CPUC-1001

Blade Supplemental Report (Vol. 1: Approach)

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ALJs: Hecht/Poirier

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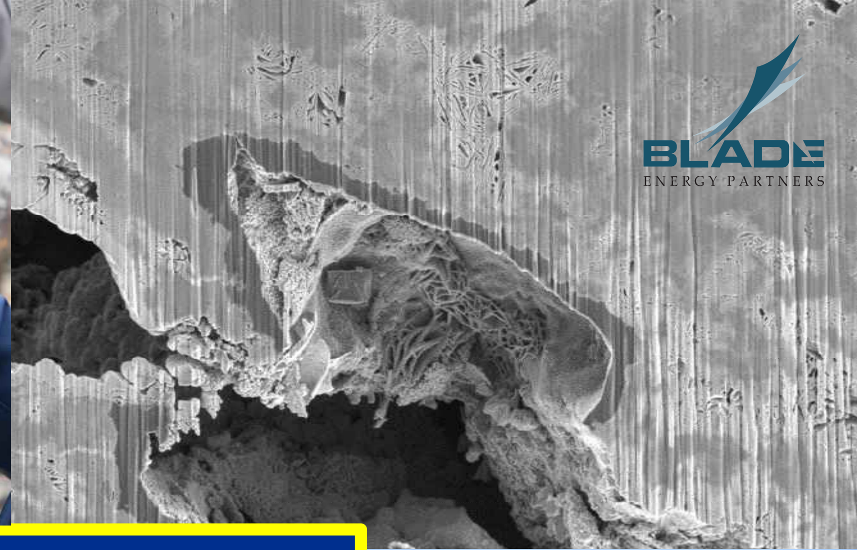

Root Cause Analysis of the Uncontrolled Hydrocarbon Release from Aliso Canyon SS-25

SUPPLEMENTARY REPORTS

May 31, 2019

VOLUME 1: APPROACH

This RCA work necessitated a substantial amount of testing, analyses, and modeling. The integrated work is reflected in the overall RCA report. Additionally, all the technical details and discussions are provided in supplementary reports—the source documents for the RCA report—in four volumes. This is Volume 1.

MAIN REPORT

Root Cause Analysis of the Uncontrolled Hydrocarbon Release from Aliso Canyon SS-25

SUPPLEMENTARY REPORTS

Volume 1: Approach

Phase 0 Summary

Phase 1 Summary

Phase 2 Summary

Phase 3 Summary

Phase 4 Summary

Volume 2: SS-25 Well Failure Causes

Volume 3: Post-SS-25 Leak Events

Volume 4: Aliso Canyon Casing Integrity

SS-25 RCA Supplementary Report

Phase 0 Summary

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Purpose:
Summarize the collection, collation, and analyses of data used in the SS-25 Root Cause Analysis.

Date:
May 31, 2019

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Abstract

The gas storage well Standard Sesnon 25 (SS-25) in the Aliso Canyon Gas Storage Field located in Los Angeles County, California started leaking gas in October 2015. A relief well was drilled, and SS-25 was brought under control. The leak stopped in February 2016.

In January 2016, as part of their investigation of the leak, the California Public Utilities Commission (CPUC) and the Division of Oil, Gas, and Geothermal Resources (DOGGR) selected and gave provisional authority to Blade Energy Partners (Blade) to perform an independent Root Cause Analysis (RCA). The Blade Team and parties under Blade's direction were responsible for directing the work of subcontractors who performed the extraction of the SS-25's wellhead, tubing, and casings and the preservation and protection of associated evidence. Blade's RCA Reports, including this report, document and describe the key activities undertaken in support of the RCA effort.

A large amount of data was collected and analyzed as part of the RCA. This document summarizes the data sources and describes how data was received and managed. The report also discusses data subjects, file types, data storage, data volume, and some challenges faced by Blade.

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1 Introduction

The purpose of this document is to summarize Phase 0 of the SS-25 RCA, which consisted of the collection, collation, and analyses of data. Phase 0 began in January 2016 when Blade personnel started work in Aliso Canyon and continued through Phase 5 of the project that ended in May 2019. The data came from Southern California Gas Company (SoCalGas) as a result of information requests by Blade and regulatory agencies, as well as from publicly available data. The terms “information requests” and “data requests” are used interchangeably in this document.

Data played a key role in the RCA process. SoCalGas as the operator of the Aliso Canyon field maintains a detailed file on each well in the field. Each file contains records starting from when the well was proposed. Aliso Canyon well records go back to when the field was discovered in the 1930s. Table 1 summarizes the types of data typically found in well records.

Table 1: Types of Records Kept by SoCalGas

Well	Correspondence	Other Records

• Permitting
• Drilling
• Completing
• Well testing
• Well servicing
• Injecting and withdrawal
• Plug and abandonment
• Other events
	• Interoffice
	• With outside entities
	  – Regulatory bodies
	  – Service companies
	  – Other operators
		Relating to the field and field operations
		• Reservoir
		• Geology
		• Field injection and withdrawal

1.1 Abbreviations and Acronyms

Term	Definition
B&C	Boots & Coots
Blade	Blade Energy Partners
CBL	Cement Bond Log
CPUC	California Public Utilities Commission
DOGGR-IT	Division of Oil, Gas, and Geothermal Resources – Investigation Team
RCA	Root Cause Analysis
SoCalGas	Southern California Gas Company

2 Data Sources

2.1 SoCalGas Information Requests

Blade made numerous formal information requests throughout the RCA project. Some of the requests were question-and-answer type requests, and others were specifically for data or records, such as well files. Most of the data requests were to SoCalGas, because, as the operator, they have the most complete field and well data. Information requests from Blade were sent to the California Public Utilities Commission (CPUC) and the Division of Oil, Gas, and Geothermal Resources – Investigation Team (DOGGR-IT), in addition to SoCalGas. They also received copies of SoCalGas responses.

2.2 DOGGR Website

DOGGR maintains a *Well Search* website with public access to well records [1]. The website contains well records, injection and withdrawal data, and well log data that operators submit to DOGGR. Data from the website was downloaded and used extensively in the RCA.

2.3 CPUC and DOGGR-IT Information Requests

CPUC and DOGGR-IT also made information requests to SoCalGas. The information and data responses from their requests were made available to Blade.

2.4 Interviews

Blade requested and was granted access to SoCalGas Aliso Canyon personnel to verify and confirm the factual data provided for the RCA. A meeting was held on August 24, 2018, and the discussion was helpful in understanding how the field was operated prior to October 2015. Details of the data provided were discussed, and additional data was requested as a result of the meeting.

A meeting with Boot and Coots (B&C) personnel with direct knowledge of the SS-25 kill attempts was requested. The objective was for Blade personnel to get a better understanding of the details of the kill attempts and modeling, and the formation of the crater around the wellhead. It was not possible to make the arrangements for this discussion with B&C. Available information and details for the kill attempts were collected from documentation and analyzed as part of the RCA.

3 Data Management

Blade received and collected a large amount of Aliso Canyon data. The data requests responses from SoCalGas were timely, and the data was mostly complete.

Most of the field and well file data was provided in .pdf files with Bates numbers[i]. Some documents and files had Bates numbers as the file names.

3.1 Data Transfer

The types of data transfer varied and depended on the file and document size. The methods of transfer included email attachments, CDs, USB flash drives, and ftp downloads. Some files were compressed to reduce file size.

3.2 Data Subjects

The subjects of data and information varied, and much of it was well files and logs data for individual wells. Field data included reservoir, area geology, and surface and subsurface maps. Gas injection and withdrawal, water injection and disposal, and field observation well data were provided, along with the analysis of field gas and produced fluids.

Data for SS-25 included kill attempts, well logs, photos, videos, and well files.

3.3 File Types

The data was provided in various file types, including:

- .pdf — for scanned documents and existing files.
- .docx, .xlsx, and .pptx — for MS Office files in their native format.
- .txt, .las, and .csv — for logs and data normally stored and used in text files.
- .mov — for video files.
- .wav — for noise log audio data.
- Other proprietary formats for various computer program input and output files.

3.4 Data Storage

A secure server was set up with restricted access to store and manage the data and to maintain its confidentiality. The original files were copied for safe-keeping. A data administrator managed the data and databases.

The data were reviewed, organized, and catalogued using Excel files. This allowed the data to be sorted, filtered, and searched by team members. The system worked well and allowed access by authorized users while maintaining the required security.

[i] Bates numbering places unique identifying numbers on each page of a document as it is scanned for identification and reference.

3.5 Volume of Data

The approximate volume of data collected for the project follows:

- 57,670 Files
- 223 GB

3.6 Challenges

The quality of the scanned paper documents was generally very good, considering some of the old records were of poor quality. Some of the old records were carbon paper copies.

Challenges included data that was not in sequential order by date and multiple copies of the same documents. This made the process of reviewing the data time consuming and tedious. Many of the documents and files had the Bates number as the file name. This slowed the process of reviewing and cataloging the data into a useable data base where users could search and retrieve the desired data. Some data was provided late in the RCA process and included data that had been previously received along with data that had not been sent, requiring additional time to make sure all of the data was reviewed.

4 Use of Data

The data was used extensively by RCA team members to develop an understanding of the history of the Aliso Canyon wells and field. Blade modeled a number of field and well processes using the data. These included the gas injection surface network, well kill modeling, well thermal simulation, and timing of the casing failure in SS-25.

5 References

[1] DOGGR, "Division of Oil, Gas, and Geothermal Resources - Well Search," [Online]. Available: https://secure.conservation.ca.gov/WellSearch/. [Accessed 31 January 2019].

Appendix A Blade Information Requests

Table 2 shows the list of Blade information requests tracked by request date. The summary for each request is paraphrased from the request document. A scan of each information request document is included in Appendix B Information Request Documents.

Table 2: Blade Information Requests

Request Date	Summary
January 31, 2016	SS-25 Well File, injection and withdrawal history, analysis of injection and withdrawal fluids, relief well file.
February 01, 2016	Compositional analysis of SS-25 gas, sampling process, analog wells.
February 11, 2016	SS-25 withdrawal and injection data, kill operations daily reports, formation tops, withdrawal procedures. Information on hydrates, P&ID, typical completion schematics, field maps. SS-25 injection and withdrawal records, water injection data.
February 19, 2016	Field Earth Vision model, location plat for site SS-25, cement bond logs, and well files for SS-5 and SS-4-0.
April 07, 2016	Clarification on injection and withdrawal schedules, injection worksheet, how is gas measured and allocated. Well files for Frew 3, FF-34, FF-34A, P-38. Sand test information, reservoir simulation study. SS-25 borehole gas measurements, temperature, noise and CBL logs Feb. 2016, cloud point data, drone photos and video. SS-25 log data. Well file for Frew 7.
April 22, 2016	Photos and bubble view of SS-25 wellhead prior to the incident.
April 26, 2016	SS-25 Temperature and Noise Logs Dated 11/7/2006 and 6/1/2012.
May 04, 2016	Follow up to previous request. Resend CBL log run on Feb. 17, 2016. Well file for FF-34.
May 04, 2016	Wellhead Plumb Measurements.
May 04, 2016	Kill Attempt Data. Photos and videos during SS-25 leak events and kill attempts.
May 04, 2016	Well files for FF-33, P-44, P-50A, SF-1, SS-11, SS-14.
May 04, 2016	SS-25 formation tops, fluid top in the 7 in. annulus and the type of fluid. Daily mud reports for P-39A.
May 13, 2016	SS-25A and SS-25B work and well status.
May 19, 2016	Well file for P-39A, open hole logs, mud log, directional survey.
July 08, 2016	Confirm SS-25, SS-25A, SS-25B kill fluid Composition, density and volumes.
July 11, 2016	SS-25 kill fluid composition.
July 21, 2016	Where are injection pressures monitored, SS-5 pressure data, P-71 daily reports, anti-collision run #33 for P-39A.
August 08, 2016	Information on drilling fluids for future SS-25 work.
August 08, 2016	Drilling fluids recap report for P-39A.
August 17, 2016	LiDAR data for elevation of survey lines.
August 23, 2016	Boots and Coots end of job reports for P-39A and SS-25. Daily reports for SS-25, Aliso Canyon inventory and pressure data, P&ID for SS-25 site wells, injection procedures for SS-25 site wells.

Request Date	Summary
December 28, 2016	Phase III Investigation SS-25 Site Safety and Emergency Response Plan.
December 28, 2016	Work product by Mr. Thom Davis.
December 28, 2016	Water injection well data, injection zones, records of water injection volumes, piping and instrumenting diagram and process flow diagram documents.
February 18, 2018	Well files for Frew 6, Frew 7, Frew 8, P-47, PS-42, SF-3, SF-4, SF-6, SS-2, SS-13, SS-14, SS-17, SS-24, SS-30.
February 18, 2018	Cathodic protection information for SS-25, SS-25A, SS-25B. The use of cathodic protection on the surface casings in the Aliso Canyon field.
February 18, 2018	List of production casing integrity problems. Instances of through wall defects. Surface casing inspection logs.
February 18, 2018	SS-25A Torque Turn data. SS-25 noise, temperature and gyro surveys.
February 18, 2018	Provide list of wells referenced in the testimony presented in the 2016 General Rate Case.
March 23, 2018	Photos of the SS-44A longitudinal split, availability of the split casing from SS-44A.
April 20, 2018	Gas analysis on produced gas from P-50A in April 2016 and May 2016.
April 20, 2018	Job log for the November 2015 coiled tubing cleanout and pumping operations.
June 29, 2018	Interview with SoCalGas to get clarification on SS-25 historical operations, kill data, field withdrawal and injection, reservoir pressure, and well integrity.
August 29, 2018	Follow up to interview discussions on August 24, 2018. Description of events related to discovery of the SS-25 leak. Injection data on October 25, 2015. Injection volumes. Information on craters, kill modeling documents. Kill attempt data.
August 29, 2018	Field observation wells information, injection and withdrawal worksheets, choke sizes, well test data, cellar details, a list of casing leaks, surface and subsurface hydrology, casing inspection log for SS-44A.
October 07, 2018	Information from DOGGR including daily field notes, photos and videos, daily reports, Lawrence Berkeley National Laboratory kill analysis, Jet Propulsion Laboratory data, and flyover data.
October 26, 2018	SS-25 pressure data, fluid level data related to the kill attempts. Procedure and methodology used to calculate the quantity of gas that leaked from SS-25. SS-5 surface pressure reading.
December 18, 2018	Aliso Canyon organization chart, roles and responsibilities, storage integrity management integrity department role, casing inspection logs, corrosion study results.
December 19, 2018	Request for a discussion regarding SS-25 kill data and the evolution of the gas leak.
January 02, 2019	Details of the equipment used in the kill attempts.
April 12, 2019	Information on mechanical integrity testing requirements for Aliso Canyon gas storage wells.

