps" (WPB, 1946, p. 499, emphasis added). TCE was widely used in the AAF, primarily for vapor degreasing of items used "in electroplating, in spark plug, propeller and engine repair, and in reclamation" (p.). Lesser but significant quantities of TCE were used for caffeine extraction, and to lower the freezing point of CT in fire extinguishers intended for winter use (CT freezes at −22.9°C or −9.3°F; TCE freezes at approximately −89°C or −123°F). TCE was also used at AAF stations in dry cleaning facilities, and for cleaning small arms (Parrish and Byram, 1945, p. 196).

The production of TCE, PCE, and tetrachloroethane was closely interrelated due to the nature of the primary production process in use at the time. Each chemical was manufactured from "crude" tetrachloroethane produced by the chlorination of acetylene. Producers therefore had the flexibility to produce varying quantities of the three end products in accordance with demand.

Major TCE producers during the war years were E. I. du Pont de Nemours (DuPont) and Westvaco; however, more than 90% of wartime TCE was produced by DuPont (Leppart, 1945). Dow Chemical also produced some quantities of TCE (US Tariff Commission 1941–1945). The combined production capacity of DuPont and Westvaco at war's end was approximately 22 million pounds per month. DuPont operated a production facility in Niagara Falls, New York, that was expanded twice during the war. A DuPont facility in Wyandotte, Michigan, was constructed during the war, producing approximately 6 million pounds per month, approximately doubling the capacity existing at the time (Leppart, 1945). The Marshall Army Chemicals Plant of the Chemical Warfare Service (CWS) located north of New Martinsville, West Virginia, originally built for tetrachloroethane and hexachloroethane production, was converted in the closing months of the war to produce up to 4 million pounds of TCE per month. The Army financed this conversion, but other expansion and construction of TCE facilities were privately financed (WPB, 1946). TCE production volumes during the war years, as documented in a 1945 history, are shown in Table 2 (Leppart, 1945).

Perchloroethylene

The largest wartime use of PCE was as a raw material in the production of hexachloroethane, which was used in smoke-producing devices. A 1946 WPB history notes that PCE was also used during the war "as a metal degreasing agent for all types of equipment for direct and indirect military use. Only very small amounts were released from time to time for other special uses, such as dry cleaning and animal medicines." The writer also noted that "Full preference was given at all times to direct and indirect military demand" (p. 504).

PCE producers during the war years were Dow Chemical, Westvaco, and DuPont (US Tariff Commission 1940–1945). The major wartime PCE production facility was the CWS Marshall Army Chemicals Plant in West Virginia that began operation in July 1943. PCE produced at this location was used to make hexachloroethane. In late 1943 and early 1944, Dow Chemical expanded plants in Pittsburg, California, and Freeport, Texas, to produce PCE for hexachloroethane production. (WPB, 1946, West Virginia Development Office, n.d.). Available production figures for PCE are shown in Table 2 (US Tariff Commission 1943–1944; WPB, 1946). The significant increase in production over these years was primarily attributable to the increasing demand for hexachloroethane (WPB, 1946).

1940: Production Goals and a Voluntary Priorities System

As of 1940, the US was in its eleventh year of economic depression, with unemployment at 17%. Franklin Delano Roosevelt (FDR), in his eighth year as president, was commander-in-chief of the world's 18th largest army, a force smaller than those of Poland, Portugal, Sweden, Switzerland, Belgium, and the Netherlands. Only 1,800 airplanes had been manufactured in the US during all of 1939. Military equipment on hand included a stock of World War I era Springfield rifles, approximately 500 mostly outdated tanks, and approximately 5,000 aircraft, many of which were poor quality and none of which were battle-tested. These weapons were no match for the highly mechanized, mass-produced, modern equipment possessed in great quantities by the German Army. The total US capacity for aircraft production at this time was 2,000 planes per year, while Germany's was approximately 10 times greater (Nelson, 1946; Goodwin, 1995).

After a period of military inactivity, Germany regained the world's attention by invading Norway and Denmark in April and Belgium, Luxembourg, France and the Netherlands in May. In a May 16, 1940, speech to Congress, FDR called for an increase in US warplane production to a level of 50,000 planes per year. The magnitude of this goal was evidenced by the fact

that the total US production of planes of all kinds from 1903 (when the Wright Brothers made their first flight) to September 1939 was slightly more than 30,000 (Durr, 1950). Two weeks after FDR's speech, Britain successfully evacuated more than 300,000 stranded troops from the beaches of Dunkirk, France, but left behind huge quantities of weapons, tanks, and vehicles. After the evacuation, Britain was left with an air force of only 238 planes. After the fall of France in June 1940, Britain was left virtually alone as the sole unconquered combatant against the German onslaught.

In the days following the Dunkirk evacuation, FDR ordered that "every spare rifle, every spare bit of ammunition, every spare field piece that we could find in our warehouses and arsenals be sent to Britain as fast as ships could be obtained to transport them" (Nelson, 1946, pp. 77–78) Although the US in fact had no spare quantities of any of these items, the military declared much of its supply as "surplus" so that aid could be given to Britain (Nelson, 1946; Goodwin, 1995).

On May 29, 1940, FDR created the National Defense Advisory Commission (NDAC) to coordinate the provision of aid to Britain and other allies. The NDAC comprised seven commissioners, each representing a different industry segment. Probably the most important component of NDAC was the Industrial Production Division, which was assigned the difficult task of retooling industry for war production without impacting the civilian economy. The Industrial Production Division attempted to persuade industries to retool, but had no real authority and no funding to support industry expansion (Nelson, 1946; Smith, 1959).

NDAC's Raw Materials Department included a Chemicals and Allied Products Division, with the objective to ensure that chemicals would be available in the necessary quantities and at the necessary times and places. The work of the Division began by obtaining information from the Army and Navy Munitions Board (ANMB) on the type and approximate quantities of chemicals that were anticipated under a rearmament program. The ANMB responded with information on 110 chemicals required by the Armed Services. This response was combined with information on non-military demands, imports and exports, production data, and industrial capacities to identify materials likely to be in short supply (WPB, 1946). Almost immediately after its formation, the Division listed 14 materials as "strategic" and 15 as "critical" (Nelson, 1946, p. 94). Among the most critical items were toluene and nitrogen compounds, both used in the production of explosives. However, little was done to increase the supply of these materials until the spring of 1941 (WPB, 1946).

On June 25, 1940, the Reconstruction Finance Corporation Act was amended to allow the creation of government–controlled corporations with the authority to build, expand, purchase and lease military production facilities and equipment. The Act allowed the leasing of the new or expanded plants to private companies, who would then operate them. The authority to create such a corporation was exercised on August 22, 1940, when, despite opposition from many in government and industry, the Defense Plant Corporation (DPC) was founded. The first DPC contract, signed on September 3, 1940, authorized the Packard Motor Company to construct an aircraft engine plant. After a period of contract negotiation and standardization, other contracts were signed. These contracts allowed DPC to retain title to the new plants, and included a 90-day option for the private operator to purchase the facility after the emergency period had ended (Durr, 1950; Smith, 1959; White, 1980).

During the war, approximately $93 million was disbursed by DPC for plants and equipment for the production of industrial chemicals. Projects sponsored by the War Department included construction or expansion of facilities producing toluene, sulfuric acid, potassium perchlorate, and other munitions-related chemicals, while projects sponsored by other agencies included facilities for producing oxygen, acetylene, DDT, ammonia, caustic soda, phthalic anhydride, CFCs, and chlorine. Dow Chemical received the ninth-largest amount of financing of all US companies (primarily for magnesium production), and DuPont the 24th largest (Smith, 1959; White, 1980).

On August 12, 1940 the ANMB issued a directive that set up a classification system for ranking military orders in terms of importance. This system formed the basis of the "priorities" system that remained in use throughout the war. The rankings ranged from A-1 (highest priority) to A-10 (lowest priority), with a higher "AA" rating reserved for emergency use. The A-1 rating was assigned to orders needed to provide equipment for the Regular Army and National Guard, and attain the "first aircraft objective" (Smith, 1959, p. 510) of providing 12,385 planes and associated facilities by October 1, 1941. Orders needed to attain the "second aircraft objective" (Smith, 1959, p. 510) (18,000 planes by April 1, 1942) were assigned an A-4 rating. The A-7 rating was designated for "expansion and construction of facilities (government or private) for 18,000 annual plane production and for production of critical equipment for maintenance of *[a]* 2,000,000-man Army" (Smith, 1959, p. 510). The priorities system was to be put into practice through the issuance of preference rating certificates for priority orders that would bear the appropriate rating for the material ordered. Under the system, the highest-rated orders would be filled first. Lower-rated orders would then be filled in order based on their priority ratings. The system as originally designed was entirely voluntary, and its use was limited to items named on a "Critical List" to be created by ANMB. Because ratings for civilian orders were not created by the ANMB's directive, and the system was voluntary, it did nothing to directly restrict civilian consumption (Smith, 1959).