Appendix B Information Request Documents

A scan of the Blade information request documents is included in this section.

BLADE ENERGY PARTNERS

January 31, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, California 90013

Attn: Mr. Jimmie Cho, Senior Vice President

Subject: Blade RCA Information Request - SS25 & P39 Well Files.

This letter is a Blade Energy Partners request to SoCalGas for information and files pursuant to the Aliso Canyon RCA Project. Blade requests that the following be provided as soon as possible in electronic file format to Bill Whitney or me at the earliest possible time.

Incident Well SS25

- Complete well file with history from before first ever spudding of the Aliso Canyon leaking well through January 31, 2016, to include geologic & geophysical, basis of design, rig & service company daily field reports, all tubular (casing & tubing), fluids and cementing, downhole completion tools (including packers), wellhead, and flowline information. Include all interventions (slickline, electric, and stranded wireline, coiled tubing, through tubing) and kill attempts and washouts, stimulation, chemical injection treatments, inhibitors, pressure tests, logs or other integrity assessment tests.

- Complete production & injection history records from date of first use thorough all production, injection, shut-in and other periods - covering production & injection rates (gas, oil, water), wellhead and casing head pressures & temperatures, days & times & elapsed periods of each rate tested through a test separator or how estimated, bottomhole pressures/temperatures when surveyed, notes when well was shut-in and why.

- Composition and chemistry of well production and injection fluids/solids, including hydrocarbon and non-hydrocarbon and water analyses, and source of sampling with sampling conditions. Non-hydrocarbons besides water may include sand, minerals, corrosives (H_2S, CO_2), and added odorizers (mercaptans).

- Well schematics and general histories of adjacent or analog field wells and those wells' remediation issues, if any.

- Field structure maps, formation tops, and well geologic correlation. Subsurface lithologies and location of all natural water and hydrocarbon zones for the leaking well and all wells adjacent to it 360deg.

- Listing of all Aliso Canyon wells with date of their original drilling and running casing, and whether these other wells are still in use, have been shut semi-permanently (before 01Jan15) yet not plugged, or the date plugged, if plugged.

- Package of information provided to regulators to date.

Relief Well P39

- SoCalGas' complete:
  - well files,
  - daily operations/drilling reports,
  - service company reports & supplier invoices,
  - all the above - historically from original well drilling, and,
  - all the above - on a daily continuing basis until further notice.

Thank you & Regards,
Blade Energy Partners, Ltd.
Bob Pilko
[redacted]@blade-energy.com; c: +1.[redacted]

copy:
Bill Whitney, Blade Energy Partners
[redacted]@blade-energy.com; c: +1.[redacted]

February 1, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Jimmie Cho, Senior Vice President

Subject: Blade RCA Information Request : SS-25 Gas Compositional Analysis

A critical and fundamental aspect of Blade's RCA work will be to evaluate the effect of the gas that has been produced from the SS-25 well on the surface equipment and downhole tubulars in the well. A detailed compositional analysis of the gas is therefore needed.

Ideally, Blade would like to arrange for a sample of the gas to be taken directly from the well before the well has been killed. However, we realize that at present, access to the well site is necessarily limited from a health and safety standpoint, and that access will likely be even more limited once the kill operations are underway. We also understand that some post-leak gas sampling has been done by various State agencies, and assume that SoCalGas has internal records regarding the composition of both the produced and injected gas.

As such, Blade requests the following information:

1.) A compositional analysis of the gas being produced from the SS-25 well that: 1.) comes from a gas sample that was taken from the well after the leak was detected, or 2.) comes from recent pre-leak internal testing done by SoCalGas. The actual lab report including the lab's name, date and time when the sample was taken, date and time of the actual testing and the results is preferred.

The following supplementary information regarding the gas sampling process is also requested:

- A detailed description of where and how the samples were obtained (e.g. location on the wellhead/tree, type of sample chamber and material).
- Does the sampling process specifically account for the potential presence of H_2S in terms of procedures used and sample container material selection?

2.) Information about the gas sampling that has been done by the State agencies.

3.) The names of analog wells currently producing from the same reservoir interval (i.e. producing the same gas) as the SS-25 from which representative gas samples could be taken.

Attached is an example gas analysis that shows the type of data that will be needed for Blade's RCA work.

Thank you and Regards,

Blade Energy Partners
Bob Pilko
[redacted]@blade-energy.com c: +1.[redacted]

copy:
Bill Whitney, Blade Energy Partners
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Attachment: Example Gas Compositional Analysis Results

Attachment:
Example Gas Compositional Analysis Results

Table 1 Gas Composition

Compositional Analysis of Flash Gas

	Component	Mole %	GPM at 15.025 Psia	Weight %	Molecular Weight
N_2	Nitrogen	0.542	0.000	0.536	28.013
CO_2	Carbon Dioxide	0.199	0.000	0.310	44.010
H_2S	Hydrogen Sulfide	0.000	0.000	0.000	34.082
C1	Methane	61.884	0.000	35.063	16.043
C2	Ethane	13.489	3.673	14.325	30.070
C3	Propane	10.687	3.004	16.644	44.097
iC4	Iso-Butane	1.528	0.510	3.136	58.123
nC4	N-Butane	4.738	1.524	9.726	58.123
iC5	Iso-Pentane	1.550	0.579	3.951	72.150
nC5	N-Pentane	2.028	0.749	5.169	72.150
C6	Hexanes	1.738	0.733	5.291	86.177
C7	Heptanes	0.976	0.421	3.278	95.065
C8	Octanes	0.438	0.206	1.661	107.351
C9	Nonanes	0.146	0.075	0.623	120.886
C10+	Decanes Plus	0.057	0.037	0.287	142.638
	Total	100.000	11.511	100.000	

February 11, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy

<u>Subject</u>: Blade RCA Data Request: Follow-up to Monday Meeting

Dear Ms. Tracy:

The meeting on Monday, February 8th, 2016 with Dan Neville and Hillary Petrizzo was very informative and insightful. As a follow-up to that meeting Blade requests the following information.

1. Please provide a narrative of the ongoing wellbore operations, from July 23rd to October 23rd 2015, just prior to leak discovery on SS25. Please provide any and all reports and any data including anecdotal data for the period July 23rd to October 23rd 2015. Also, include the following:
    a. If shut in, what were the SITP, SICP and any other data?
    b. If withdrawing, what were the flow rate, flowing pressure, temperature?
    c. If injecting, what were the Injection pressure, flow rate and temperature?
2. Please provide daily reports, in any form, during the kill operations on SS25 starting on October 23rd, 2015:
    a. Provide the detail reports including all quantitative measurements of FWHP or other pressure, temperature and flow rates. These reports may be in any form including emails and formal reports.
    b. There was a discussion of a temperature tool run during October 29th, 2015. Was this tool ever run? If so, please provide such data.
    c. There were mentions of various logs run following the discovery of the leak; please provide such data if the logs were run and data was obtained.
    d. NO2 tracer studies were undertaken during the kill; please provide the data, analyses/interpretation and reports for these studies.
3. Describe the various formation tops on SS25 and the wells analog to SS25.
    a. We already have type log/generalized geologic column. Are there any known aquifers? If such aquifers exist, please provide the associated data, including depth, and thickness of such aquifers.
4. Please provide a copy of withdrawal procedures and processes for individual well or multiple wells.

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5. Please provide a copy of the injection procedure and process for individual well or multiple wells.
6. Were there ever hydrates observed in any of the Aliso Canyon wells? If so, please describe the conditions under which they were observed.
    a. Please provide any reports that were conducted on this topic.
7. Please provide the details on the facility network (P&ID or a schematic) for withdrawal / injection for the Sesnon/Porter wells.
8. Please provide the completion schematics for:
    a. a typical well injecting/withdrawing from tubing only
    b. a typical well injecting/withdrawing from casing only
    c. a typical well injecting/withdrawing from both tubing and casing
9. Please provide full-scale hard copies of following large-scale plots/figures from engineering study titled "Guidelines for Gas Storage Projects", which was originally submitted to California DOG on 10/7/1976 with "Notice of Intent to Increase Maximum Operating Pressure in the Aliso Canyon Gas Storage Field" by P. S. Magruder, Jr.: Display clearly:
    a. Contours on Top of Sesnon Zone
    b. Contours on Top of Frew – Hard Zone & Frew Unconformities Indicated
    c. Cross Section of Storage Zone Cap Rock
    d. Isopach Sesnon Gas Sands
    e. Net Gas Isopach of Frew Sand
    f. M.P. Marker to S-4 Marker Isopach
    g. Isobar for Shut in Period Pressures for Jan 22, 1976
    h. Full-scale hard copy of the SS-4 top contour map presented during the meeting on 2/8/2016
10. Enclosed is a Well List* that is in a spreadsheet form with some of the information described below using data from the DOGGR website. <u>Please provide the data from columns Z through AI.</u>
    a. Date drilled
    b. Vertical or deviated
    c. Surface elevation
    d. TD depth (subsea or BML, let us know which one is used for the wells)
    e. Injection / Withdrawal / Both / Observation / Monitoring
    f. Injection / Withdrawal from Casing / Tubing / Both
    g. Date(s) of re-completion, workovers, etc.
    h. Completion type (screen, cased & perforated, etc.)
    i. Tubing present (yes/no)
    j. Zone(s) open for injection/withdrawal
    k. Field zone (east, central, west)

    **This list includes all wells in Aliso Canyon field, whether they are used for gas storage or not, and whether they are shallow or deep. For wells operated by others, include as much information as available (e.g., name, operator, etc.)*
11. We have the monthly Injection and production (withdrawal) records from the DOGGR database. Please provide daily injection and production data allocated by well for July 2015 to December 2015.
    a. For production/withdrawal, indicate oil/gas/water.
    b. For injection, indicate gas/water. Include wells operating in the shallow zones only.

12. Did SS 25 have any reservoir damage issues through its life?
    a. Was SS25 treated with solvent and/or acid.
    b. When were these treatments done?
    c. Please provide reports and summaries and emails that describe any methodologies used to repair the skin damage in SS 25.
13. We understand that water is injected to the Pliocene.
    a. Describe how the water is treated prior to injection into the Pliocene.
    b. Please provide the water chemistry prior to treatment including water from gas storage, oil producers and other wells.
14. We understand that SS-4-0 was hydraulically fracture stimulated in 1995 and 2005.
    a. Please provide a detail report of those operations, including any and all reports such as engineering, reservoir and others.

Thank you and Regards,

Ravi Krishnamurthy
Blade Energy Partners

February 19, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
<u>Subject</u>: Blade RCA Data Request

Dear Ms. Tracy:

We are going through the reports available on DOGGR websites, and the data provided by SoCalGas on Wells 25, 25A and 25B. Your data files contain a lot of valuable data. We await response to our last data request. This is a supplemental data request. Please get us the data as they come in, we will track it.

Blade requests the following.

1. Please provide us with the Earth Vision model for the field. We will access it using the Earth Vision software. This model will contain all relevant geologic data regarding the field. Further it will allow us to visualize the three dimensional geology of the field, especially with regards to the structure, faulting and well geometries.
    a. If there are any reservoir simulation studies or models, please provide them too.
2. Please provide a plat of SS25 Location showing the 3 wells and the following:
    a. Well centers and distances between well centers, and the outline of the covers on 25A and 25B.
    b. Edges of the flat part of the location including the entrance road.
    c. Scaled drawing hard copy (minimum 11"x17") and electronic copy.
3. We understand that a CBL log was run in the well around May 26th 1973. Please provide a copy of that log.
4. Please provide a complete well file for SS5. If possible, please provide the data in a chronological order. If this slows the process of compiling the data, please provide it as you have it.
5. Please provide a complete well file for SS4-0. If possible, please provide the data in a chronological order. If this slows the process of compiling the data, please provide it as you have it

Thank you and Regards,

Ravi Krishnamurthy, Blade Energy Partners

April 7, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
Subject: Blade RCA Data Request

Dear Ms. Tracy:

Thank you for all the data already provided. Based on that ongoing review, we have some additional data requests.

1) In AC_BLD_0003625 Injection Schedule:
   A. What do the terms T, C, TK and CK mean in the STR column?
   B. Under the AVAIL. PRIOR. columns, there are numbers (e.g., "Y 1", "Y 2"). Do these refer to the priority of the wells for injection? We assume that wells are opened in the order of priority (e.g., first 1, then 2, and so on to 6). Is this correct?
2) In AC_BLD_0003626 Withdrawal Schedule:
   A. Under the AVAIL. PRIOR. columns, there are numbers (e.g., "Y 1", "Y 2"). Do these refer to the priority of the wells for withdrawal? We assume that wells are opened in the order of priority (e.g., first 1, then 2, and so on to 6). Is this correct?
   B. Under RATE column, what is the number shown? Does this refer to the maximum withdrawal rate for that well? Are the proper units MMscf/d (instead of MMCF shown in the table?
   C. Please explain the following comment at the bottom of the schedule: "Red Flag Event: Use wells starting with priority 3 through 6 to reduce liquid production."
3) AC_BLD_0003627 is a "Withdrawal Worksheet". Please provide the analogous "Injection Worksheet" if available.
4) In injection mode, is the injected gas measured and/or metered? If so, where and how?
5) In withdrawal mode, is the withdrawn gas measured and/or metered? If so, where and how?
6) What is the procedure for allocating injected gas to individual wells? Please provide a written procedure, if available.
7) What is the procedure for allocating withdrawn gas to individual wells? Please provide a written procedure, if available.
8) Please provide the complete well file Frew 3.
9) Please provide the complete well file for FF-34 and FF-34A.
10) Please provide the complete well file for Porter 38.
11) There are references to "sand testing" (e.g., AC_BLD_0003641):
   A. What is the purpose of these tests?
   B. Are these tests still being conducted? The references we have seen are from 1980s and 1990s.

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C. Please provide a sample procedure for the sand test.
D. Please provide a recent sand test data from SS-25 (or the closest well to SS-25).
E. Is sand production a problem with gas storage wells? If so, how is the produced sand handled? How much sand is produced?