In September 1940, FDR signed legislation authorizing the nation's first peacetime draft. An amendment gave the government the authority to take over manufacturing facilities whose owners were unwilling to fulfill defense orders; however, this authority was not immediately exercised (Nelson 1946). At approximately the same time, NDAC in conjunction with the Army and Navy approved its first chemically-related project: the production of toluene from petroleum at Humble Oil's Baytown Refinery in Houston, Texas (WPB, 1946).

By the end of September 1940, the newly created ANMB priorities system was already running into difficulties. The Warner

& Swasey Company, a machine tool manufacturer, reported that 97% of their orders carried an A-1 priority. Similar situations across the country prompted calls to subdivide the A-1 ranking to allow manufacturers to determine which orders needed to be filled first. In response, the ANMB issued a directive on November 27 that subdivided the A-1 class into 10 subgroups designated A-1-a to A-1-j. The A-1-a class was reserved for supplies needed by manufacturers of critical machine tools and gauges, so that they could produce the tools needed for the subsequent manufacture of planes, tanks, and other military equipment (Smith, 1959).

On October 8, the Second Revenue Act of 1940 was signed into law. The Act included several important features that stimulated privately financed construction of much-needed production facilities, including a 5-year amortization period for costs associated with constructing or purchasing facilities to be used for defense production, and suspension of existing laws limiting profits on contracts for building ships and aircraft (Smith, 1959).

An Executive Order issued on October 21 directed NDAC to establish a Priorities Board that, in conjunction with ANMB, had the authority to assign priorities to important Army and Navy contracts. Donald Nelson, a former executive at Sears Roebuck, was named administrator of the new Board. According to Nelson, the Board quickly ran into difficulties because, in its advisory role, it had no decision-making authority (Nelson, 1946). According to a WPB history, "This power *[to assign priorities]* was welcomed at the time, but later proved to be hopelessly inadequate to the task at hand. Its use in the Chemicals Bureau in 1940 was little exercised as far as chemicals were concerned, but it served as a worthy instrument in obtaining equipment for the chemical industry" (WPB, 1946, p. 5; emphasis added).

On December 20, 1940, FDR announced plans for a new agency, the Office of Production Management (OPM), to carry on the work started by NDAC. Among its missions was to "increase and regulate the production and supply of defense materials, equipment and emergency plant facilities" (p. 118). Although vested with little more authority than NDAC, OPM managed to make advances in the standardization of parts to be used for aircraft and tanks, which helped facilitate the mass production that would later take place (Nelson, 1946).

Due to the demand for armaments and supplies from allies, and the recognized need for the US to strengthen its military, companies began the process of converting from civilian to wartime production well before the US entered the war. During 1940, Procter & Gamble prepared to manufacture ammunition, US Shoe Machinery prepared to build tank guns, and General Motors, AC Spark Plug, and Frigidaire started the process of making Browning machine guns. Similar efforts were made in countless companies across the country (Nelson, 1946).

1941: Government Control Increases

On January 7, 1941, the OPM was officially established, and the NDAC was abolished and its functions transferred to OPM. The NDAC Chemicals and Allied Products Division continued its work as the Chemical Section of the Materials Branch of the Production Division of OPM, working primarily on production problems. A separate Chemicals Group was established in the Priorities Division of OPM to deal with priorities-related issues. This group comprised military, government, and industrial representatives that met weekly to identify and devise strategies for mitigation of potential shortages. Initial concerns included the supply of polyvinyl chloride, tricresyl phosphate, cresylic acid, formaldehyde, methanol, phthalic anhydride, naphthalene, nitrogen, potassium permanganate, plastics, toluene, casein, and chlorine (WPB, 1946; OPM, 1941).

On January 31, 1941, the OPM's Priorities Division requested that machine tool builders stop delivering products to customers without priority ratings as of February 28. OPM's first mandatory industry-wide order was issued on February 24, when aluminum producers and machine tool builders were required to fill orders according to the priority system (Nelson, 1946).

FDR's efforts to assist Britain and other allies through the supply of weapons and equipment led to the enactment of the Lend-Lease Act on March 11, 1941. The Act allowed the transfer of arms and equipment to occur at the discretion of the President, and overcame obstacles placed by the Neutrality Acts passed in the late 1930s. Seven billion dollars were appropriated to implement the act (Goodwin, 1995).

Later in March 1941, OPM's Priorities Division established a formal Priorities Plan in conjunction with ANMB, and revised the Critical List of items and materials to which the military could affix priority ratings. The Priorities Plan retained the major features of the ANMB's priority system, but was designed in anticipation of the impending need to require mandatory compliance by industry. The revised Critical List included a variety of general military items ranging from "Aircraft: all types" to "Wire: service types," and added many new items, including chlorine and most of the major metals and alloys (OPM, 1941; Nelson, 1946; Smith, 1959).

As of the spring of 1941, aircraft production was 30% behind schedule. Part of the problem was that increased employment led to a rise in demand for civilian products, diverting scarce resources from military production. In a May 27, 1941, radio address, FDR stated "I have tonight issued a proclamation that an unlimited national emergency exists, and requires the strengthening of our defense to the extreme limit of our national power and authority" (Goodwin, 1995, pp. 238–239). This proclamation was to lead to a level of government involvement in private industry and civilian life that seems unimaginable today, particularly in light of the fact that the US was not yet at war.

Concern over the supplies of chlorine was evident in the late spring of 1941. At the June 3 meeting of the Chemicals Priority Committee, data from a War Department report on the supply of chlorine was presented. The report stated that a shortage was expected in 1941, and that chlorine would need to be diverted from civilian paper and chemical industries to meet military needs. The shortage was expected to be temporary due to anticipated production increases (Chemicals Priority Committee, 1941a). These production increases materialized during 1941 and 1942, when approximately 200 million pounds per year of new chlorine production capacity were brought on line. During

the war years, 21 new chlorine plants were erected, 10 of which were government financed. The eventual diversion of chlorine from pulp and paper production to defense needs totaled approximately 120 million pounds per year (Skeen, 1948).

Two weeks later, the chlorine subcommittee reported that companies had agreed to voluntary reductions in the use of chlorine for the production of CT, TCE, ethylene glycol, and ethyl gas. With previous steps taken to lower the use of chlorine in the production of anti-freeze and dry-cleaning fluid (e.g., PCE), these agreements were expected to increase the quantity of chlorine available for defense needs. Nonetheless, the Chemicals Priority Committee "agreed that all assistance possible be given to plants needing additional equipment for the production of chlorine" (Chemicals Priority Committee, 1941b, p. 2). In accordance with a general policy of setting minimum civilian requirements at no less than 50% of the peacetime demand, a level of 300,000 tons per year of chlorine was established for civilian purposes (Chamberlain, 1942).[1] On July 28, 1941, chlorine was placed under full priorities control (Nelson, 1942).

On June 14, FDR froze German and Italian assets in the US. Five weeks later, Japanese assets in the US were frozen and diplomatic relations suspended. In an interview published in July 1941, the head of OPM stated, "You can't have 500 bombers per month and business as usual," and called for a 50% cut in the production of civilian automobiles, refrigerators, and washing machines (Goodwin 1995, p. 231). On August 21, 1941, a major step towards conversion of the auto industry to wartime production was taken when automakers were ordered to cut passenger car production by more than 26%. Greater cuts were expected after November 30 (Nelson, 1946).

By August 1941, the difficulties with the priorities system were reaching a critical stage. The root of the problem was that available supplies were insufficient to simultaneously build up the US military, provide for the Lend-Lease program, and meet increasing civilian demands. Under these conditions, the priorities system failed to provide a balanced distribution of the available supply. Although the highest-rated orders might be filled, many lower-rated orders were not being filled at all, regardless of their importance to the overall war effort. In response, OPM established a Requirements Committee to provide rulings on conflicting claims for materials. However, this measure did little to address the fundamental problem (Nelson, 1946).

In an attempt to resolve the supply crises and the problems of the priorities program, FDR on August 28 established the Supply, Priorities, and Allocations Board (SPAB). The SPAB's mission was to allocate the available supply of materials among the various military, Lend-Lease, and civilian needs. SPAB had the authority to step in wherever shortages existed, and allocate the available supply among the various competing needs through the issuance of priority certificates. This authority extended to the allocation of materials to specific industrial or manufacturing uses by civilians (Nelson, 1946). OPM continued to exist, but reported to SPAB from August until December 1941 (WPB, 1946).

[1]Chamberlain was the chief of the Chlorine Unit of the WPB's Chemical Section.

In the first week of September 1941, OPM issued Priorities Regulations 1 and 2, which officially replaced the voluntary priorities system with a mandatory priorities system. The new priorities system adopted all of the ANMB's ratings for military orders (which at that time were AA through A-10), and added new priority ratings B-1 through B-8 for essential civilian orders. Manufacturers were required to accept all orders with priority ratings, whether they be military or civilian, with few exceptions. For each material subject to priority ranking, manufacturers were required to keep records of inventories, orders and deliveries, and make these records available to SPAB for use in the allocation program. The regulation prohibited the accumulation of excess inventory, and included criminal penalties for violators (WPB, 1942a; Time, 1941).