12) There is a presentation on reservoir simulation study by SI International dated 10/2002. Is the reservoir simulation model available?
13) Well SS 25:
    A. We have received some of the gas measurements in the wellsite bore holes after SS25 seal; however can we have all of the data collected to date from these bore holes on SS25 site.
    B. Need a copy of the temperature, noise and CBL log runs around 16-17 February 2016. Including gamma ray if run. Need the status of the well including tubing pressure, and 'A' annulus pressure when the logs were run.
    C. Need well head and tree purchasing specifications. Should be included in the purchase order. Data needed includes complete description, manufacturer, serial numbers.
14) Please provide a complete well file for Frew 7.
15) Please provide the AECOM 3-D cloud point model, data along with drone pictures and video that was acquired as part of Phase I.
16) Please provide digital data either in ASCII or LAS formats the following log information:

Log Name or Type	Log Date	Open or Cased Hole	From (ft)	To (ft)	Comments
Schlumberger Electrical Log (SP and Resistivity)	13-Nov-53	Open	86	4,909	Combined Runs 1, 2, 3, 4
Schlumberger Electrical Log (SP and Resistivity)	14-Feb-54	Open	3,860	8,749	Combined Runs 5 (ST), 6, 7, 8, 9, 10, 11
Dresser Atlas Acoustic Cement Bond Log VDL	25-May-73	Cased	6,950	8,737	
Dresser Atlas Neutron Lifetime Log	25-May-73	Cased	8,000	8,742	
Dresser Atlas Compensated Density Log	28-May-73	Cased	8,000	8,560	
Dresser Atlas Acoustic Log	28-May-73	Cased	8,000	8,560	
Western Wireline Temperature Down	9-Nov-15	Cased	0	8,432	
Western Wireline Noise Temperature	9-Nov-15	Cased	0	8,432	

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

Fw: Photographs and or Bubble view of SS 25
Ravi Krishnamurthy to: Randall L Rudolf 05/11/2016 05:29 PM

Ravi M. Krishnamurthy
281 206 2000 (office)
[redacted] (cell)
[redacted]@blade-energy.com

----- Forwarded by Ravi Krishnamurthy/Blade on 05/11/2016 05:28 PM -----

From:	Ravi Krishnamurthy/Blade
To:	JTracy@semprautilities.com,
Cc:	fhamze@semprautilities.com, "Epuna, Matthewson" [redacted]@cpuc.ca.gov>, [redacted]@conservation.ca.gov, [redacted]@cpuc.ca.gov, [redacted]@cpuc.ca.gov
Date:	04/22/2016 03:04 PM
Subject:	Photographs and or Bubble view of SS25

Dear Jill:

Could we please have a copy of photographs and / or bubble view of SS25 wellhead and other associated equipment prior to the incident. This will allow us to confirm our disposition on the removal of the associated piping.

Regards,

Ravi M. Krishnamurthy
281 206 2000 (office)
[redacted] (cell)
[redacted]@blade-energy.com

From: Ravi Krishnamurthy
To: JTracy@semprautilities.com
Cc: [redacted]@conservation.ca.gov; [redacted]@cpuc.ca.gov; Epuna, Matthewson; Bill Whitney; Randall L Rudolf
Subject: Data Request
Date: 04/26/2016 06:50 PM

Dear Jill:

Thank you for all the information already provided from our last data request.

The logging company is in the process of analyzing the recent log data obtained from SS25. As part of that they are comparing it to older data.

Please provide digital data either in ASCII or LAS formats the following noise and temperature log information.

1. Noise Temperature log run on 11/7/2006 by a company called WELACO.

2. Noise Temperature log run on 6/1/2012 by a company called WAC (Well Analyses Corporation).

Thank you very much.

Regards,

Ravi M. Krishnamurthy
281 206 2000 (office)
[redacted] (cell)
[redacted]@blade-energy.com

May 4, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
<u>Subject</u>: Clarifications from Previous Data Request dated April 7th, 2016

Dear Ms. Tracy:

This is a follow-up from previous data requests.

(1) Question 13 B. We received a response to this data request from SoCal on April 25th 2016. The transmittal email is attached for reference. The CBL log file is not complete. Please resend the file. The file we are requesting is the CBL log run about February 17th 2016 in a .pdf format. The incomplete file we received (AC_BLD_0035416.pdf) is attached for reference.

(2) Question 9. There were two parts to this request. We received the well file for FF-34A as requested; however haven't received the file for FF-34. Please send the file for FF-34.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

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Fw: SoCalGas Response to Blade Request RE : Wellhead Plumb Measurements
Ravi Krishnamurthy to: Randall L Rudolf, Bill Whitney 05/12/2016 09:07 AM

Ravi M. Krishnamurthy
281 206 2000 (office)
[redacted] (cell)
[redacted]@blade-energy.com

----- Forwarded by Ravi Krishnamurthy/Blade on 05/12/2016 09:07 AM -----

From: "Healy, Gregory" <GHealy@semprautilities.com>
To: "'Ravi Krishnamurthy'" <[redacted]@blade-energy.com>,
Cc: "[redacted]@blade-energy.com'" <[redacted]@blade-energy.com>, "'Bruno, Kenneth'" <[redacted]@cpuc.ca.gov>, "Epuna, Matthewson" <[redacted]@cpuc.ca.gov>, '[redacted]@cpuc.ca.gov" <[redacted]@cpuc.ca.gov>, "'Robledo, Monica'" <[redacted]@cpuc.ca.gov>, "[redacted]@DOC'" <[redacted]@conservation.ca.gov>, "[redacted]@conservation.ca.gov'" <[redacted]@conservation.ca.gov>, "Schwecke, Rodger" <RSchwecke@semprautilities.com>, "Tracy, Jill" <JTracy@semprautilities.com>
Date: 05/12/2016 09:00 AM
Subject: SoCalGas Response to Blade Request RE: Wellhead Plumb Measurements

Attached please find SoCalGas' responses to the May 4, 2016 dated data request from Blade.

Please let me know if you have any questions. Thanks.

Gregory Healy
Regulatory Case Manager
Southern California Gas Company
PH: (213) 244-3314
ghealy@semprautilities.com

From: Ravi Krishnamurthy [mailto:[redacted]@blade-energy.com]
Sent: Wednesday, May 4, 2016 4:26 PM
To: Tracy, Jill
Cc: [redacted]@conservation.ca.gov; Epuna, Matthewson; [redacted]@cpuc.ca.gov; [redacted]@cpuc.ca.gov
Subject: Wellhead Plumb Measurements

Dear Jill:

As a follow-up to our conversation this morning, could you please forward us the Wellhead Plumb measurements that were conducted on SS25.

Thank you,

Regards,

Ravi M. Krishnamurthy
281 206 2000 (office)
[redacted] (cell)
[redacted]@blade-energy.com

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This email originated outside of Sempra Energy. Be cautious of attachments, web links, or requests for information. Blade-13.pdf AC_BLD_0035446 - 35453.pdf

May 4, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
Subject: Blade RCA Data Request

Dear Ms. Tracy:

Thank you for all the data already provided.

A. Kill Attempt Data:
For Kill Attempt number 6, substantial amount of data was provided. For the rest of the kill attempt, please provide the following:

a. Actual job time
b. Cumulative volume pumped vs. time
c. Pump rate vs. time
d. Pump pressure vs. time
e. Fluid density vs. time
f. Other recorded data vs. time

The Kill Attempts that we need the data above for is:
g. #1 October 24, 2015
h. #2 November 13, 2015
i. #3 November 15, 2015
j. #4 November 18, 2015
k. #5 November 24, 2015
l. #6 Data provided previously
m. #7 December 22, 2015

B. If available, please provide photographs and/or video recordings that are available during the SS25 leak events and kill attempts with the associated timing of such documentation.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

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May 4th 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
Subject: Blade RCA Data Request

Dear Ms. Tracy:

Thank you for all the data already provided. Based on the ongoing review, we have some additional data requests.

Please provide the complete well file for each of the wells listed below:

a. FF-33
b. Porter 44
c. Porter 50A
d. SF-1
e. SS-11
f. SS-14

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

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BLADE ENERGY PARTNERS

May 4, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
Subject: Blade RCA Data Request

Dear Ms. Tracy:

1) Please confirm the SS25 formation tops identified from surface to TD.
2) Please provide the Fluid top in the 7" annulus for SS25; further please identify the type of fluid in the SS25 annulus.
3) Please provide daily mud reports for the relief well P39A.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

BLADE ENERGY PARTNERS

May 13, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
<u>Subject</u>: Blade RCA Data Request

Dear Ms. Tracy:

Thank you for all the data already provided. Based on the ongoing review, we have some additional data requests.

We need this data to prepare for the upcoming logging on SS-25A and SS-25B.

1) Please provide the well status for SS-25A and SS-25B including the following:
    a. History of work done on each well since October 1, 2015.
    b. Details of fluid pumped in each well, volume, density, date, etc., since October 2015.
    c. We understand there are plugs set in the wells. Please confirm the setting depths.
    d. What is the current tubing pressure?
    e. What is the current 'A' annulus pressure?
    f. Is the tubing full of liquid to surface? Some of the planned logs (MID) require liquid in the tubing to surface.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

May 19, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
<u>Subject</u>: Blade RCA Data Request

Dear Ms. Tracy:

Thank you for all the information already provided.

1) The document previously provided by SoCalGas (AC_BLD_0001956 - AC_BLD_0003855.pdf) had an incomplete set of P39A daily morning reports from the relief well drilling operation. Please provide the following missing reports:

- reports before 6 December, 2015 (report numbers 1 through 6)

- reports for 12, 13, 14, and 15 December, 2105 (report numbers 13 through 16)

- reports from 8 January, 2016 through to the end of the relief well operations (i.e. rig release)

2) Please provide all open-hole logs (wireline & LWD) acquired in P-39A well in both numerically digitized (e.g., LAS) format and also in print/plot (e.g., PDF) format.

3) Please provide a complete mud log acquired in P-39A well in both color print/plot (e.g., PDF) and, if available, numerically digitized (e.g., LAS) formats. The current mud log provided extends to 6195 ft, and is in black-and-white.

4) Please provide the final directional survey data (tabular listing) for the P39A well.

5) It is understood that the P39A wellbore is very close to the SS-25 wellbore, and essentially parallels SS-25 below 4000 ft. Please provide the actual directional survey data (tabular listing of x and y coordinates) that shows the relationship between the P39A and SS-25 well profiles from surface to TD. We have the plans for the directional survey, however we require the actuals.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

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July 8th, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
Subject: Blade RCA Data Request (Kill Fluid Composition)

Dear Ms. Tracy:

Thank you for all the data already provided. Based on the ongoing review, we need to confirm the composition, density and volumes of the fluids pumped during the SS-25 kill attempts as noted in the table below. We have noted conflicting information in various reports. It is important for us to know the base fluid composition, i.e. $CaCl_2$, KCl, NaCl, just lease water etc., and other fluid details for the RCA.

Please provide data for the column listed as "CLARIFICATIONS" below.

Well	Date Pumped	Reported Composition	Reported Density (ppg)	CLARIFICATIONS
SS-25	Oct 24, 2015	Polymer Brine and XC Polymer	10.0	Confirm the base fluid composition of the 11.8bbl pumped down the tubing.
SS-25	Nov 13, 2015	Polymer Pill	9.4	Confirm the base fluid composition of the first 10bbl pumped down the tubing.
SS-25A	Oct 31, 2015	Polymer Pill	9.8	Confirm the base fluid composition and density of the first 30bbl pumped down the tubing.
SS-25A	Oct 31, 2015	Polymer Pill	8.7	Confirm the base fluid composition and density of the first 30bbl pumped down the tubing.
SS-25A	Oct 31, 2015	Polymer	10.8	Confirm the base fluid composition and density of the reported 178bbl pumped down the tubing, following the first 30bbl. Confirm if 178bbl is the correct volume pumped.
SS-25A	Oct 31, 2015	KCl	8.5	Confirm the base fluid composition and density of the reported 152bbl pumped down the tubing, following the first 30bbl. Confirm if 152bbl is the correct volume pumped.
SS-25A	Oct 31, 2015	Brine	10.8	Confirm the base fluid composition and density of the reported 205bbl pumped down the annulus.
SS-25A	Oct 31, 2015	KCl	8.5	Confirm the base fluid composition and density of the reported 205bbl pumped down the annulus.
SS-25B	Nov 1, 2015	Polymer Pill	8.7	Confirm the base fluid composition and density of the first 30bbl pumped down the tubing.
SS-25B	Nov 1, 2015	KCl	8.5	Confirm the base fluid composition and density of the reported 387bbl pumped down the tubing, following the first 30bbl. Confirm if 387bbl is the correct volume pumped.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

BLADE ENERGY PARTNERS

July 11, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
Subject: Blade RCA Data Request

Dear Ms. Tracy:

Thank you for all the data already provided. Based on the ongoing review, we need to confirm the composition of some of the fluids pumped during the SS-25 kill attempts as noted in the table below. The description provided does not show the base fluid composition. It is important for us to know the base fluid composition, i.e. $CaCl_2$, KCl, NaCl, etc., for the RCA.

Well	Date Pumped	Reported Composition	Reported Density (ppg)	Notes and Comments
SS-25	Oct 24, 2015	Polymer Brine / XC Polymer Pill	10.0	Confirm the base fluid composition of the 11.8bbl pumped down the tubing.
SS-25	Nov 13, 2015	Polymer Pill	9.4	Confirm the base fluid composition of the first 10bbl pumped down the tubing.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

July 21st, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
Subject: Blade RCA Data Request

Dear Ms. Tracy:

Thank you for all the data already provided.

1. During injection operations, where are the pressures monitored (e.g., at compressor outlet)? Is (are) there a pressure relief valve(s) at the compressor outlet(s)? What are their setting? Provide pressure data (and temperature data, if available) for the compressor(s) feeding the SS-25 well during the period from July 1, 2015 to when SS-25 injection was stopped.
2. Provide pressure data from SS-5 (west reservoir pressure monitoring well) from July 1, 2015, to present.
3. This is a request for the daily reports for the workover done in November or December 2015 on well Porter 71 to perforate the zone ~563 – 623'. Also please provide any gas analyses reports on the gas recovered from this well.
4. Anti-Collision report run #33 for relief well P39A.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

August 8th, 2016- Part 1

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Todd Van de Putte
Subject: Blade RCA Data Request

Dear Mr. Van de Putte:

This is a request for information related to drilling fluids and services for the future rig work on Well SS-25.

1. Mud product data sheets for the Poly-Tek mud system used by SoCal.
2. Details and specs on the 100bbl pre-mix tank for LCM pills.
3. Lubricity results for the Poly-Tek mud.
4. Maximum recommended percent drill solids for 9ppg Poly-Tek mud.
5. Complete mud check for the 9ppg mud that is in storage for use on SS-25.
6. Product formulation for the 9ppg mud that is in storage for use on SS-25.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

August 8th, 2016- Part 2

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
Subject: Blade RCA Data Request

Dear Ms. Tracy:

Thank you for all the data already provided.

This is a request for the Drill Fluids Recap Report for Well Porter 39A.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

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August 17, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
<u>Subject</u>: Blade RCA Data Request

Dear Ms. Tracy:

This is a request for LiDAR, or other similar digital elevation data, to be used for determining elevation along the survey lines that Advisian is running for the current shallow geophysical investigation work. The preferred data format would be some asci format like .csv that has the elevation, eastings and northings at each location. If this format is not available, please let us know what data formats are available. Please provide the data by Friday August 19th, 2016. This will be data that will be used by Advisian and speed up their process.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

BLADE ENERGY PARTNERS

August 23rd, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
Subject: Blade RCA Data Request

Dear Ms. Tracy:

Thank you for all the data already provided.
Please provide the following information.

1. Boots and Coots end of Job Report for the relief well P39A.
2. Boots and Coots end of Job report for the kill attempts on SS25.
3. Are there daily SoCalGas operational daily reports for SS25 from the start of the leak, October 23, 2015 through April 2016? If so, could you please provide them? We do have reports from other third parties including DOGGR and Boots and Coots.
4. Aliso Canyon Inventory and Pressure data from December 15, 2015 to the present from well SS-5. Similar data was provided previously through late December 2015.
5. P&ID for Site 25 surface piping for all three wells, SS-25, 25A and 25B.
6. Description of normal injection procedures that were in place in October 2015 before the event on SS-25 including the following.
    a. Is it normal procedure to inject in one well at a time or to inject in multiple wells at the same time at Site 25?
    b. While injecting in SS-25 on Oct 23, 2015, was gas being injected in SS-25A or SS-25B?
    c. What are the onsite valve settings when injecting in one well or in more than one well. i.e., which valves were open and which valves were closed?
    d. Are there check valves in the injection lines at each well to prevent cross flow from one well to another? This should show on the P&ID.

We would like to receive items (1) and (2) by August 26th, 2016; the rest of the items by September 2nd 2016.

Thank you,

Best Regards,

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Ravi Krishnamurthy, Blade Energy Partners

December 28th, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
Subject: Blade RCA Data Request

Dear Ms. Tracy:

Thank you for all the data already provided.

This is a request for the final version of the SoCalGas document:

Phase III Investigation SS-25 Well Site Safety and Emergency Response Plan

The latest version we have is a final draft version.

Please provide the data by January 16, 2017.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

2600 Network Boulevard, Suite 550 Frisco, TX 75034 • Telephone +1 972.712.8407 • Fax +1 972.712.8408

December 28th, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
<u>Subject</u>: Blade RCA Data Request

Dear Ms. Tracy:

Thank you for all the data already provided.

This is a request for the work product prepared by [redacted] for SoCalGas. This would include the electronic logs and other associated information. We understand [redacted] worked as a consulting geologist for SoCalGas.

Please provide the data by January 16th, 2017.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

December 28th, 2016

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Ms. Jill Tracy
<u>Subject</u>: Blade RCA Data Request

Dear Ms. Tracy:

Thank you for all the data already provided.

This is a request for information regarding water disposal, water flood and water injection wells in the Aliso Canyon field.

Provide data including but not limited to the following:

1. List of Aliso Canyon wells used for water disposal, water flood and water injection since January 1, 2000.
2. Injection formation, zone and perforation depths by well.
3. Records of injected water volume and injection pressure by well, by day or month, etc., since January 1, 2000.
4. Water injection station P&ID and PFD similar to the gas injection and withdrawal PFD documents AC_BLD_0003725 and AC_BLD_000376 that were provided by SoCalGas in previous data requests.

Please provide the data by January 16th, 2017.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

2600 Network Boulevard, Suite 550 Frisco, TX 75034 • Telephone +1 972.712.8407 • Fax +1 972.712.8408

February 18th, 2018

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Glenn La Fevers
Subject: Blade RCA Data Request

Dear Mr. La Fevers:

Thank you for all the data already provided.

This is a request for the well files, including the P&A daily reports, for the following wells.

Frew 6
Frew 7 (File was provided in April 2016. Please provide daily reports after April 2016)
Frew 8
Porter 47
Porter Sesnon 42
Sesnon Fee 3
Sesnon Fee 4
Sesnon Fee 6
Standard Sesnon 2
Standard Sesnon 13
Standard Sesnon 14 (File was provided in July 2016. Please provide daily reports after July 2016)
Standard Sesnon 17
Standard Sesnon 24
Standard Sesnon 30

Please provide the data by March 5th, 2018

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

2600 Network Boulevard, Suite 550 Frisco, TX 75034 • Telephone +1 972.712.8407 • Fax +1 972.712.8408

February 18th, 2018

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Glenn La Fevers
<u>**Subject**</u>**: Blade RCA Data Request**

Dear Mr. La Fevers:

Thank you for all the data already provided.

This is a request for information related to Cathodic Protection (CP) systems use in Aliso Canyon.

1. Please provide information on CP systems used in the past or present on the well casings of the three wells on Site SS-25, SS-25, SS-25A and SS-25B or any underground pipelines in the area that might affect these wells. Include details on rectifier data, On-Off potential surveys or any other relevant data.

2. Please provide data and comments on the use of CP on surface casing on any and all wells in the Aliso Canyon Field. Has CP been used in the past, is CP currently used, list of wells where CP has been used, is currently used, etc.

Please provide the data by February 18th, 2018.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

February 18th, 2018

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Glenn La Fevers
Subject: Blade RCA Data Request

Dear Mr. La Fevers:

Thank you for all the data already provided.

This is a request for information collected as part of the SIMP casing integrity program.

1. Please provide a list of production casing integrity problems (such as a leak/rupture or failure) found during the SIMP P&A Program including the well name, the type of integrity problem, casing size, casing weight, casing grade and casing connection. Further, please identify wells that exhibited significant external casing metal loss (>40% wall thickness loss), especially above 1200 feet.
2. Have there been instances of casing with longitudinal or circumferential through wall defects identified by **logs** or **visual inspection**? If so, please provide the well name, the description of the failure, casing size, casing weight, casing grade, casing connection, etc. Also provide all daily reports, failure reports and documentation related to the failure analysis.
3. Please provide casing inspection logs that have been run on surface casing in Aliso Canyon wells plugged and abandoned in 2016 and 2017.

Please provide the data by March 4th, 2018.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

2600 Network Boulevard, Suite 550 Frisco, TX 75034 • Telephone +1 972.712.8407 • Fax +1 972.712.8408

BLADE ENERGY PARTNERS

February 18th, 2018

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Glenn La Fevers
Subject: Blade RCA Data Request

Dear Mr. La Fevers:

Thank you for all the data already provided.

Please provide the following information:

1. Aliso Canyon **Well SS-25A** Weatherford Torque-Turn Report for the tubing that was pulled and laid down from approximately May 12 through May 19, 2017.
2. This is a request for copies the following log surveys run in **Well SS-25** approximately December 14 – 15, 2017. We would like copies of the graphical and digital data as provided by the service companies.
    a. Noise Survey
    b. Temperature Survey
    c. Gyro Survey

Please provide the data by March 4th, 2018.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

2600 Network Boulevard, Suite 550 Frisco, TX 75034 • Telephone +1 972.712.8407 • Fax +1 972.712.8408

February 18th, 2018

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Glenn La Fevers
Subject: Blade RCA Data Request

Dear Mr. La Fevers:

Thank you for all the data already provided. This data request is regarding a reference document that was the direct testimony of Philip E. Baker.

Reference Document:

Company: Southern California Gas Company (U 904 G)
Proceeding: 2016 General Rate Case
Application: A 14-11-XXX
Exhibit: SCG-06

SOCALGAS
DIRECT TESTIMONY OF PHILLIP E. BAKER
UNDERGROUNG STORAGE
November, 2014

Doc #292223

1. Please provide the names of the two (2) wells referenced in the statement below.

   Page PEB-19 Lines 5, 6 and 7 state " ~two wells were found to have leaks in the production casing at depths adjacent to the shallower oil production sands."

2. Please provide the names of the fifteen (15) wells referenced in the statement below.

   Page PEB-19 Lines 17, 18, 19, 20 and 21 state "Ultrasonic surveys conducted in storage wells as part of well repair work from 2008 to 2013 identified internal/external casing corrosion, or mechanical damage in 15 wells. External casing corrosion has been observed at relatively shallow depths in the production casing, and at deeper intervals near the Aliso Canyon oil production zone at which is being water-flooded."

Please provide the data by March 4th, 2018.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

March 23rd, 2018

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Glenn La Fevers
<u>Subject</u>: Blade RCA Data Request

Dear Mr. La Fevers:

Thank you for all the data already provided.

This is a follow-up to the responses provided on March 23rd, 2018 regarding the SIMP casing integrity program.

1. A response was provided, and it identified that in Standard Sesnon 44A a longitudinal split was visually identified in the production casing.
    a. Are there any photographs of the split, that was visually identified, in SS 44A? Could you please provide them? Please provide any reports specific to the split, other than the daily reports already provided.
    b. Is this longitudinal split from SS44A still available for examination? Could we have access to the split in SS44A?
    c. Are the rest of the casing joints extracted from this well available for visual examination? Could you provide access to these joints?

Please provide the data by April 6th, 2018.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

BLADE ENERGY PARTNERS

April 20th, 2018

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Glenn La Fevers
Subject: Blade RCA Data Request

Dear Mr. La Fevers:

Thank you for all the data already provided.

This is a request for information related to shallow gas production at Porter 50A.

The well records show shallow gas was produced from Porter 50A in April 2016 into a SCG LP line.

1. If a gas analysis was run on the produced gas around April 2016, please provide the gas analysis.

The well records also show the produced gas was tied into a SCG withdraw line on May 23, 2017.

2. If a gas analysis was run on the produced gas around May 2017, please provide the gas analysis.

Please provide the data by May 4th, 2018.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

April 20th, 2018

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Glenn La Fevers
Subject: Blade RCA Data Request

Dear Mr. La Fevers:

Thank you for all the data already provided.

On or around November 6, 2015, a coiled tubing operation was carried out on the SS-25 well to clean out an ice plug from the tubing.

1. Please provide the Service Company (Halliburton) Job Log for the coiled tubing operations, including but not limited to the events, time, depth, pressure, pump rate, comments, etc. Provide the time stamped data in a digital format if available.
2. Please provide the Service Company (Halliburton) Job Log for the pumping services operations, including but not limited to the events, time, fluid type and density, pressure, rate, comments, etc. Provide the time stamped data in a digital format if available.

Please provide the data by May 4th, 2018.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

2600 Network Boulevard, Suite 550 Frisco, TX 75034 • Telephone +1 972.712.8407 • Fax +1 972.712.8408

June 29th, 2018

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Glenn La Fevers
<u>Subject</u>: Meeting to verify and confirm the Factual data provided for the RCA on SS25

Dear Mr. La Fevers:

Thank you for all the data already provided. We have reviewed the data and would like to meet with key personnel to confirm the factual information that we have collated.

We would like to propose a discussion at a location and time of your choice. The topics we would like to address during the meeting are as follows:

1. SS25 historical operations and kill data confirmation. Listed below are some of the topics on our list.
    a. Pre-kill and Post Kill B annulus pressure measurements
    b. SS25 reservoir pressure mimicking SS5
    c. Observations recorded in the reports during kill attempts
    d. Anecdotal data regarding the formation of the South Crater and the behavior of the North Crater
    e. Normal SS25 operations, and the condition of the 'B' annulus valve.
    f. Is SS 25 operated primarily as an injector?
    g. We have Boots and Coots data; we want to confirm that, along with ADD energy report, we have all the data from the kill attempts.
    h. IPR estimation for SS25.
    i. Data that we have already reviewed, and whether there are any other kill data that we have not analyzed.
    j. Was kill modeling done prior to each kill attempt? If so who did the modeling?
    k. Are there any other anecdotal data regarding the effectiveness of the kill attempts, especially the last ones?
2. Overall field withdrawal and injection, and reservoir understanding (pressure and production) and well integrity.
    a. Well categorization, and the identification of injectors and producers
    b. Historical casing leak reports, and the data available.
        i. Recovery and visual observations of the casing strings
        ii. Other anecdotal data regarding casing condition.

iii. There appear to be no failure analyses or any photographic data of any of the casing failures. Is it correct to assume that none of the leaking casings were ever recovered?

c. Injection rates and withdrawal rates and volumes; and allocation to wells versus measurements.
d. What are the existing stormwater disposal procedures? How have they evolved from the past (1970's and 1980's) to today?
e. Injection and withdrawal procedures. How wells were opened to injection or withdrawal, and how they were isolated from injection or withdrawal prior to October 23, 2015.
f. Operation history at the SS-25 pad (SS-25, SS-25A and SS-25B wells) for the period from October 1 to October 23, 2015.
g. Operation history at the SS-25 pad (SS-25, SS-25A and SS-25B wells) on October 23-24, 2015, in response to the discovery of the gas leak on October 23. Which valves were isolated and when?

Above are some of the topics that we would like to discuss and confirm during our meeting. From Blade, Randy, Bill, Nigel, and Ismail will join me at the meeting. We will take notes during the meeting and if required follow up with additional data requests. We would like to have some key folks from SoCalGas join this meeting. We suggest Todd, Hilary, Tom, Firaz, Larry, Dan Neville and Boots & Coots personnel associated with planning and executing kill attempts join these discussions. Suggested Boots & Coots personnel are [redacted] and [redacted]. If they are not available, alternates are [redacted] or [redacted]. We would suggest that regulatory affairs and legal abstain from attending this meeting. The intent is to have an informal discussion regarding data that has already been provided, and confirming and clarifying its completeness. We suggest that SoCalGas allocate one working day (eight hours) for this meeting.