At the first SPAB meeting on September 2nd, a statement was prepared that proclaimed "Every available man and machine must be employed either on direct defense requirements or at work essential to the civilian economy . . . the less essential must go" (Nelson, 1946, p. 161). This statement, coupled with the fact that approximately 16% of the nation's income was being spent on a war in which the US was not an official participant, highlights the sense of urgency felt at the time.

A key component of the SPAB's authority was the power to allocate supplies rather than simply set priorities. In contrast to the priorities system, the allocation approach involved the direct assignment of specific quantities of scarce materials to designated uses. To implement the allocation system, the agency assembled information on the available supply of the essential material for a defined period of time, typically the upcoming month or year. This available supply information was then compared with information on the quantities requested by all users for delivery during that period. In cases in which the demand exceeded the supply, the supply would be divided, or allocated, between the various users with the goal of achieving the best overall result. This approach prevented the highest rated users from consuming all of the available supply and typically allowed lower priority users to fulfill at least some of their needs. Nelson (1946) stated that "it is safe to say that without *[the allocation system]* the war production program could not have succeeded" (p. 353).

The process of setting up an allocation system proved difficult. Reliable statistics on production and consumption were lacking, and the demand for scarce materials was rapidly changing as new weapons were being designed, tested, and modified. SPAB set out to compile the necessary information and take actions to prevent hoarding of scarce materials by suppliers and users (Nelson, 1946).

The first direct action affecting chlorinated solvents was taken on October 15, 1941, when the Priorities Division of OPM issued General Preference Order M-41 "to conserve the supply and direct the distribution of chlorinated hydrocarbon solvents" (p. 1). The M-41 Order was one of many "M" orders issued to control the supply and distribution of materials needed for the war effort. The solvents affected by this order were CT, TCE, PCE and 1,2-dichloroethane (Nelson, 1941; Federal Register, 1941). The issuance of the order was prompted at least

partially by the Department of Agriculture's warning that the nations' food supply was threatened due to the lack of these solvents for use in grain fumigation (Ind. Eng. Chem., 1941a). Order M-41 regulated "all future transactions of any kind" for the four chemicals, and explicitly assumed control of their supply and distribution (Nelson, 1941, p. 1). Rather than setting up a system of allocating the available supply, the order assigned priority ratings to various uses according to their importance (WPB, 1946). Military uses were assigned ratings of A-10 or higher as determined by military procurement personnel. A B-2 rating was assigned to solvent orders for grain fumigation, use in fire extinguishers, refrigerant manufacture, and manufacturing of food, chemicals, rubber, and petroleum (Nelson, 1941; Ind. Eng. Chem., 1941a).

On November 15, 1941, the ANMB wrote to OPM's Priorities Division requesting that TCE be added to the Critical List. The letter cited the use of TCE in degreasing gears, and named DuPont as the sole producer. The author claimed that defense contractors were having difficulty procuring TCE from DuPont due to the lack of an assigned preference rating for the desired uses (Hines, 1941).

The defining event of 1941 for the US was the December 7, 1941, attack on Pearl Harbor, and the declaration of war on Japan the following day. In response, Germany declared war on the US on December 11. The weeks following Pearl Harbor were a time of great concern: The US naval fleet was crippled, Japan had taken or was about to take control of the world's major rubber-producing areas in the Far East, Germany controlled most of Europe, and, for the first time in 125 years, real worries existed of a potential invasion of the US mainland (Nelson, 1946).

The attack added to the work of the Chemicals Bureau as the "long-threatened interruption of trade with the East Indies materialized, affecting supplies of rubber, fats, and certain minerals" (p. 7). The Bureau worked to stimulate further construction of new production facilities, leading to the implementation of "over a hundred major expansion projects contributing to the supply of 40 or more chemicals . . ." at a cost of approximately 200 million dollars (p. 8). More than 50% of this amount was for ammonia production, while 7.5 million was spent for "synthetic resins and solvents" and approximately 5 million for chlorine (WPB, 1946, p. 9).

Meeting minutes dated December 30, 1941, document a meeting between OPM, DuPont, and Oakite (a manufacturer of alkali cleaning chemicals) to discuss the potential for substituting alkali cleaners for chlorinated solvents. The minutes stated that the current and projected future chlorinated solvent demand was driven by usage in cleaning aircraft engines and parts, and that the Army's demand (which included the AAF) was much larger than the Navy's. Degreasing prior to aqueous cleaning was cited as comprising up to 30% to 40% of TCE use at the time, and Ford, Chrysler, General Motors, and General Electric were identified as chlorinated solvent users. Measures considered to reduce demand included converting small vapor degreasers to alkali soak tanks, and placing limits on the use of chlorinated solvents for cold cleaning, paint shields, degreasing prior to aqueous cleaning, and general industrial cleaning. To provide additional data, DuPont agreed to compile lists of new plants coming on line and descriptions of how the new supplies would be used, and lists of chlorinated solvent uses and their corresponding volumes (Baxter, 1941).

1942: Production Increases and Growing Pains

The year 1942 saw the largest expansion of production in US history. Private businesses across the country converted to military production, including a merry-go-round factory making gun mounts, a corset factory making grenade belts, a toy company producing compasses, and a pinball machine maker producing armor-piercing shells. Silk stockings became unavailable because the material was needed for parachutes, and distilleries were converted to the production of industrial alcohol. To meet the demand for new ships, the apprenticeship period for shipfitters was reduced from four years to seven weeks. The average time to produce a ship was cut from 355 days in 1940, to 194 days in 1941, and to 60 days in early 1942. By the end of 1942, the US was producing more war material than any other country (Goodwin, 1995; White, 1980).

At the same time as industry was converting to wartime production, restrictions were being implemented to eliminate non-essential civilian consumption. One of the many restrictions put in place was Order L-41, which prohibited all but the smallest non-essential construction projects, effectively preventing new home construction and building additions. Many consumer items, including gasoline, were rationed. A national speed limit of 35 miles per hour was imposed in October to preserve rubber.

The conversion of the American manufacturing base to defense production resulted in profound changes in the conduct of business. Former competitors freely exchanged materials, equipment, and knowledge to facilitate increased production. If urgent production at a factory was held up due to the shortage of materials or certain equipment, calls would go out to other manufacturers, and the missing items would often be quickly provided. Chrysler, the war's first major tank manufacturer and a leader in tool manufacturing, opened its doors to newcomers so that they could learn manufacturing methods. Of the aircraft industry, Nelson (1946) wrote:

> Commercial rivalries vanished in the smoke of war, and all of the major airplane firms plus literally hundreds of thousands of little business enterprises—including even some basement workshops – which produced parts, sub-assemblies, equipment and supplies, were integrated into a vast system of aircraft production that dwarfed anything on earth (p. 235).

In his State of the Union speech on January 6, 1942, FDR set the following production goals for 1942; 60,000 planes, 45,000 tanks, 20,000 anti-aircraft guns, and 6 million tons of merchant shipping. For 1943, he called for new planes to be produced at a rate of one every 4 minutes, a tank every 7 minutes, and two new ships per day. To meet these goals, he called for work to take place 24 hours per day, 7 days per week, and asked that every

available tool be used to produce munitions for the war effort (Goodwin, 1995). In the opinion of Donald Nelson, then OPM Director of Priorities, attainment of these goals was "completely out of the question" (Nelson 1946, p. 186).

A January 9, 1942, memorandum to the Bureau of Industrial Conservation from W. H. Chamberlain, Chief of the Chemical Section Chlorine Unit, highlighted the severity of the chlorine shortage at this early stage of US involvement in the war. The memo stated that less than 75,000 tons of chlorine were available for civilian use for all of 1942, even without considering the increased needs that would arise from FDR's latest production goals. The memo compared the available quantity with the 600,000 tons used for civilian purposes in 1939, and the prewartime civilian allotment of 300,000 tons for 1941. Efforts to convert civilian users to alkali cleaners were cited as a means of freeing supplies of chlorine for wartime use. The use of chlorine in the manufacture of TCE, CT, PCE, 1,2-dichloroethane, and methyl chloride, all of which were used in metal degreasing, was cited as "one of the biggest single demands for chlorine" (p. 1). Chamberlain stated that producers would be unable to meet the demand for these chemicals in airplane motor plants under construction at the time, and that the additional demand arising from FDR's new production goals would further exacerbate the shortage. Chamberlain (1942) believed that "the switch-over from chlorinated solvents to alkali cleaners will not work too much of a hardship on industry if the idea of using the alkali cleaners can be sold to those who are not now using them" (p. 2).