Please respond by July 20th with a convenient date and time for the meeting. We would prefer to have the meeting no later than August 31st, 2018.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

August 29th, 2018

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Glenn La Fevers
Subject: Blade RCA Data Request

Dear Mr. La Fevers:

Thank you for data sharing at the data clarification meeting on August 24th, 2018. As a follow-up to that meeting here is a series of data requests regarding the SS25 incident, kill attempts, and operational data.

1. We understand there is a detailed description of the events leading up and following the discovery of the SS25 leak on October 23rd, 2015. Please provide this description of events of 10/23/15 and subsequent days (if available).
2. The SS 25 leak was discovered on October 23rd, 2015; When was the last visit, before October 23rd, 2015, to the SS25 pad? Is there any documentation of what was observed during that last visit? Formal or anecdotal?
3. We understand that a call was received from the other operators' employee regarding the gas odor from the SS25 pad; Is there a logbook or record of when the call was received? If yes, what was the time of this call regarding the gas odor from SS25?
4. We understand that the tubing pressure, tubing by production casing annulus (A annulus), and production casing by surface casing annulus (B annulus) pressure measurements are done weekly for the Aliso gas storage wells. Please provide such pre-incident pressure data for SS-25, SS-25A and SS-25B wells for the period from 1/1/2015 to 10/31/2015. Is the pressure data absolute or gauge?
5. There is data in documentation referenced as AC_BLD_0001957 that indicates that there were field injections occurred on 10/29/2015 through 10/31/2015. However, during the discussion on August 24th, 2018 it was indicated that field injection was stopped after 10/25/2015. Please provide clarification along with appropriate documentation on this topic.
6. For the same document referenced as AC_BLD_0001957: For the following dates 9/8/15, 9/9/15, 9/10/15, 9/11/15, and 10/23/2015 through 10/31/2015 there are injection volumes. However, the no wells have been identified. Please provide clarification along with appropriate documentation on this topic.
7. We understand there are continuous pressure and temperature transducer measurements; please provide the transducer data for 0:00 on 10/22/2015 (beginning of

the day) through 23:59 on 10/31/2015 (end of the day) for the following locations. Please identify the location closest to SS25.

   a. PT-306A_DY1
   b. PIT-WFI_DY1
   c. AI_STA_PT-306
   d. AI_STA_TE-506

8. Is there any other pressure or temperature transducer located on the injection lines between the above transducers and SS-25 pad? If yes, please provide that transducer data for the period from 0:00 pm 7/1/2015 through 23:50 on 10/31/2015.
9. Are there any pressure or temperature transmitter on the withdrawal network? Please identify their location on the withdrawal network and identify the ones closest to SS25. If yes, could you provide that data from July 1, 2015, to June 30th, 2016? Please provide daily withdrawal volumes for the same period.
10. The North and the South craters were formed at various times during the kill operations. We have reviewed the available information, and there are references to the crater formation. However, the timeline is unclear. Are there any Halliburton daily reports or other anecdotal reports that provide a timeline on the formation of the craters? Please provide any such information, reports, email or any recollection from Halliburton or SoCalGas or other onsite personnel.
11. Review of documents indicates that there was kill modeling that was conducted by Halliburton. Please provide any such documents that summarize the modeling/analyses that were conducted before various kill attempts by either Halliburton or SoCalGas or others.
12. Based on Halliburton daily reports fluid levels were shot on 10/28/2015 and 10/29/2015. Only the data for 10/28/2015 was reported. Please provide the fluid level data for 10/29/2015. If the data was not acquired, please provide the rationale for the absence of this measurement.
13. There are multiple sources of data for the various kill attempts, and include the following: Boots and Coots daily reports, DOGGR reports. SoCalGas daily reports, Halliburton Job reports, File of emails from Todd (starting on November 20th, 2015).
   a. Are there any other sources of data for the Kill attempts? Please provide any other available data.
   b. Please provide the emails from Todd that was before November 20th, 2015, if such emails exist.

Please provide the data by September 17th, 2018.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

August 29th, 2018

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Glenn La Fevers
Subject: Blade RCA Data Request

Dear Mr. La Fevers:

Thank you for data sharing at the data clarification meeting on August 24th, 2018. As a follow-up to that meeting here is a series of data requests regarding the general operation of the Aliso storage wells, other casing leaks, other SS25 data and other miscellaneous clarification.

1. We understand that there are observation wells. Please provide a list of observation wells, their locations, and their purpose.
2. The reference document for the injection schedule that we have is AC_BLD_0003625. From the meeting, we understood that the allocation of injection volumes to an individual well was based on the period it has been open to injection and a strength factor. Please provide some clarity on the strength factor used for injection allocation. Further, please provide the strength factor for injection allocation as of the incident date (10/23/2015). Please provide this information for all injection wells.
3. Injection allocation changes are captured in the injection worksheet. Please provide the three most recent versions of the injection worksheet as of the incident date, October 23rd, 2015.
4. For the withdrawal worksheet (AC_BLD_0003627): please provide the three most recent versions preceding the SS25 incident on 10/23/2015.
5. Please verify the choke sizes as of the incident date (10/23/2015). Please provide this information primarily for SS-25, SS-25A, and SS-25B wells; and if available for all the wells.
6. We have already received well test data dated 9/8/1978 till 1/29/2014 for SS25. Please confirm if the test dated 1/29/2014 is the last test. If there are other well test data following this date, please provide them.
7. The cellar construction can vary between the various wells. Did SS-25 well cellar have a cement bottom? Is there a photograph or other available data regarding the SS25 cellar? Was the SS-25 well cellar drained using vacuum trucks, similar to other wells with cement bottom?

8. We understand that there was cathodic protection on wells at the SS25 pad. Where is the closest cathodic protection system for any buried pipeline or well compared to the SS25 pad?
9. For a CPUC query, an excel file was developed that summarized all the casing leaks associated with storage wells. Please provide this excel file with the summary of the casing leaks.
10. Do you have any studies of the surface and subsurface hydrology (e.g., part of environmental impact studies or assessments)?
11. Well files are a repository for all of the failure data for the respective wells. Are there any other sources of failure analyses, root cause analyses, corrosion and other studies that have not yet been provided? Please provide any such reports that may be available.
12. We have decided to review the shallow corrosion on two joints from P45. Please provide the casing tally for the 7" casing that was pulled from P-45 in August 2018.
13. Well SS-44A has a USIT log that is available on the DOGGR website; however, this file appears to be corrupted. Please provide a copy of the Ultrasonic Imaging Tool Log from SS-44A that was run on July 2014.

Please provide the data by September 17th, 2018.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

October 7th, 2018

State of California Department of Conservation
Division of Oil, Gas, and Geothermal Resources
801 K Street, MS 20-20
Sacramento, CA 95814-3530

Attn: Ms. May Soe
Subject: Blade RCA Data Request

Dear Ms. Soe:

This data request is based on the October 3, 2018, teleconference discussion between DOGGR IT, DOGGR District, CPUC and Blade. This was a very informational meeting. We appreciate the contribution from the team. As discussed in the meeting could you please provide electronic or hard copies, whichever is convenient, of the following documents and items as we discussed during the meeting.

1. The DOGGR Field Book that includes the daily field notes recorded during the SS-25 leak event.
2. Photographs and videos taken by DOGGR during the SS-25 leak event.
3. Email daily reports from Kris, Scott, Scott and others to Al and other upper management during the SS-25 event including the pressure chart attachments from SoCalGas.
4. DOGGR daily reports on the SS-25 event.
5. The DOGGR SS-25 well file.
6. The LBNL kill analysis report, if such a document exists. (We have the published technical paper.)
7. The JPL data and reports.
8. Reports from the flyovers to collect gas readings for SoCalGas.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

BLADE ENERGY PARTNERS

October 26th, 2018

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Glenn La Fevers
Subject: Blade RCA Data Request

Dear Mr. La Fevers:

Thank you for all the data already provided.

1. In the response to Question 1 of the Blade Data Request dated August 29, 2018, Part 1. SoCal document: Blade-Follow Up Request_82918_1.pdf, the following sentence was included as part of the response. "The team began recording well pressures every 30 minutes until 3:00 am Saturday morning, then began recording pressures hourly."
   a. Please provide a copy of the well pressures referenced vs. time from when the leak event was identified on October 23, 2015 until the kill attempt was started on October 24, 2015.
2. The response to Question 12 of the Blade Data Request dated August 29, 2018 Part 1, indicates the question was not stated clearly. This is a re-statement of Question 12.

   The Halliburton / Boots and Coots Daily Report of 10/28/2015 shows the fluid levels were shot from 12:45 hours to 14:15 hours and the 7" x 11-3/4" annulus fluid level was 43 ft and the 2-7/8" annulus fluid level was 164 ft. Refer to the report shown below.

   The Halliburton / Boots and Coots Daily Report of 10-29-2015 shows the fluid levels were shot from 10:30 hours to 10:45 hours. No fluid levels were reported. Refer to the report shown below.

   a. Please provide the fluid level data for 10/29/2015. If the data was not acquired, please provide the rationale for the absence of this measurement.

Halliburton / Boots and Coots Daily Report of 10/28/2015

Well Summary		
Standard Senson 25 has broached to surface with several fissures on pad site.		
11-3/4" casing to 990 ft. 7" casing to 8,585 ft. 5-1/2" slotted liner to 8,745 ft. 2-7/8" tubing to 8,510 ft. Packer depth 8,468 ft.		
Hour	Hour	Activity on Site
6:45	7:15	Traveled from hotel to location.
7:15	7:45	Attended morning safety/operations meeting.
7:45	8:00	Performed site assessment. Gas flow from fissures on well pad appear to have decreased.
8:00	9:30	Checked pressures on 25 well. 7" x 11-3/4" - 325 psi. 2-7/8" x 7" - 128 psi. 2-7/8" - 170 psi. Bled tubing pressure to 86 psi.
9:30	11:30	Closed all casing valves. Installed A-Frame on well. Continued rigging up slick line. (10:00) Checked pressure on
		2-7/8" x 7" annulus - 134 psi. Bled to 124 psi.
11:30	12:15	Made up 1-5/8" sample bailer. Stabbed lubricator. Opened up well. 2-7/8" x 7" - 109 psi. 2-7/8" - 87 psi. RIH with sample bailer
		Sat down hard at 467 ft. Pulled out of the hole. Inspected sample bailer. Observed polymer on tool. Tool temperature 47 deg F.
		Fluid level - 300 ft.
12:15	12:45	Lunch
12:45	14:15	Shot fluid levels on 7" x 11-3/4" and 2-7/8" x 7" annulus. 7" x 11-3/4" - 43 ft. 2-7/8" x 7" - 164 ft.
14:15	15:30	Lined up Halliburton to pump 8.7 ppg Flozane down tubing.
15:30	16:15	Filled kill line with 9.5 bbls. Pumped 3.1 bbls. Pump pressure increased to 350 psi. Monitored 5 minutes. Pressure increased
		to 377 psi. Pumped 0.2 bbls. Tubing pressure 500 psi. Monitored for 5 minutes. Tubing pressure increased to 525 psi.
		Pumped 0.5 bbls. Tubing pressure increased to 776 psi. Monitored for 5 minutes. Tubing pressure increased to 801 psi.
		Pumped 0.1 bbls. Tubing pressure 998 psi. Monitored for 5 minutes. Tubing pressure increased to 1,027 psi. Pumped 0.1 bbls.
		Tubing pressure 1,220 psi. Monitored for 5 minutes. Tubing pressure increased to 1,337 psi. Pumped 0.1 bbls. Tubing pressure
		1,480 psi. Monitored for 5 minutes. Tubing pressure 1,603 psi.
16:15	17:00	Tubing pressure 1,824 psi. Bled to 1,790 psi. Continued monitoring well. (16:50) Tubing pressure 2,400 psi. Closed tubing
		head valve. Tubing pressure remained constant. Pressure on pump truck increased to 2,595 psi. Suspect communication with
		field injection lines. Made up 1-5/8" sample bailer.
17:00	17:30	Ran in hole with sample bailer. Tagged hard at 467 ft. Pulled out of the hole. Secured well.
17:30	18:00	Attended end of the day meeting.
18:00	18:30	Travel to hotel.

Halliburton / Boots and Coots Daily Report of 10/29/2015

Date:	29-Oct-2015	Well Name and Number:	Standard Senson 25	Report #	5

Well Summary		
Standard Senson 25 has broached to surface with several fissures on pad site. Surface casing pressure fluctuates between 505 psi and 770 psi.		
11-3/4" casing to 990 ft. 7" casing to 8,585 ft. 5-1/2" slotted liner to 8,745 ft. 2-7/8" tubing to 8,510 ft. Packer depth 8,468 ft.		
Hour	Hour	Activity on Site
6:30	7:00	Traveled from hotel to location.
7:00	7:30	Attended morning safety/operations meeting.
7:30	8:15	Performed site assessment. Observed ice on fissures around cellar. Fissures appeared to have made fluid overnight. Checked
		pressures on SS 25. 2-7/8" - 429 psi. 2-7/8" x 7" - 353 psi. 7" x 11-3/4" - 505 psi.
8:15	8:30	7" x 11-3/4" pressure - 515 psi. Flowed annulus for fifteen minutes. Shut in. Casing pressure 509 psi.
8:30	9:30	Moved in and rigged up crane. Laid down lubricator. Removed A-Frame from well. 2-7/8"- 360 psi. 2-7/8" x 7" - 420 psi.
		7" x 11-3/4" - 560 psi. Checked pressures on 25B. 2-7/8" - 2,450 psi. 2-7/8" x 7" - 2,450 psi. 7" x 11-3/4" - 44 psi.
9:30	10:30	Western wireline added sinker bar and lubricator.
10:30	10:45	Shot fluid levels on SS 25.
10:45	11:00	Bled 2-7/8" x 7" annulus f/ 456 psi t/ 440 psi.
11:00	12:00	Installed 2-9/16" 5M upper master valve. 2-7/8" - 375 psi. 2-7/8" x 7" - 462 psi. 7" x 11-3/4" - 591 psi.
12:00	12:30	Hold PJSM to discuss slick line operations.
12:30	13:15	Made up 1.625" sample bailer. Stabbed lubricator. RIH. Sat down at 37 ft. POOH. Tool temperature 59 deg F. 2-7/8" - 54 psi.
13:15	13:45	Stabbed lubricator. RIH with 1.625" sample bailer. Sat down at 37 ft. POOH. Tool temperature - 19 deg F. Observed ice
		in sample bailer. Rigged down slick line.
13:45	14:15	Met with HALCO representatives to discuss coiled tubing operations. A coiled tubing unit is being mobilized from Houma, LA.
14:15	15:30	Blow down with draw and kill lines from 450 psi to 50 psi. Discussed removing lines to isolate SS 25 from facility lines.
15:30	16:00	Attended end of the day meeting. Coiled tubing unit will take 2 days to arrive at location. Will remove lateral lines from SS 25.
		Will move Halliburton pump truck closer to SS 25. SCGC will continue running diagnostics on nearby wells.
16:00	18:00	Continued monitoring pressures. (16:30) 2-7/8" - 51 psi. 7" - 685 psi. 11-3/4" 731 psi. (17:00) 2-7/8" - 55 psi. 7" - 634 psi.
		11-3/4" - 697 psi. (17:30) 2-7/8" - Shut in. 7" - 631 psi. 11-3/4" - 770 psi.
18:00	18:30	Traveled to hotel.