On January 16, 1942, FDR announced the creation of the War Production Board (WPB) to replace both OPM and SPAB. The WPB was to be a central planning and coordinating agency whose mission was to convert the nation to a "full war economy," and whose chairman would have "complete and absolute control over the production of all implements of war and over all related activities" (pp. 18–19). The authority granted to WPB, and the centralization of that authority in a single office, were the major differences between WPB and its predecessor agencies (Nelson, 1946). Donald Nelson was appointed Chairman of the WPB.

On January 20, 1942, WPB issued its first order, stopping production of all passenger cars and trucks effective February 1. Any vehicles in production or in the possession of dealers as of January 15 were rationed first to the Lend-Lease program, and the remainder to vital users such as doctors, police, and public safety personnel. In the ensuing months, the entire manufacturing capacity of the US auto industry was converted to the production of military items such as tanks, planes, guns, bombs, armored cars, jeeps, and troop carriers. Many auto dealerships were put out of business, and more than 400,000 dealer employees lost their jobs (Nelson, 1946; Goodwin, 1995).

On January 27, WPB gave its Division of Industrial Operations the authority to operate the priorities system, and the power to compel manufacturers to accept defense-related orders (Nelson, 1946). On January 30, an Emergency Price Control Bill was signed that set up a preliminary rationing system to control civilian demand, and gave the government the power to set ceilings on prices of consumer items (Goodwin, 1995; Smith, 1959).

Other WPB orders soon followed. Direct allocation of chlorine began on February 1, 1942, in accordance with the amendments to General Preference Order M-19. Under the amended order, no deliveries of chlorine could be made without specific approval of the Director of Priorities, regardless of priority ratings (Nelson, 1942).

On March 2, 1942, the WPB Chemicals Branch issued a release warning metal fabricators "to investigate every possible cleaning method other than chlorinated solvents applicable to their operations" (p. 1). The release acknowledged that a shortage of chlorinated solvents existed and would get worse, and would affect defense contractors as well as others. It was estimated that at least 30% of chlorinated solvent applications could be performed using alkalis, mineral spirits, or emulsions (WPB, 1942b).

The March 21, 1942, Monthly Progress Report of the Chemicals Branch noted that the WPB had approved a 400 million pound (200,000 ton) per-year Chlorine Expansion Program, and that 80 55-ton tank cars had been ordered by the DPC to transport chlorine from the Basic Magnesium Plant in Las Vegas, Nevada. The cars were expected to be available by June 1, 1942 (Chemicals Branch, 1942a; Chemicals Branch, 1942b). Transportation of the large volumes of chlorine produced at various facilities proved to be a limiting factor in the supply of chlorine throughout the war (Skeen, 1948).

In a departure from previous assessments, the March 21 Progress Report also noted that "There is now a surplus of trichloroethylene above that required for war purposes" (Chemicals Branch, 1942a, p. 2) due to the addition of production capacity at DuPont's Niagara Falls facility, and the anticipated addition to a facility in Wyandotte, Michigan. The report stated that some TCE had been made available for civilian use, and that DuPont would be stockpiling TCE to meet future demands. CT was noted to be in a similar situation, with supplies anticipated to meet both defense requirements and other uses listed in the M-41 Order. Further improvement in the supply of CT was expected in the short term due to forthcoming increases in production capacity (Chemicals Branch, 1942a; 1942b).

A March 25 memo from the Chief of the Field Services Section at AAF's Wright Field noted that CT "is now used extensively by the Air Corps for cleaning of small aircraft parts. The toxicity of this material and halogenated hydrocarbons generally is well known" (Carroll, 1942a, p. 1). The memo recommended that all Technical Orders (TOs) that specified the use of CT include a paragraph warning of its toxicity, and noted that CWS was asked to provide warning labels on all CT containers (Carroll, 1942a).

The M-41 Order that prioritized chlorinated solvent distribution was scheduled to expire on March 31, 1942, but was extended to May 15, 1942 by the issuance of Amendment No. 1 on March 26th. At this time, Frank Talbot of the WPB Chemicals Bureau noted that "Order No. M-41 is not in all respects satisfactory" and "the Chemicals Branch is discussing with

representatives of the industry a new type of Order for these products" (Talbot, 1942a, p. 1). Approximately 1 month later, he wrote that Order M-41 "was not satisfactory and has been difficult to administer" (Talbot, 1942b, p. 1).

An additional amendment to the M-41 Order was announced in a May 2 WPB press release and a May 5 Federal Register notice. This amendment attached A-10 ratings to uses including fumigating grains; charging fire extinguishers; manufacturing rubber, chemicals, and refrigerants; and vapor degreasing for defense manufacturing. B-2 ratings were issued for dry cleaning, use in vapor degreasers for non-defense manufacturing, and use in packaged spotting and cleaning preparations. B-2 users could receive no more than 50% of the average monthly consumption calculated from the 12 months ended September 30, 1941 (WPB, 1942c; Talbot, 1942b; Federal Register,1942).

On May 5, 1942, the WPB's issuance of Order M-126 stopped the manufacture of more than 400 civilian products using iron or steel. To further control demand, WPB's conducted a broad review of government and military specifications with the goal of utilizing substitutes for scarce materials wherever possible. Specifications for approximately all weapons were reviewed, and countless changes were made in an effort to conserve materials in short supply (Nelson, 1946).

The WPB progress report for the week ending May 30, 1942, noted that "the arrangements for stockpiling of several chlorinated hydrocarbons are proceeding in a satisfactory manner" (WPB 1942d, p. 10). TCE stockpiling was to be handled directly by DuPont, and CT stockpiling by several producers including the Dow Chemical and the Diamond Alkali Company. The latter two companies were directed to ship CT to other producers so that they would have approximately 75% of their normal production on hand for distribution in June 1942 (WPB, 1942d).

By this time it had become obvious to WPB personnel and others that the priorities system was failing. The competition for scarce materials fostered by the system led to "ratings depreciation", as evidenced by February 1942 statistics indicating that well more than half of all orders carried A-1-a ratings. To meet the production goals outlined in FDR's 1942 State of the Union speech, the creation of four new "super rating" classes, designated AA-1 through AA-4, was announced by ANMB on June 12, 1942, with an effective date of July 1, 1942. However, these new ratings further diverted materials from other essential needs, and made no allowance for civilian needs, regardless of urgency. In an attempt to address this problem, an AA-2X rating was established in mid-August for essential civilian and foreign needs. An AA-5 rating was added in September 1942 to provide for essential metals not included in classes AA-1 through AA-4. Emergency orders formerly assigned AA ratings were redesignated AAA (Nelson, 1946; Smith, 1959).

In response to a June 23, 1942, WPB Chemical Section memo inquiring about the use of phenols for degreasing, Colonel O. R. Cook, Chief of the AAF Production Engineering Section, noted that TCE was being used for the degreasing of metal aircraft parts, and that 326,000 gallons (approximately 4 million pounds) were being procured by the AAF for the 1943 fiscal year (i.e., July 1942 to June 1943). Cook's (1942) response indicated that, due to the variety of cleaning operations performed on aeronautical equipment, the armed services were given "a wide latitude in the choice of materials" (Cook 1942, p. 1), and that stabilized TCE was adequately meeting the AAF's cleaning demands.

The WPB's weekly progress report for the week ending June 27 noted that the new DuPont facility in Wyandotte, Michigan, was producing 3 million pounds of TCE per month. Combined with DuPont's Niagara Falls output of 9 million pounds per month, it was thought that DuPont might achieve their goal of stockpiling 20 million pounds before anticipated demand increases occurred. For CT, four of the five producers reported having surpluses on hand, and were seeking relief from the amended M-41 Order so that the excess could be distributed more freely to civilians. If relief could not be obtained, decreased CT production would be necessary, which would in turn lead to cuts in chlorine production (WPB, 1942e).

By the summer of 1942, comprehensive rationing and price controls were in place. Civilians were issued booklets of stamps to be used for rationed items. To conserve cotton and wool needed for military uniforms, the WPB mandated that women's skirts be several inches above the knee, and men's suits be made without cuffs and with narrower lapels. To conserve vital rubber, an order was issued in December forbidding the sale of new automobile tires, and gasoline rationing began in May on the East Coast. Penalties up to 10 years in jail or fines up to $10,000 could be assessed for misrepresenting one's status to the Gasoline Rationing Board. To divert ships transporting coffee from Central and South America to military use, the Office of Price Administration (OPA) made an announcement 3 days before November mid-term elections that coffee would be rationed at the rate of one cup per day per person older than age 15 years. To conserve iron and steel, the manufacture of items such as electric refrigerators, vacuum cleaners, sewing machines, washing machines, lawn mowers, toasters, radios, phonographs, and stainless steel tableware was prohibited (Goodwin, 1995).

In response to a vendor seeking to supply a degreasing solvent to the AAF, Experimental Engineering Chief Colonel F. O. Carroll responded on July 18, 1942: ". . . stabilized trichloroethylene for use in vapor degreasers and for other degreasing operations . . . has proved satisfactory in service, and to date no difficulty has been encountered in procurement of adequate supplies for use by the U. S. Army Air Forces" (Carroll, 1942b, p. 1).

Among the numerous technical Orders (TOs) issued by the AAF for various military procedures was TO 01-1-1 for Cleaning of Aeronautical Equipment. This TO specified procedures, materials, and equipment to be used in the cleaning of interior and exterior portions of aircraft. The August 12 and November 12, 1942, revisions of TO 01-1-1 contained a section on vapor cleaning. The TO noted that "the use of trichloroethylene vapor for the removal of grease and oil from parts, prior to plating or refinishing, has been found to be highly satisfactory" (War Department, 1942, p. 6). However, the TO noted that:

> due to the cost of trichloroethylene, it will be necessary to restrict the above cleaning method *[i.e., vapor cleaning using TCE]* to depots and such stations as are specifically authorized by the Chief, Air Service Command, Wright Field, Dayton, Ohio (War Department, 1942, emphasis added, p. 8).

Other indications of efforts to reduce the use of chlorinated solvents included an October 1943 article recommending that volatile cleaning fluids should only be used when aqueous cleaners were found to be unsuitable, and that CT use should be limited due to its toxicity (Parrish, 1943).

On August 18, the WPB Conservation Division announced a program for the "reclamation of millions of gallons of war-essential chemical solvents and oils". Director S. Donald Perlman was quoted as saying, "Too often these chemicals are thrown away after a single use". The purpose of the program was "making available for war production reclaimed dirty or contaminated solvents which in the past have been discarded as waste" (p. 1). The program included compiling and publishing, for the first time, a list of reclaiming plants, and conducting an industry-wide education program on the need to reclaim and recover solvents. It was estimated that more than a billion pounds of solvents were being recovered annually, and that approximately double that amount could be reclaimed if all producers participated. The program applied to a variety of solvents including chlorinated compounds and other metal degreasers (WPB, 1942f).

On August 22, 1942, the WPB announced that, effective September 7, military contracting and procurement officers would no longer have the authority to assign preference ratings, and that this function would be assumed by WPB. Donald Nelson wrote:

> The fundamental weakness in the present administration of priority ratings by the Army and Navy contracting officers is that it is an attempt to administer a control system, which must often restrict parts of the program for the benefit of the whole, through field officers whose primary function is expediting the particular parts of the program entrusted to them. Accordingly, the War Production Board will immediately undertake supervision over the functions now exercised by contracting and procurement officers of the armed services with relation to the issuance of priority orders and certificates (Smith, 1959, p. 518).

Under the new system, contracting officers would propose ratings to WPB, who would make the final decision. The new system went into effect on September 10 (Smith, 1959).

The WPB report for the week ending August 22 noted that DuPont was meeting essential TCE requirements while continuing to add to its stockpile. However, during the week, officials at the AAF Wright Field placed orders for 6 million pounds of TCE to be delivered prior to January 1, 1943. At the same time, CWS increased its tetrachloroethane requirements by an additional 3.5 million pounds, the production of which would prevent DuPont from producing an equivalent amount of TCE. The effect of these orders was that approximately 10 million pounds of TCE production capacity was to be consumed or diverted. In response, DuPont requested authority to refuse B-rated orders for TCE and PCE until January 1, 1943. For CT, the report noted that the supply was considered adequate to fulfill orders rated B-2 and higher (WPB, 1942g).

The following week, WPB reported that the TCE supply situation grew tighter with the receipt of a Navy order for approximately 7.5 million pounds. The net effect of this order, together with the prior AAF and CWS orders, "changes the situation from one which was comparatively easy to a point where this solvent will be critical. DuPont is being directed to refuse all B-rated orders for trichloroethylene and perchloroethylene for an indefinite period" (WPB, 1942h, p. 15). Supplies of CT remained adequate, and the period within which all B-rated orders would be filled was extended from September 30, 1942, to January 1, 1943 (WPB, 1942h).

At a meeting held in September 1942 between WPB, CWS, and DuPont, the requirements were discussed for TCE, PCE, hexachloroethane and RH-195 (a decontaminating agent) to be produced at DuPont's existing facilities in Wyandotte and Niagara Falls, as well as in a new facility under construction near New Martinsville, West Virginia (later to be known as the Marshall Plant). It was agreed that DuPont would expand its Niagara Falls production of tetrachloroethane from 72 million to 96 million pounds per year, and that the construction underway at the New Martinsville plant, intended for hexachloroethane, tetrachloroethane, and RH-195 production, was to "proceed without interruption" (WPB, 1942i, p. 1).

The WPB report for the week ending September 19 noted that sales of TCE and PCE would be restricted until the end of the calendar year due to shortages of both chemicals. To meet military and essential civilian demands for chlorine, certain non-essential uses were curtailed until at least October 1942. A temporary breakdown at a chlorine plant in Corpus Christi, Texas, was cited as a factor contributing to this shortage (WPB, 1942j). The following week's report noted no improvement in the chlorine supply situation. Supplies of CT were said to be plentiful, and suppliers were requesting authorization to increase sales to B-2 rated users (WPB, 1942k).

As of December 1942, the Chemicals Bureau staff had increased to 627 regular employees, 75 "dollar-a-year men" (primarily borrowed from major industries), and 26 personnel assigned from other branches. During the year, 515 chemically related projects were completed at a cost of $300 million, and 490 additional projects were under way. Of the more than 2,000 commodities handled by the Bureau, 221 were subject to individual customer allocations implemented through 65 allocation orders (WPB, 1946).

1943: Peak Production Achieved; Tide of War Turns

During 1943, the production of war materials increased even further than in the previous year. Relative to 1942, production of aircraft tonnage increased 140%, merchant shipping by 100%, naval shipping by 75%, and munitions by 83% (Goodwin, 1995). Production of synthetic rubber, a process in its infancy at the

beginning of the war, was providing 83% of new rubber in the US. In March 1943, the Chemicals Bureau reached its peak level of employment (WPB, 1946).

The WPB report for the week ending January 30 noted that DuPont had accumulated a "satisfactory stockpile" of TCE for emergency purposes (WPB, 1943a, p. 29). It was proposed that DuPont begin to accumulate PCE so supplies would be available to meet anticipated needs for hexachloroethane production (WPB, 1943a).

On May 13, 1943, German and Italian troops surrendered in North Africa. At the same time, the progress of industrial production, and that of the war in general, prompted WPB to consider laying the groundwork for "reconversion" of US manufacturing back to a peacetime economy. In September 1943, the WPB Bureau of Planning and Statistics was instructed to undertake a broad study of reconversion. The surrender of Italian forces to the Allies on September 8 further increased the incentive to begin planning. However, in September 1943, the use of CT for dry cleaning was banned by WPB due to "exceptionally heavy military requirements and limited facilities for making this solvent" (WPB, 1944b, p. 1).

In October 2, 1943, Colonel W. M. Morgan, Chief of the AAF Production Engineering Section, noted in a memo entitled "Trichloroethylene" that "It is understood that the Air Service Command have an excess of the subject material in stock. At the present time, a requirement exists for trichloroethylene in the winterization of A-2 carbon tetrachloride fire extinguisher" (Morgan, 1943, p. 1).

Total wartime production of materials in the US peaked in November 1943. At this time the US was producing $6 billion of munitions per month, approximately as much as the entire defense appropriation for 1940. At the November 30 WPB meeting, Donald Nelson laid out a policy to allow production of non-essential goods as materials became available. As of the fall of 1943, US factories required significantly fewer workers to meet military needs, and only localized labor shortages existed.

The WPB report for the week ending November 20 noted that "all requests for chlorine are now being taken care of in full" but that TCE and PCE were "still in short supply" (WPB 1943b, p. 23). During the week, efforts were made to transfer the excess TCE from the Air Service Command to another Armed Services division for use in winterization of fire extinguishers (WPB, 1943b).

The following week's report noted that:

> the demand for carbon tetrachloride continues to increase and the situation is still very tight. The Legal Dept. is working on the initial draft of an order placing carbon tetrachloride under allocation and this will be pushed as rapidly as possible" (WPB, 1943c, p. 30).

A meeting with DuPont had been held during the week to discuss TCE and PCE requirements and DuPont's ability to meet them. The report further stated that,

> Many companies knowing that a serious shortage exists are inflating their requirements feeling that, if a horizontal cut is made, they may still receive all the solvent they need. As a result, the orders placed with the DuPont Co. are approximately 5,000,000 pounds greater than the capacity of DuPont's plants to produce and it will be necessary to make a horizontal cut, instructing the DuPont Co. to supply approximately seventy-five percent of the quantity of these two solvents which is called for on orders carrying AA-1 ratings. . . There is a continued wide spread abuse of the ratings system. So many people are using AA-1 ratings to which they are not entitled, it would be almost impossible to correct this situation within a reasonable time. The demand for these solvents is so great that it is considered that the quickest and best way out of this undesirable situation is to place trichloroethylene and perchloroethylene under allocation at the earliest possible date. The legal staff is working on such an order. (WPB, 1943c, p. 30).