3. In the Data Discussion Meeting held August 24, 2018, SoCalGas indicated that the Annulus Safety Systems had been removed from wells Frew 3 and FF-34A prior to casing leaks and underground flow. Blade's interpretation of the well records indicates the following.

Frew 3
The Otis Annulus Safety System was installed on September 17, 1977

The casing leak and underground flow was identified on June 10, 1984
The Annulus Safety System was removed on February 6, 1986

FF-34A
The Otis Annulus Safety System was installed on December 18, 1979
The casing leak and underground flow was discovered on September 10, 1990
The Annulus Safety System was removed on May 8, 1991

a. Please confirm the Annulus Safety Systems were installed and removed in each well as reported in the well records.

b. Assuming the annulus safety systems were installed at the time of the casing leaks, are there any records that indicate that the Annulus Safety Systems operated as designed to shut off flow in the annulus when the casing leaked?

4. Refer to Response 1 of the SoCal Document Blade-Follow Up Request_82918_1.pdf file, second line from the bottom of page 1. It states "At approximately 7:00 pm, gas was detected on the main road at the SS25 site."

    a. Please clarify which road is considered the "main road". The road that goes by Site 25 on the east side or the road that goes to Site 25, etc.

    b. Where on the main road was the gas detected? Indicate the location relative to some landmark or mark the location on a map.

5. Please provide FLIR images/video taken on the SS-25 pad during the leak event. Images of the cellar area and fractures where gas leaks were reported are of particular interest.

6. Please provide a copy of the Aliso Canyon Field Operations Organization Chart that was in place on October 1, 2015.

7. Please provide the date the decision was made to drill the relief well P-39A.

8. The amount of gas leaked from Aliso Canyon Well SS-25 was reported to be 4.62 bcf of natural gas which translates to approximately 84,200 metric tons of methane, as reported in "Ensuring Safe and Reliable Underground Natural Gas Storage", Final Report of the Interagency Task Force on Natural Gas Storage Safety, October 2016, page 31.

    a. Please provide the procedure and methodology SoCalGas used to arrive at these values.

    b. What was the amount of gas in the underground storage reservoir at the time of (i.e., just before) the SS-25 incident on October 23, 2015? Please provide both working gas and cushion gas amounts.

c. Please provide any procedure used to calculate the amounts of working gas and cushion gas as a function of reservoir pressure. How often is this calculation made?

d. Regarding the calculation procedure in item c above, please provide the following:

    i. Last three calculations made prior to the SS-25 incident on October 23, 2015.

    ii. All calculations made between October 23, 2015, and December 31, 2016.

e. In the past, have there been occasions where the in place gas volume was adjusted. If so by how much and why?

9. We understand that the surface pressure on observation well SS-5 was measured and reported daily. Please provide additional information for the SS-5 pressure readings on October 21, 22, 23, and 24, 2015.

    a. What time of day was the pressure reading taken on each day?

    b. Provide a copy of the original document where each pressure reading was recorded each day; i.e., log book, hand written sheet, print out from an electronic device, etc.

Please provide the data by November 5th, 2018.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

BLADE ENERGY PARTNERS

December 18th, 2018

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Glenn La Fevers
<u>Subject</u>: Blade RCA Data Request

Dear Mr. La Fevers:

Thank you for all the data already provided.

1. In the response to Question 6 of the Blade Information Request dated October 26, 2018, SoCalGas provided Aliso Canyon Field Operations Organization Charts in documents AC_BLD_0077056 through AC_BLD_0077072. Document AC_BLD_0077058 does not show the organization under certain departments, i.e., Storage Risk Management, Drilling Department, SIMP, and others.

    a. Was there staff in place under the Storage Risk Management position pre-October 2015? If so, what was the role and job description of the staff? How much staff time was dedicated to Aliso Canyon?

    b. Was there staff in place under the Drilling Department pre-October 2015? If so, what was the role and job description of the staff? How much staff time was dedicated to Aliso Canyon?

    c. Was the SIMP Department along with staff in place pre-October 2015? If so, what was the role and job description of the staff? How much staff time was dedicated to Aliso Canyon?

    d. Was there a department along with staff that was responsible for wellbore integrity pre-October 2015? If so, what department? If so, what was the role and job description of the staff? How much staff time was dedicated to Aliso Canyon?

2. Refer to documents AC_CPUC_0000064 through AC_CPUC_0000066 and AC_CPUC_0000063 regarding Interoffice Correspondence recommending casing inspections for a list of casing flow wells of 1940s and 1950s vintage to determine the

mechanical condition of each well casing. SS-25 was included in the list of wells recommended for casing inspection.

   a. Please advise if the recommended casing inspection (Vertilog) was run in SS-25. If so, provide the inspection survey. If not, what was the reason for not running the inspection survey in SS-25?

3. Refer to Frew-3 documents AC_BLD_0032691 through AC_BLD_0032692, Page 2, next to the last paragraph that states the following.

   "If the cause of the leak is determined to be corrosion from the fresh water, a review program should be established to determine the number of wells that are also exposed to this action. Alternatives should then be considered as to the most effective solution to remedy the corrosion problem."

   a. Was the work completed to determine if the cause of the Frew-3 leak was due to fresh water corrosion? Is so, please provide any study results or reports related to corrosion and the cause of corrosion.

Please provide the data by January 4th, 2019.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

December 19th, 2018

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Glenn La Fevers

Subject: Follow-up Meeting to verify and confirm the Factual data provided for the RCA on SS25

Dear Mr. La Fevers:

Thank you for all the data already provided. We gleaned substantial amount of insight from our meeting on August 24th, 2018.

We have obtained some of the follow-up information and awaiting some additional data. However, based on our review we still have some open items around the condition of the well bore after October 24th, 2018, crater evolution during the kill attempts, fissures where the gas was escaping during the period of uncontrolled well flow. kill attempts and kill associated data.

We would like to propose a discussion at a location and time of your choice. The topics we would like to address during the meeting are as follows:

1. SS25 kill data and the evolution of gas leak during November 2015 to January 2016. Listed below are some of the topics on our list.
    a. Post Kill B annulus pressure measurements
    b. Observations recorded in the reports during kill attempts
    c. Anecdotal data regarding the formation of the South Crater and the behavior of the North Crater
    d. The condition of the 'B' annulus valve post failure.
    e. We have Boots and Coots data; we want to confirm that, along with ADD energy report, we have all the data from the kill attempts.
    f. IPR estimation for SS25.
    g. Data that we have already reviewed, and whether there are any other kill data that we have not analyzed.
    h. There are daily reports that mention modeling SS25 flow dynamics and also flow velocity estimates. Was kill modeling done prior to each kill attempt? If so, any results including input data?
    i. Are there any other anecdotal data regarding the effectiveness of the kill attempts, especially the last ones?
    j. Rationale for the tubing plug prior to some of the kill attempts.

Above are some of the topics that we would like to discuss and confirm during our meeting. From Blade, Randy, Bill, Nigel, and Ismail will join me at the meeting. We will take notes during the meeting and if required follow up with additional data requests. We suggest Boots & Coots personnel who were onsite and were associated with planning and executing kill attempts join these discussions. Names that we have seen in the daily reports and may have knowledge include: [redacted], [redacted], [redacted], [redacted], [redacted], [redacted] and [redacted].

Please identify Boots and Coots team members that can address the items listed above. Like our previous discussion, we would suggest that regulatory affairs and legal abstain from attending this meeting. The intent is to have an informal discussion regarding data that has already been provided, and confirming and clarifying its completeness. We suggest that one working day (eight hours) is allocated for this meeting. We could have the meeting either in Houston or in Los Angeles.

Please respond by January 9th, with a convenient date and time for the meeting. We would prefer to have the meeting no later than January 30th, 2019.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

January 2, 2019

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Glenn La Fevers
Subject: Blade RCA Data Request

Dear Mr. La Fevers:

Thank you for all the data already provided.

1. Please provide the following data for each of the SS-25 kill attempt operations. According to the SS-25 well records, 7 kill attempts were made on or about the following dates: 24 October 2015, 13 November 2015, 15 November 2015, 18 November 2015, 24 November 2015, 25 November 2015, 22 December 2015.
   a. Confirm that Halliburton was the supplier of the pumping equipment for each kill attempt.
   b. Confirm that the pumps used in the kill attempts were Halliburton HT-400 pumps. If not, provide the specs for the actual pumps used. Specs including but not limited to, manufacturer, pump bore and stroke, number of fluid end sections, maximum pressure rating, maximum output rate or strokes per minute, pump prime mover rated horsepower, etc.
   c. The number of pump trucks or skid units that were on location for each kill attempt.
   d. The number of pumps that were on each truck or skid.
   e. Describe the type of device that was used to provide the reported pump rate; for example, stroke count, in-line flow meter, or other.
   f. The rated horsepower for the prime mover for each pump that was used.

Please provide the data by January 18th, 2019.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

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April 12, 2019

Southern California Gas Company
555 W. 5th Street, GT21C3
Los Angeles, CA 90013

Attn: Mr. Glenn La Fevers
Subject: Blade RCA Data Request

Dear Mr. La Fevers:

Thank you for all the data already provided.

Blade understands from previous data requests and responses that prior to October 2015, the mechanical integrity test (MIT) program for Aliso Canyon gas-storage wells was to run a temperature log annually. Other MITs were conducted if temperature surveys showed anomalous results. This was stated as following DOGGR requirements in one of your data responses.

This data request is regarding the Attachment that shows the 2015 California Statutes and Regulations, Section 1724.10. Filing, Notifications, Operating, and Testing Requirements for Underground Injection Projects.

As stated in 1724.10 (g); pipeline-quality gas injection wells were exempt from the requirement of tubing and a packer. Section 1724.10 (j) (1) states: Prior to commencing injection operations, each injection well must pass a pressure test of the casing-tubing annulus to determine the absence of leaks. Thereafter, the annulus of each well must be tested at least once every five years; prior to recommencing injection operations following the repositioning; or replacement of downhole equipment; or whenever requested by the appropriate Division district deputy.

Please confirm whether the underlined requirement above is applicable to Aliso Canyon gas storage wells. If that requirement is not applicable to Aliso Canyon gas storage wells, Why not? Is there a documented exception to this requirement?

Please respond by April 19th, 2019. We require this response to complete our RCA.

Thank you,

Best Regards,

Ravi Krishnamurthy, Blade Energy Partners

Attachment 1

§ 1724.10. Filing, Notification, Operating, and Testing Requirements for Underground Injection Projects

(a) The appropriate Division district deputy shall be notified of any anticipated changes in a project resulting in alteration of conditions originally approved, such as: increase in size, change of injection interval, or increase in injection pressure. Such changes shall not be carried out without Division approval.

(b) Notices of intention to drill, redrill, deepen, or rework, on current Division forms, shall be completed and submitted to the Division for approval whenever a new well is to be drilled for use as an injection well and whenever an existing well is converted to an injection well, even if no work is required on the well.

(c) An injection report on a current Division form or in a computerized format acceptable to the Division shall be filed with the Division on or before the 30th day of each month, for the preceding month.

(d) A chemical analysis of the liquid being injected shall be made and filed with the Division whenever the source of injection liquid is changed, or as requested by the Supervisor.

(e) An accurate, operating pressure gauge or pressure recording device shall be available at all times, and all injection wells shall be equipped for installation and operation of such gauge or device. A gauge or device used for injection-pressure testing, which is permanently affixed to the well or any part of the injection system, shall be calibrated at least every six months. Portable gauges shall be calibrated at least every two months. Evidence of such calibration shall be available to the Division upon request.

(f) All injection piping, valves, and facilities shall meet or exceed design standards for the maximum anticipated injection pressure, and shall be maintained in a safe and leak-free condition.

(g) All injection wells, except steam, air, and pipeline-quality gas injection wells, shall be equipped with tubing and packer set immediately above the approved zone of injection within one year after the effective date of this act. New or recompleted injection wells shall be equipped with tubing and packer upon completion or recompletion. Exceptions may be made when there is:

(1) No evidence of freshwater-bearing strata.

(2) More than one string of casing cemented below the base of fresh water.

(3) Other justification, as determined by the district deputy, based on documented evidence that freshwater and oil zones can be protected without the use of tubing and packer.

(h) Data shall be maintained to show performance of the project and to establish that no damage to life, health, property, or natural resources is occurring by reason of the project. Injection shall be stopped if there is evidence of such damage, or loss of hydrocarbons, or upon written notice from the Division. Project data shall be available for periodic inspection by Division personnel.

(i) To determine the maximum allowable surface injection pressure, a step-rate test shall be conducted prior to sustained liquid injection. Test pressure shall be from hydrostatic to the pressure required to fracture the injection zone or the proposed injection pressure, whichever occurs first. Maximum allowable surface injection pressure shall be less than the fracture pressure. The appropriate district office shall be notified prior to conducting the test so that it may be witnessed by a Division inspector. The district deputy may waive or modify the requirement for a step-rate test if he or she determines that surface injection pressure for a particular well will be maintained considerably below the estimated pressure required to fracture the zone of injection.

(j) A mechanical integrity test (MIT) must be performed on all injection wells to ensure the injected fluid is confined to the approved zone or zones. An MIT shall consist of a two-part demonstration as provided in subsections (j)(1) and (2).

(1) Prior to commencing injection operations, each injection well must pass a pressure test of the casing-tubing annulus to determine the absence of leaks. Thereafter, the annulus of each well must be tested at least once every five years; prior to recommencing injection operations following the repositioning or replacement of downhole equipment; or whenever requested by the appropriate Division district deputy.

(2) When required by subsection (j) above, injection wells shall pass a second demonstration of mechanical integrity. The second test of a two-part MIT shall demonstrate that there is no fluid migration behind the casing, tubing, or packer.

(3) The second part of the MIT must be performed within three (3) months after injection has commenced. Thereafter, water-disposal wells shall be tested at least once each year; waterflood wells shall be tested at least once every two years; and steamflood wells shall be tested at least once every five years. Such testing for mechanical integrity shall also be performed following any significant anomalous rate or pressure change, or whenever requested by the appropriate Division district deputy. The MIT schedule may be modified by the district deputy if supported by evidence documenting good cause.

(4) The appropriate district office shall be notified before such tests/surveys are made, as a Division inspector may witness the operations. Copies of surveys and test results shall be submitted to the Division within 60 days.

(k) Additional requirements or modifications of the above requirements may be necessary to fit specific circumstances and types of projects. Examples of such additional requirements or modifications are:

(1) Injectivity tests.

(2) Graphs of time vs. oil, water, and gas production rates, maintained for each pool in the project and available for periodic inspection by Division personnel.

(3) Graphs of time vs. tubing pressure, casing pressure, and injection rate maintained for each injection well and available for periodic inspection by Division personnel.

(4) List of all observation wells used to monitor the project, indicating what parameter each well is monitoring (i.e., pressure, temperature, etc.), submitted to the Division annually.

(5) List of all injection-withdrawal wells in a gas storage project, showing casing-integrity test methods and dates, the types of safety valves used, submitted to the Division annually.

(6) Isobaric maps of the injection zone, submitted to the Division annually.

(7) Notification of any change in waste disposal methods.

Authority: Section 3013, Public Resources Code. Reference: Section 3106, Public Resources Code.

SS-25 RCA Supplementary Report

Phase 1 Summary

Purpose:

Summarize field activities for Phase 1 of the Root Cause Analysis for SS-25.

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Date:
May 31, 2019

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Abstract

The gas storage well Standard Sesnon 25 (SS-25) in the Aliso Canyon Gas Storage Field located in Los Angeles County, California started leaking gas in October 2015. A relief well was drilled, and SS-25 was brought under control. The leak stopped in February 2016.

In January 2016, as part of their investigation of the leak, the California Public Utilities Commission (CPUC) and the Division of Oil, Gas, and Geothermal Resources (DOGGR) selected and gave provisional authority to Blade Energy Partners (Blade) to perform an independent Root Cause Analysis (RCA). The Blade Team and parties under Blade's direction were responsible for directing the work of subcontractors who performed the extraction of the SS-25's wellhead, tubing, and casings and the preservation and protection of associated evidence. Blade's RCA Reports, including this report, document and describe the key activities undertaken in support of the RCA effort.

This report of the SS-25 gas leak incident discusses two high-level components of the overall root cause investigation. It covers the qualitative and quantitative surveys of the area's topography and discusses the stabilization and inspection of the wellhead and conductor casing. This phase concluded with the completion of the wellhead inspection. The inspection showed that the wellhead was not related to the failure.

Aerial photography was used to qualitatively document the physical, as-found failure site and the extent of the incident. It was used to assist in finding any components or fragments that may have been ejected under pressure during the blowout. A wide-area laser scanner was then employed to quantitatively document the SS-25 site topography and the resultant crater's internal dimensions.

With the second phase of the investigation being site reclamation, it was critical to search the site for evidence in the as-found condition. This included laying out search grids roughly centered on the wellhead. These search grids were physically and visually searched with the exception of the crater. Within the crater, debris such as oil, tar, water, dirt, concrete, etc. were removed from the crater and stored in readiness in the event that a search of their contents was necessary to locate missing evidence. The outer search grid was extended to a radius of 400 ft centered on the SS-25 wellhead. Blade personnel searched this extended area by rappelling the slopes with the aid of ropes and local firefighters.

The wellhead cleaning portion of this phase began by evaluating cleaning techniques. Test coupons and test articles were used to empirically develop confidence in a local contractor's cleaning procedures. This contractor, Argus, and their procedures had been used for years on the SoCalGas site. However, Blade needed to develop confidence in Argus' procedures before applying them to the wellhead.

Once confidence was gained, wellhead access was addressed. This required significant site cleaning and use of tensioning cables to right the wellhead vertically. The base of the wellhead was then cemented to secure it in place. Scaffolding was erected for 180° access to the wellhead from the ground-level circumferential welds of the conductor casing to the top of the wellhead.

Magnetic particle inspection (MPI) was employed after cleaning. This inspection found no evidence of catastrophic cracking of the wellhead. Some minor cracks were found in the conductor casing welds, but these were not attributed to leaks.

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1 Introduction

In October 2015, Southern California Gas (SoCalGas) experienced a blowout in their SS-25 well. This was a gas storage well located in the Standard Sesnon lease of the Aliso Canyon field. Blade was contracted to conduct a third-party RCA of the blowout. The investigation was divided into the following six phases:

1. Phase 0—Data collection, collation, and analysis
2. Phase 1—Well site evidence collection and documentation
3. Phase 2—Well site restoration to rig readiness
4. Phase 3—Tubing, casing, and wellhead extraction
5. Phase 4—Metallurgical examination
6. Phase 5—Data integration and interpretation and final report

This report describes the activities completed for Phase 1. The objective of Phase 1 was to locate, document, and collect any physical evidence surrounding the SS-25 site that may have been related to the blowout. Phase 1 included activities such as a site survey, evidence documentation and collection, and wellhead cleaning and examination. The site survey was conducted to document the SS-25 site, equipment, and surrounding terrain. The photos served as a record for the as-found condition of the well site. Phase 2 was site restoration. Any evidence not collected and documented before the execution of Phase 2 operations would have been lost. The purpose of the wellhead examination was to determine if the wellhead contributed to or was affected by the blowout. Phase 1 concluded with the completion of the SS-25 wellhead inspection.

1.1 Abbreviations and Acronyms

Term	Definition
API	American Petroleum Institute
ASNT	American Society for Nondestructive Testing
Blade	Blade Energy Partners
CPUC	California Public Utilities Commission
DOGGR	Division of Oil, Gas, and Geothermal Resources
GW	Girth Weld
GPS	Global Positioning System
GTC	General Terms and Conditions
LKR	Legacy and Kill Related
MPI	Magnetic Particle Inspection
NDE	Nondestructive Evaluation
NDI	Nondestructive Inspection
NDT	Nondestructive Testing
PAUT	Phased Array Ultrasonic Testing
RCA	Root Cause Analysis

Term	Definition
RCS	Riccardelli Consulting Services
SAE	Society of Automotive Engineers
SEAL	Scanning Electron Analysis Laboratories
SoCalGas	Southern California Gas Company
SS	Standard Sesnon
TOL	Texas OilTech Laboratories
UT	Ultrasonic Testing
UV	Ultraviolet
VOC	Volatile Organic Compound
YS	0.2% Yield Stress

2 Site Survey

2.1 Initial Site Photo Documentation

The initial site survey was completed on March 28, 2016. Blade selected 12 vantage points for photo documentation purposes. Vantage points were selected to cover the SS-25 site and surrounding terrain. Two example images are included for each vantage point with the viewing directions listed. Vantage points were also selected to document specific items located on the SS-25 site and to orient the wellhead with respect to the surrounding terrain. Figure 1 shows the location of the vantage points. Figure 2 through Figure 13 show example photos from each vantage point. The objective of the photos was to document the SS-25 site and surrounding topography for the RCA.

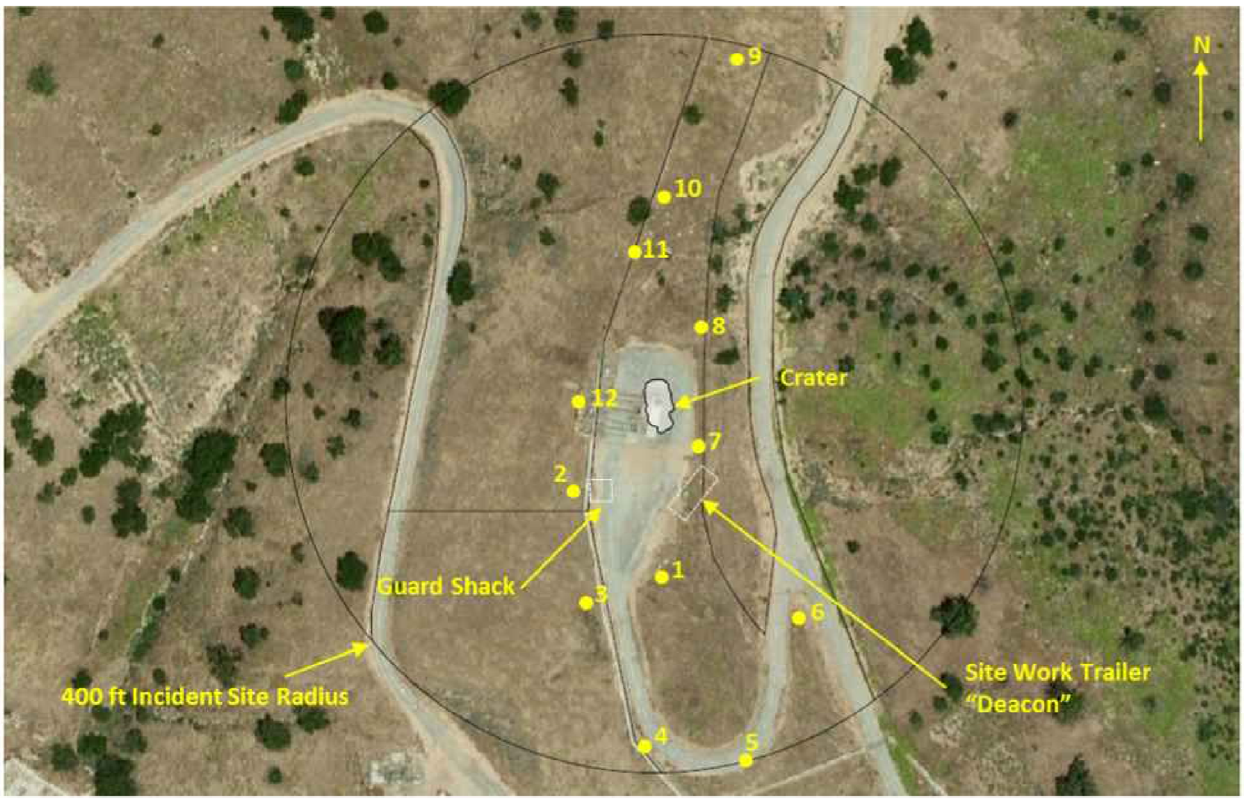

Figure 1: Site Survey Vantage Points

Figure 2: Vantage Point 1

Figure 3: Vantage Point 2

Figure 4: Vantage Point 3

Figure 5: Vantage Point 4

Figure 6: Vantage Point 5

Figure 7: Vantage Point 6

Figure 8: Vantage Point 7

Figure 9: Vantage Point 8

Figure 10: Vantage Point 9

Figure 11: Vantage Point 10

Figure 12: Vantage Point 11

Figure 13: Vantage Point 12

2.2 Aerial Imagery and 3D Laser Scan

A comprehensive understanding of the incident site post-event condition was necessary for the RCA. Thorough documentation of the crater, wellhead, and the surrounding area provided valuable data for modeling and sequencing of events. Capturing the post-event condition of the site was time-critical as the condition of the site was subject to change when subsequent phases of the investigation were executed.

The SS-25 incident site was to undergo extensive changes during the Phase 2 site restoration for rig readiness. The Phase 2 work scope included site clean-up, excavation, and crater stabilization.

The initial site photo documentation discussed in Section 2.1 provided extensive data of the as-found condition of the SS-25 site. The photos provided visual data but were limited when physical measurements or overall images were required.

Professional land surveying was provided by Cannon, who was contracted to assist with site documentation in the post-event condition. Cannon used drone and laser scanning technologies to survey the site. On March 31, 2016, they arrived at the SS-25 site to set up equipment and to establish horizontal and vertical control points using static GPS observations with Leica G15 GPS receivers. Secondary horizontal and vertical control points were developed to control the targets used for the 3D scanner and aerial imagery.

A DJI Inspire 1 Model T600 drone was paired with an X3 FC350 camera to capture aerial images and videos. The FARO Focus3Dx330 scanner was used at various positions around the SS-25 site to capture laser data. Details regarding the drone and 3D laser are discussed in Section 2.2.1.

2.2.1 Inspire 1 Model T600 Drone

An Inspire 1 Model T600 drone was used to provide a birds-eye-view of the SS-25 site using photos and videos. A total of 25 videos were taken during the survey. The videos are a combination of flyovers, flybys, and 360° views. The flyovers were performed in various directions and at different elevations. Some 360° views were centered on the SS-25 wellhead at varying elevations. Views were also captured farther from the wellhead at various distances and heights. Table 1 is a list of the videos recorded by the drone. The list includes the duration and a brief description of the videos.

Table 1: DJI Inspire 1 Model T600 Drone Video List

Video	Duration	Description
DJI_0084	0:01:11	360° around SS-25 wellhead
DJI_0086	0:00:43	360° around SS-25 wellhead closer than previous (DJI_0084)
DJI_0087	0:00:03	Hovering on north side of SS-25 wellhead near the top of the bridge
DJI_0089	0:03:11	360° around SS-25 wellhead further than DJI_0084 and at higher elevation
DJI_0090	0:00:51	360° around SS-25 wellhead similar to DJI_0090 at a faster speed
DJI_0110	0:03:00	360° around SS-25 wellhead further than DJI_0089 and at higher elevation
DJI_0111	0:00:56	360° around SS-25 wellhead similar to DJI_0110 at a faster speed
DJI_0146	0:00:25	Flyover from north to south with camera fixed in the southern direction
DJI_0150	0:00:05	Hovering over SS-9 with camera fixed on SS-25 well site
DJI_0151	0:00:42	Flyover from south to north with camera fixed in the northern direction. Camera rotates towards SS-25 wellhead near end of video.
DJI_0153	0:00:25	Flyover from northwest to southeast with camera fixed in the southeastern direction
DJI_0154	0:00:20	Flyover from east to west with camera fixed in the western direction
DJI_0155	0:00:23	Hovering near the south end of bridge with camera fixed on SS-25 wellhead
DJI_0156	0:00:29	Flyover from south to north and north to south just over bridge. Camera fixed in the northern direction.