Chemical production in 1943 was 23% greater than that of 1942. However, the rapid and prolonged increase in production during this time strained both equipment and labor resources. The constant operation of chemical production facilities at maximum levels led to deterioration of plants and increased maintenance problems. A WPB history noted that, during 1943, "manpower problems increased in severity because chemical plants were unattractive to workers (especially women)" (WPB, 1946, p. 15). Efforts to increase wages in chemical plants were denied by the government (WPB, 1946).

The WPB report for the week ending December 25th noted that "the supply of trichloroethylene and perchloroethylene is still short . . . During the past four months orders carrying AA-1 ratings have been so great that it has been necessary to make a horizontal cut each month, even on the AA-1 rated orders. It is expected that these solvents will be under allocation before time for February deliveries" (WPB, 1943d, p. 16). During 1943, the Chemicals Bureau issued 44 new priorities and/or allocation orders and revoked 13, leaving a total of 97 in force at the end of the year (WPB, 1946).

1944: Reconversion Plans Begin; Solvent Supplies Tighten

During 1944, the staff of the Chemicals Bureau decreased more than 20%, from 488 to 387 employees. However, the United States' chemical industry was operating at the highest level in its history, approximately 11% above that of 1943 and 124% more than 1939. Despite increased production of CT, PCE, and TCE, the period from 1944 to approximately July 1945 was the time of greatest wartime shortage of these solvents (WPB, 1946; Morgan and Talbot, 1945).

At a January 3, 1944, meeting of the WPB's Chemicals Division Requirements Committee, tentative supply requirements for TCE and PCE were discussed. A document prepared several days earlier set out approximate amounts of TCE and PCE to be distributed under the forthcoming allocation order. For TCE, production for 1944 was estimated at 220 million pounds, with more than 92% proposed to be allocated for metal degreasing. Other applications designated for allocation included use in fire extinguishers, extraction of caffeine for medicinal use, use in aircraft manufacturing, and exports under the Lend-Lease

program. For PCE, approximately two-thirds was to be allocated to hexachloroethane production, and one-third toward miscellaneous metal degreasing uses. Smaller amounts were proposed for allocation directly to the Navy, and for a "small but essential requirement for medicinals for sheep and other animals" (WPB, 1944c, p. 3).

In January 1944, the WPB issued Order M-363, directing that CT be placed under full allocation. The new order replaced Order M-41, which had "not fulfilled the purpose for which it was designed, namely to direct the products covered to essential uses. . ." (WPB, 1943e, p. 2). Under the M-363 order, customers ordering more than 7,000 pounds per month needed individual authorization from WPB. Customers ordering more than 700 but less than 7,000 pounds per month would be required to obtain a certificate indicating the end use (WPB, 1943e). Order M-363 became effective on February 1, 1944 (War Department, 1946).

On February 11, 1944, WPB "announced that it had placed trichloroethylene and perchloroethylene, chemicals used respectively in degreasing metals and smoke for chemical warfare, under allocation for the first time" (WPB, 1944d, p. 1). The allocation was implemented on the following day by the issuance of Order M-371, which prohibited suppliers from delivering TCE or PCE to users not authorized by the WPB. Deliveries of 10,000 pounds or more needed to be individually authorized, while smaller orders could be filled under approvals granted to specific end uses, subject to maximums established for each type of use. The order became effective on March 1, 1944 (WPB, 1944d; Federal Register, 1944).

The WPB report for the week ending February 26, 1944, stated that the demand for CT was "far greater than production, and all civilian requests are being denied" (WPB, 1944q, p. 21). The use of CT in the manufacture of CFCs was cited as a factor in the increased demand, in addition to a Navy order for 5.4 million pounds for use in fire extinguishers. For PCE, increased demand was anticipated due to CWS's need for hexachloroethane; however, new facilities at Dow Chemical's Freeport, Texas plant and proposed improvements to the Marshall plant in West Virginia were expected to improve the supply situation (WPB, 1944q).

On March 3, 1944, the Carbon Tetrachloride Manufacturer's Advisory Committee, one of the many Industry Advisory Committees that provided input to the WPB on supply and production matters, met in Washington, DC. Industries represented included Dow Chemical, Diamond Alkali Company, Westvaco, PennSalt, and Stauffer. The allocation of 16.8 million pounds (8,388 tons) of CT for March 1944 (including 15.75 million pounds to be produced and the remainder from stocks) was presented as shown in Table 3.

The proposed March 1944 allocation for CFCs was greater than that from previous months due to expansion of a Chicago CFC production facility that was expected to demand 2.8 million pounds of additional CT per month beginning on September 1. CT demand was projected to grow further in the following months due to Navy plans to place an order for 6.1 million pounds for fire extinguishers. In addition, pressure was being exerted to provide CT to small dry cleaning establishments, many of which were located in towns that had expanded rapidly during the war, but were remote from facilities using petroleum solvents for dry cleaning (WPB, 1944e).

Table 3. *Proposed allocation of Carbon Tetrachloride (CT) for March 1944*

Designated Use	million pounds (tons)
Degreasing and misc. industrial uses	4.1 (2, 038)
Fire extinguisher fluid (military use)	4.0 (2, 000)
Chlorofluorocarbons (CFC) production	3.6 (1, 800)
Hexachloroethane production	2.9 (1, 448)
Fire extinguisher fluid (industrial use)	0.9 (450)
Army	0.7 (340)
Drugs and other medicinal uses	0.3 (134)
Grain Fumigation	0.2 (112)
Navy	0.1 (66)

Data from WPB, 1944e, p. 2.

Given the severity of the supply situation, the suppliers at the meeting were asked to provide their estimates of maximum monthly CT production capacity. Responses are shown in Table 4. These seven plants represented essentially all of the US production capacity for CT (WPB, 1943d). The total estimated maximum production of 18.6 million pounds (9,300 tons) per month was considerably less that the projected minimum demand of 24 million pounds (12,000 tons) per month (WPB, 1944e).

The WPB report for the week ending March 25th indicated that the chlorine supply situation for the second quarter of 1944 would be tighter than the first, but that all facilities would operate at full capacity and all essential demands would be met. For TCE and PCE, the April allocation was expected to meet all essential demands (WPB, 1944r).

To address the CT supply situation, the committee recommended that construction of new production facilities and expansion of existing facilities be pursued (WPB, 1944a). However, US producers were reluctant to expand, given that the tide of the war had turned, and the existing CT capacity was considered likely to exceed post-war demand (WPB, 1943e). The Committee suggested that the possibility of expanding

Table 4. *March 1944 estimates of maximum Carbon Tetrachloride (CT) production*

Company	million lbs/month (tons/month)
Dow-Pittsburg Chemical (West Coast)	1.0 (500)
Dow Chemical (Midland, MI)	5.0 (2, 500)
Dow Chemical (Freeport, TX)	4.0 (2, 000)
PennSalt	1.0 (500)
Diamond Alkali	2.2 (1, 100)
Stauffer	2.8 (1, 400)
Westvaco	2.4 (1, 200)

Data from WPB, 1944e, p. 4

TCE facilities be explored, presumably so that TCE could be used in place of CT for degreasing and other cleaning purposes (WPB, 1944f).

During March, a "token allotment" of 214 drums (approximately 153,000 pounds) of CT was "wrung out of the metals degreasing and miscellaneous industrial uses of the Chemicals Bureau program" for use by civilian dry cleaners (Hamill, 1944). On April 8, WPB announced that this small amount of CT would continue to be made available to dry cleaners in isolated communities where petroleum-utilizing dry cleaners were not available. The allotment was but a small fraction of the estimated normal consumption of 5,350 drums per month (WPB, 1944b), and fell far short of filling requests from isolated communities (WPB, 1944g).

The WPB report for the week ending April 22, 1944, indicated that "May requests for carbon tetrachloride are more than twice estimated production. Two projects are being processed, providing for an increase of 3,700 tons per quarter of carbon tetrachloride production which should be in operation by fall, provided they are issued promptly" (WPB, 1944h, p. 30). Production and stocks of TCE and PCE were considered sufficient to meet essential requirements, and it was recommended that TCE be stockpiled to offset an expected production drop during the summer (WPB, 1944h).

On June 6, 1944 (D-Day), the long-anticipated Allied invasion of occupied France began. Only after the success of the invasion became apparent were serious efforts made to relax controls on production of non-essential civilian items. The minutes of a June 13 WPB meeting stated that "the war has now progressed to the stage where some reconversion machinery can safely be set in motion" (Nelson, 1946, pp. 400–401). A program was proposed that included the relaxing of controls on aluminum and magnesium, and allowing manufacturers to make prototypes of new civilian products and begin retooling for post-war production (Nelson, 1946).

On June 13, the War Department issued a directive restricting the military use of CT, stating that "In order to meet essential military and civilian requirements for carbon tetrachloride, including fire extinguishing liquid . . . it is essential that immediate economies be effected wherever possible in connection with necessary uses and that unnecessary uses and wasteful practices be discontinued" (War Department, 1944b, p. 1). Military use of CT-containing fire extinguishers was restricted to locations where ordinary extinguishers were not effective, and the removal and reuse of extinguishers from stored vehicles and equipment was mandated. The discharge of CT fire extinguishers was limited to fire-fighting and essential training and testing. CT discharged for the latter purposes was to be collected and reused. The use of CT for cleaning of clothing, automotive parts, engine parts, firearms, ordnance, or other equipment was prohibited unless approved by the Commanding General of the AAF (War Department, 1944b).

A June 21 WPB announcement stated that additional CT would be available for dry cleaning in the third quater of 1944 due to reduced military demands. However, for TCE and PCE, the supply situation remained difficult, and none would be available for dry cleaning in the third quater due to "urgent military demands" (WPB, 1944g, p. 1).

A July 1, 1944, internal WPB memo described the supply situation of CT, TCE, and PCE relative to dry cleaning demands. The memo stated that, effective July 1, the amount of CT being made available for dry cleaning was being increased from 214 drums per month (the allotment since March 1944) to 1,086 drums per month, "enough to meet about 20 percent of normal demands" (Hamill, 1944, p. 1). The author of the July 1 memo (George K. Hamill, Acting Director of the WPB's Chemicals, Drugs, and Health Supplies Division) stated,

> We could not get any *[TCE or PCE]* for dry cleaning despite the feeling . . . that some of these solvents could be squeezed out of their enormous consumption in metal degreasing. From a number of sources we heard of inefficient industrial use of these solvents and particularly of losses of recoverable solvents in the sludges from degreasing units (Hamill, 1944, p. 1).

Hamill (1944) described largely unsuccessful efforts to recover usable solvent from these sludges. He reported that PCE production had recently caught up, "at least momentarily" (Hamill, 1944, p. 1) with increased military demands, and noted that "out of all the conservation efforts, production increases and end use shifts, there have suddenly appeared some small and possibly temporary surpluses" (Hamill, 1944, p. 2) of PCE and TCE. As a result, the Chlorinated Solvents Unit of the WPB Chemicals Bureau was making 200,000 pounds of PCE and 300,000 pounds of TCE (a total of approximately 700 drums) available per month for dry cleaning use beginning in July. These amounts represented less than half the estimated normal dry cleaning requirement for PCE (450,000 pounds), but exceeded the estimated TCE normal dry cleaning requirement of 250,000 pounds per month. The net effect of the new allocations of CT, TCE, and PCE was that, "By the end of July we will be providing solvent for better than 1,500 dry cleaning units that had no legal supplies in March" (Hamill 1944, p. 2). For the remaining plants (mostly located near petroleum dry cleaning facilities), Hamill (1944) stated, "we hope to get some solvent for most of these by the end of the year unless war conditions get worse—unless chemical warfare starts" (p. 2).

On August 25, 1944, after weeks of fighting that followed the D-Day landings, Allied forces liberated Paris. On October 2nd, General Allocation under M–300 was amended by adding provisions for special releases for civilian use. However, later in the fall of 1944, supplies of TCE again tightened and remained short up until the closing months of the war (WPB, 1946). The WPB progress report for the week ending October 7 noted that "the heavy demand for perchloroethylene has been materially reduced because of cutback in hexachloroethane production. DuPont's perchloroethylene production has been further reduced to permit the manufacture of increased quantities of trichloroethylene. All normal demands for perchloroethylene are being met". The TCE supply situation "had again tightened

due to decreased production in the third quarter. Carload shipments are estimated to be about a week behind schedule" (WPB, 1944i, p. 27).

The WPB progress report for the following week (ending October 14) noted:

> Because of production difficulties *[TCE]* stocks have decreased and supplies are again tight. Approximately 97 percent has been allocated for metal degreasing in plants holding contracts for war production. It has not been possible to allocate any trichloroethylene to the dry cleaning industry in October (WPB, 1944; p. 22).

For CT, "All military and essential demand has been met for October. The military demand is exceptionally heavy at this time, however, it has not been possible to allow the dry cleaning industry sufficient material *[for]* most hardship cases" (WPB, 1944j, p. 22).

On October 28, 1944, WPB announced that dry cleaners could not expect any TCE or PCE to be available during November 1944, due to "increased military demands for these solvents, especially for metal degreasing purposes, as well as various difficulties in producing trichloroethylene and perchloroethylene" (WPB, 1944k, p. 1).

A series of memos prepared by Brigadier General Charles R. Glenn in November and December 1944, and a March 1945 Air Surgeon's Bulletin article, discussed the proposed use of CT, TCE, and/or other chemicals in formulations designed for aerial spraying of DDT. Batches of the formulation were to be prepared by dissolving 80 pounds of DDT in 20 gallons of an "auxiliary solvent" (Glenn, 1944a, p. 2), which could either be CT, TCE (referred to as "airplane engine cleaning solution" [Schreuder and Sullivan, 1945, p. 67]), 1,1,2,2-tetrachloroethane, 1,2-dichloroethane, or xylene, and then diluted to 100 gallons with fuel oil. Glenn provided cautionary notes on the use of chlorinated solvents, noting that the "permissible limit" (Glenn, 1944c, p. 1) for CT in air was 100 parts per million (ppm) and TCE was 200 ppm. He noted that all of the chlorinated solvents proposed for use were nerve and liver poisons, but that only TCE could be used with a "fair degree of safety". CT was a known "liver and kidney poison," and 1,2-dichloroethane was " more toxic than generally assumed" (Glenn, 1944c, p. 1). Protective measures were recommended for personnel involved in preparing the formulations (Glenn, 1944a; 1944b; 1944c; Schreuder and Sullivan, 1945).

On November 17, 1944, US B-29 Super Fortresses began aerial bombing of the Japanese mainland from the Mariana Islands. These missions continued until April 1945.

The WPB report for the week ending November 18 noted that additional CT production was anticipated, and therefore the "various freon demands will not tighten up supply as much as originally expected" (WPB, 1944l, p. 28). A limited amount of PCE was expected to be available for dry cleaning in December 1944 due to order cancellations and material returns. For TCE, "DuPont has been able to release enough stock to ease a very tight situation" (p. 28). Increased production anticipated in December was anticipated to be sufficient to "meet all military requirements" (WPB, 1944l, p. 28).

As of the week ending November 25, 1944, the CT and PCE supply situations appeared under control. However, the TCE supply situation remained critical. The WPB report for the week stated,

> Consumers of trichloroethylene continue to inflate their demands. December requests are 4 million pounds above production, but at the same time production has been increased between one and two million pounds. Consideration is being given to producing additional quantities at the CWS Marshall plant. This will depend on chlorine supply to a large extent. (WPB, 1944m, p. 25).

However, the WPB Chemicals Bureau noted that the supply of chlorine would be tight in December, and "no surplus will be available for special allocation except for the most essential uses" (WPB, 1944m). Although the WPB weekly summaries mention TCE production increases, a 1946 WPB history states that production difficulties were being encountered at this time (WPB, 1946).

For the week ending December 2, 1944, it was noted that December allocations would meet all military and essential civilian requirements for CT and PCE. For TCE, it was noted that supplies remained tight, and remaining stockpiles were being depleted. CWS had been requested to produce at least 1 million pounds per month at the Marshall plant, beginning in December and continuing throughout the first quarter of 1945. CWS converted the Marshall plant from PCE to TCE production in late 1944. The need for further production increases was foreseen if TCE demand continued to increase (WPB, 1944n; 1946).

On December 6, 1944, a memo prepared by the WPB Chemicals Bureau to the Standing Committee for Identification of Critical Products recommended that TCE, potassium carbonate, chlorates, perchlorates, and matches be added to the Critical List. The reasons given for adding TCE to the list were that indirect military requests exceeded production by 3 million pounds per month, stocks of TCE were essentially nonexistent, and no substitutes were available for use in existing degreasing equipment. The December demand was 24 million pounds, while monthly production was estimated at 21 million pounds (WPB, 1944o).

On December 16, 1944, overextended Allied forces in Europe were attacked in a major offensive that became known as the *Battle of the Bulge*. The WPB report for the week ending December 23, 1944, briefly mentioned the January allocations for CT, TCE and PCE, noting that "program requirements" (i.e., designated military and essential civilian needs) would be met for CT, "war production requirements" would be met for PCE, and "essential war production requirements" would be met for TCE (WPB, 1944p, p. 25).

The Christmas 1944 issue of the Air Force periodical *Plane Facts* noted that TCE was being used for vapor degreasing of engines in Australia, but that "because of a critical shortage of trichloroethylene, and lower cost of equally effective hot alkaline

treatment," continental depots would continue to use alternatives to TCE (Unknown, 1944, p. 43).

1945: War Ends in Europe and Japan

At the beginning of 1945, the chemical industry continued its record pace of production, and the staff of the Chemicals Bureau remained at the levels reached at the end of 1944 (WPB, 1946). The retooling of American industry for war production had been a great success, and, by the beginning of 1945, the US "had more planes than we knew what to do with," giving rise to the need for production cutbacks (Nelson, 1946, p. 237). However, the demand for chlorinated solvents remained strong.

The January 1945 issue of *Plane Facts* contained an article stating that the AAF Technical Service Command (ATSC) was distributing a monorail-fed vapor degreasing system to continental and overseas depots. The purpose of the system was to clean and repack engine parts in a manner that allowed preservation for indefinite periods under a variety of storage conditions. The article instructed users to distill and reuse chlorinated and other vapor degreasing solvents, and to avoid using chlorinated solvents "to clean fabrics, rubber, organic materials, or assemblies which trap solvent" (Schutte, 1945, p. 33).

Major snowstorms in the Great Lakes region and the Northeast in the early months of 1945 caused delays in delivery of needed raw materials and finished products. According to a 1945 WPB history, these storms resulted in the greatest domestic transportation problems of the war (WPB, 1946). The WPB report for the week ending January 6 noted:

> the trichloroethylene supply situation has been improved in January through imports from Canada and production at the CWS Marshall plant. Stormy weather in the Niagara Falls area in the last two days has tied up railroad traffic and will seriously delay shipments out of Niagara Falls for a temporary period. There has so far been no loss in production (WPB, 1945a, p. 23).

Weather conditions in the Niagara Falls area were also affecting chlorine supplies, and it was thought that production may need to be curtailed due to the lack of tank cars for chlorine shipment (WPB, 1945a). For PCE, the WPB report noted that "a letter has been sent to all distributors of perchloroethylene requesting them to review their customer's requests in order to convert all liquid degreasing uses and those with Circo degreasing equipment to using perchloroethylene instead of trichloroethylene" (WPB, 1945a, p. 23).

From February 4 to 11, 1945, FDR, Winston Churchill, and Joseph Stalin met to discuss post-war reorganization of Europe at the Yalta conference. For the week ending February 10, the WPB reported:

> arrangements have been completed to make substantial purchases of trichloroethylene from Canada . . . demand for this solvent as a degreasing agent continues to increase since the installation of new degreasing machines is going on at a rapid rate in various industrial plants. The Army Air Corps has indicated that a substantial procurement is about to be made" (WPB, 1945b, p. 30).

Although this account implies that imports from Canada were substantial, a February 1946 history prepared by WPB stated, "An attempt was made to set up a working agreement with the Foreign Economic Administration to import surplus trichloroethylene production from Canada, but no substantial quantities were ever imported" (WPB, 1946, p. 499). For PCE, the Quartermaster Corps forecasted that 300,000 pounds per month would be needed to meet their requirements for the first half of 1945. The chlorine situation was reported to be "gradually improving" (p. 30) due to better movement of railroad tank cars. However, chlorine plants in the impacted areas were forced to cut back production due to the lack of shipping capacity, resulting in the need to frequently adjust allocations (WPB, 1945b).

The WPB noted in its report for the week ending February 24, 1945, that transportation problems continued to affect many materials. It was reported that 1.9 million pounds of TCE went unshipped in January, and a similar or larger amount was expected to be unshipped in February. The PCE situation was described as "tight due to large Army requirements," and "March production will just meet March allocations." (WPB, 1945c, p. 5).

During these closing months of the war, the use of TCE "was confined almost 100 per cent to the metal degreasing of all types of equipment for direct and indirect military use. Very small amounts were released for use in fire extinguishers, certain essential drugs, synthetic rubber manufacture and, occasionally, to some essential demand" However, during this and other periods of shortages, "all direct military purchases were, of course, honored wherever justified" (WPB, 1946, p. 500).

On March 3, 1944, the WPB revoked the March 1944 M-371 Order due to increased military needs for TCE and PCE. In its place, increased restrictions were issued under General Allocation Order M-300, an approach frequently used by the Chemicals Bureau for imposing allocations. The restrictions, published in the Federal Register on March 6 (Federal Register, 1945), decreased both the small order exemption amount and the amount requiring individual approval for both chemicals. For TCE, the M-300 order specified that requests for use in commercial dry cleaning would be denied beginning in March and continuing "until supply permits" (OCC, 1945, p. 1). Suppliers seeking to provide TCE or PCE to commercial dry cleaners were required to file additional paperwork with the Service Trades Division (WPB, 1945d; OCC, 1945).

In a May 1, 1945, revision to AAF Technical Order 19-1-99, the AAF specified that CT-containing fire extinguishers to be used north of the 45th parallel were to be winterized by mixing three parts TCE with seven parts CT. In a *Plane Facts* article entitled, "Nose Protection Ordered for Extinguisher Fillers," it was stated that "Persons engaged in mixing liquid and filling extinguishers are to be supplied with chemical cartridge type

respirators to prevent inhalation of solvent vapors" (Unknown, 1945).

FDR did not live to see the end of the war, suffering a fatal stroke on April 12, 1945. On May 7, Germany surrendered, and May 8 was designated *V-E Day* to mark the Victory in Europe. After V-E day, a gradual decline in staff at the Chemicals Bureau ensued through voluntary resignations (WPB, 1946).

A May 1945 article urged aircraft maintenance personnel to "Quit Risky Carbon Tet Misuse," stating that 109 cases of CT poisoning of AAF depot personnel were reported in 1944. Many of these cases were due to unapproved or improper use of CT, including the unsanctioned uses described previously in the discussion of Principal Wartime Uses (Parrish and Glass, 1945).

On June 30, 1945, the Defense Plant Corporation was dissolved by Congress. The following day, a simplified priority ratings system was instituted, with all urgent military orders assigned an "MM" rating, and spot civilian purchases assigned a "CC" rating. All outstanding AA ratings were to be canceled by September 30 (Smith, 1959).

The WPB report for the week ending July 21, 1945, indicated that the TCE and PCE shortages were finally abating: "August production estimates indicate that small amounts of both trichloroethylene and perchloroethylene can be released for dry cleaning and that the monthly carbon tetrachloride dry cleaning release may be slightly increased" (WPB, 1945e). Chlorine supplies were "building up in the East, and discussions are being held toward shutting down the Rocky Mountain Arsenal immediately. The chlorine situation continues easy" (WPB, 1945e).

The WPB report for the week ending July 28, 1945, stated:

> Substantial surpluses of carbon tetrachloride, trichloroethylene, and perchloroethylene are starting to build up. It has been possible to release increased quantities of each commodity to the dry cleaning industry and for other usage. Early consideration will be given to the possibility of removing these three solvents from allocation" (WPB, 1945f, p. 25).

An August 4, 1945, "Fortnightly Operating Report" from the WPB Chemicals Bureau noted that "it will not be possible to operate the trichloroethylene facility at the Marshall, West Virginia plant of CWS after August 31" (WPB, 1945g, p. 1). The report confirmed that the TCE and PCE supply situation had improved significantly during the summer of 1945 (WPB, 1945g).

Atomic bombs were dropped on Japan on August 6 and 9, 1945, and Japan agreed to surrender on August 14, marking the end of World War II. The surrender was signed on September 2, 1945, the officially recognized *V-J Day*. In an August 27 press release, the WPB announced that laundries and dry cleaners using TCE, PCE, or CT would be "free of controls" (WPB, 1945h, p. 1) as of August 31. This action was expected to affect approximately 5,000 facilities (WPB, 1945h). By August 30, "practically every Allocation Order of the Chemicals Bureau was revoked" (WPB, 1946, p. 20).

After V-J Day, the Chemicals Bureau began reducing staff. The 41 employees that remained after November 2, 1945, were designated for transfer to the Chemicals Division of the Civilian Production Administration (WPB, 1946). The 1946 WPB history of the Chemicals Bureau stated that reconversion problems were not anticipated for TCE and PCE. For TCE, the post-war demand was correctly predicted to be heavier than the pre-war demand. For PCE, post-war production was expected to "largely be absorbed in the metal degreasing and dry cleaning fields, where perchloroethylene is reported to be the best solvent now in use" (WPB, 1946, p. 505). The history mentioned that CWS wished to sell the inactive Marshall facility to a private manufacturer. This facility was eventually purchased by PPG Industries, who currently operates the New Martinsville Natrium Plant at this location, although the Marshall plant is inactive. For CT, it was thought that dry cleaning demand would be strong, but that some producers might need to convert facilities to making other products (WPB, 1946). CT production trailed off after the war ended, but within three years began a prolonged increase due to its use in CFC production.

Between 1940 and 1945, the US had produced more than 300,000 warplanes, 2.4 million trucks, 107,351 tanks, 87,620 warships, 5,745 cargo ships, 20 million guns, and 44 million rounds of ammunition (Nelson, 1946; Goodwin, 1995). These results were achieved by a combination of conversion of the US economy to war production, sacrifices on the part of the civilian population, and strict control over the supply of materials, including the chemicals needed for defense purposes.

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