Video	Duration	Description
DJI_0172	0:00:14	Flyby on east side of bridge from south to north with camera fixed in the western direction.
DJI_0173	0:00:12	Flyby on east side of bridge from north to south with camera fixed in the western direction.
DJI_0174	0:00:30	Flyby on east side of bridge from south to north and north to south with camera fixed on SS-25 wellhead
DJI_0190	0:00:24	Zoom out from SS-25 wellhead in the northwestern direction
DJI_0191	0:00:34	Flyover from northwest to southeast with camera fixed in the southeastern direction
DJI_0221	0:00:33	Flyover from southeast to northeast with camera fixed in the northeastern direction. Camera rotates towards SS-25 wellhead near end of video.
DJI_0222	0:00:20	Flyover from northwest to southeast with camera perpendicular to the ground
DJI_0223	0:00:14	Flyover from southeast to northwest with camera perpendicular to the ground
DJI_0231	0:00:43	Flyover from north to south on west side of site with camera fixed on SS-25 wellhead
DJI_0232	0:01:28	Flyover from southeast to northwest with camera fixed in direction of SS-25 wellhead
DJI_0233	0:00:42	Flyover from north to south with camera fixed on SS-25 wellhead

In addition to the videos, Cannon took approximately 160 photos. The photos captured the SS-25 site from many angles and elevations. The photos included close-up images of the SS-25 wellhead and served as a visual aid for reporting or discussing the SS-25 site. Figure 14 shows four representative images from the drone survey.

Figure 14: Example Photos of SS-25 Well Site from Drone

Survey measurements of the SS-25 site provided valuable data for the RCA investigation. Required measurements were not always known at the time of the investigation. Information collected during the analysis and interpretation of the data revealed a need for additional measurements from the site. Although qualitative to the investigation, drone videos and photos did not provide quantitative measurement of the SS-25 site. Older methods of survey measurements, such as tape measures, plumb bobs, laser range finders, and total station theodolites, worked well for single point measurements. These devices were not practical for collecting the large amounts of data that were required to quantitatively document the SS-25 site. Further, their data requires significant time to process. Therefore, a digital laser scanning methodology was employed.

The FARO Focus3Dx330 scanner is a large volume 3D laser scanner designed for quantitative outdoor applications. 3D laser scanning technology had been adopted instead of other technologies due to the increased level of detail and accuracy. Infrared light is emitted from the scanner and reflected off of objects. The reflected light wave is converted into XYZ coordinates and used to build a point cloud consisting of millions of measurements. The 3D scanner differs from prismless or reflectorless total stations theodolites in that the laser is sent from the scanner onto a rotating mirror that projects a flat plane of laser light from the scanner. The plane of laser light is swept across a target area by rotating the scanner head. The density of the scan is a function of the rotation speed of the scanner head.

The 3D scanning method collected millions of discrete measurements with every scan rather than a single point measurement. Reference targets or objects within the composite scan environment were used to tie together multiple scans, each with their own coordinate system. The end product was a highly-dense, photorealistic, color point cloud of the SS-25 site (Figure 15). The entire site was scanned at ten locations as documented in the aerial view above the wellhead (Figure 16). Each numbered dot represents a scan location. Dots 9 and 10 represent scans of the crater. By lowering the scanner into the crater, the subsurface dimensions were captured with a high degree of accuracy (Figure 17).

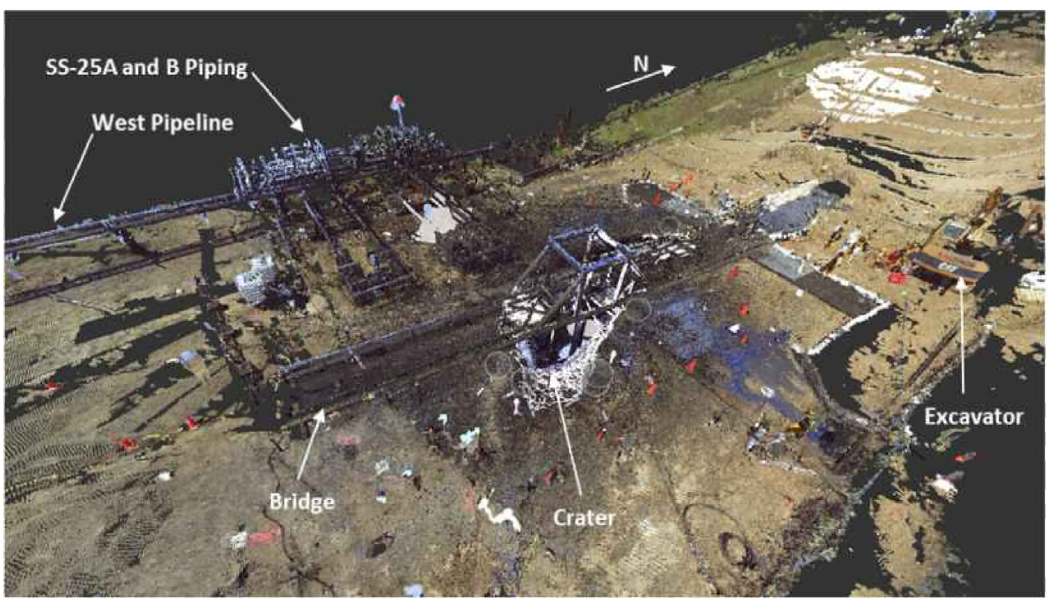

Figure 15: 3D Laser Scan Data of the SS-25 Site

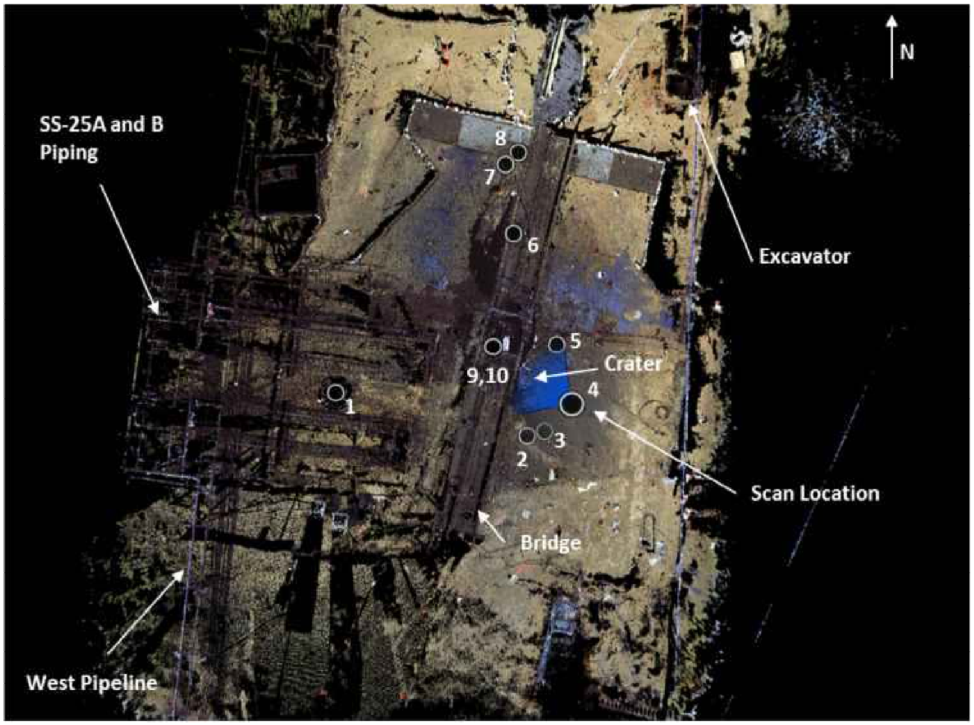

Figure 16: Map for SS-25 3D Scan Showing Ten Locations

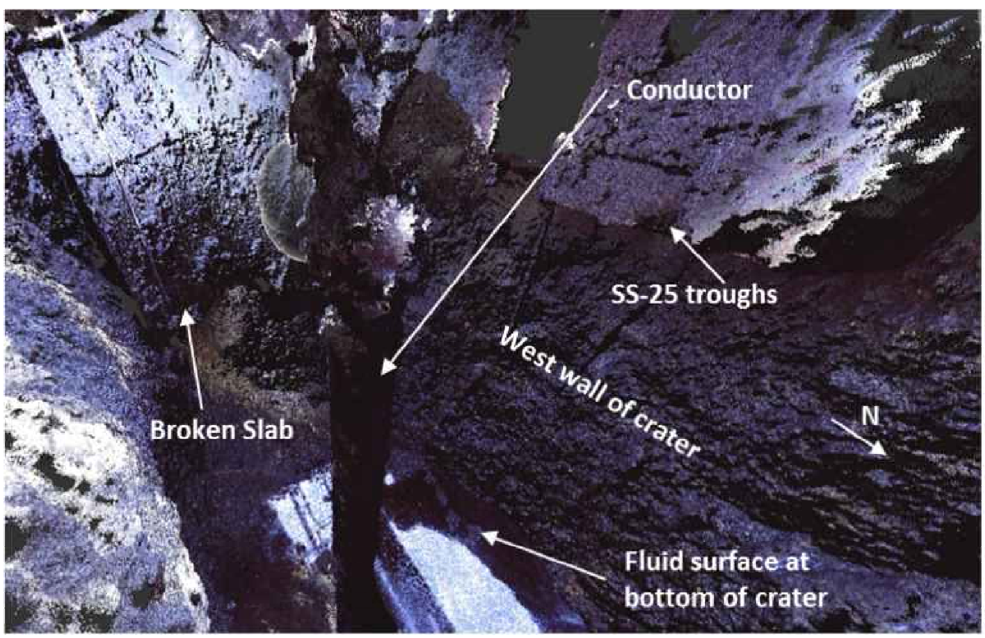

Figure 17: 3D Scan of Crater and SS-25 Conductor

3 Evidence Search, Collection, and Documentation

On February 19, 2016, CPUC sealed the SS-25 incident site. The site was previously exposed to various operations, such as kill attempts and logging. A detailed search for evidence was required prior to any additional disturbance of the SS-25 site. The objective of the search was to collect, identify, and document any evidence associated with the failure. After the official sealing of the site, CPUC established an area with a 400 ft radius centered on the SS-25 wellhead as the official incident area. A smaller, circumscribed area was subsequently adopted as the inner boundary and declared a restricted area. Personnel were not permitted within the inner boundary without permission from Blade and CPUC. Figure 18 (a) depicts the 400 ft radius outer boundary while Figure 18 (b) is a close-up image depicting the inner boundary. The inner boundary was enlarged by CPUC on February 25, 2016 to include the area outlined in blue.

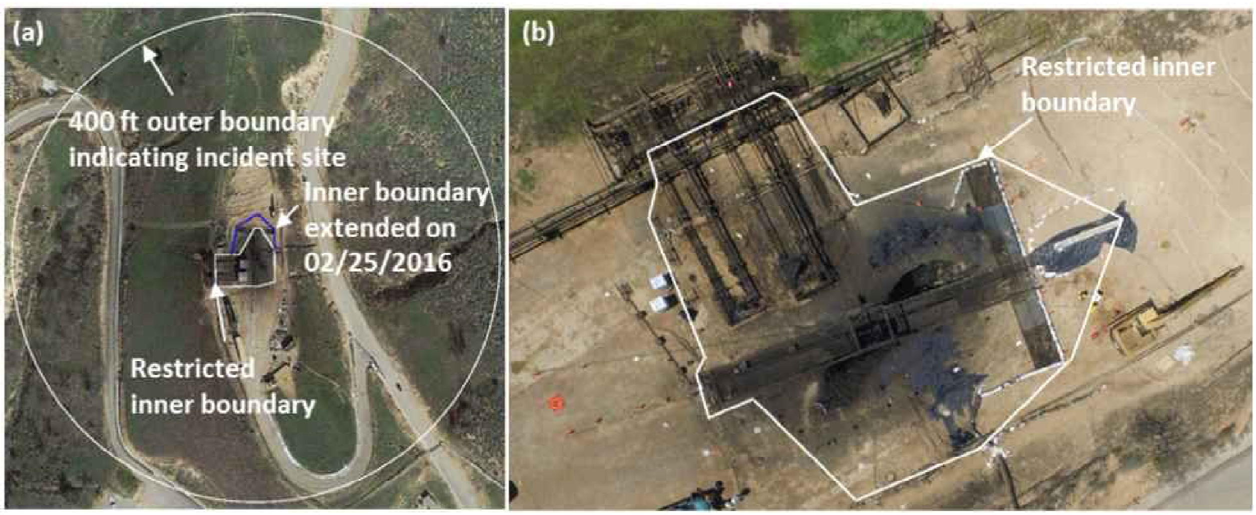

Figure 18: Aerial Image of (a) CPUC Established Boundaries and (b) Restricted Inner Boundary

The objective of the evidence search was to identify and collect all ground evidence prior to transitioning to the second phase of the investigation, which included site restoration to rig readiness. Phase 2 required a significant amount of reclamation work, including excavating the crater and reclaiming the SS-25 pad. Site work would eliminate further chances of gathering evidential items on the ground and within the crater. A thorough and complete sweep of the site was necessary to ensure all possible evidence was captured and documented. A zone and grid system was created to assist with the evidence search and to communicate the exact position of any evidence or item found.

3.1 Site Zoning and Grid System

The SS-25 site was subdivided into five zones. Zone boundaries were selected based on ease of access and safety. Figure 19 shows each of the five zones. The outer circle represents the 400 ft outer boundary which was demarcated using cones, stakes, and rope (where accessible). A significant percentage was inaccessible due to terrain conditions and safety concerns. These areas were identified as no-go areas, indicated by red hatching in Figure 19. The restricted inner boundary was contained within Zone 1. The five accessible searches were:

- Zone 1—Inner zone surrounding SS-25, SS-25A, and SS-25B and all associated piping
- Zone 2—Areas north and south of Zone 1 accessible without special equipment (e.g., harnesses)

- Zone 3—South side of west slope (harnesses required)
- Zone 4—North side of west slope (harnesses required)
- Zone 5—No-go areas of the 400 ft radius, inaccessible due to safety or accessibility

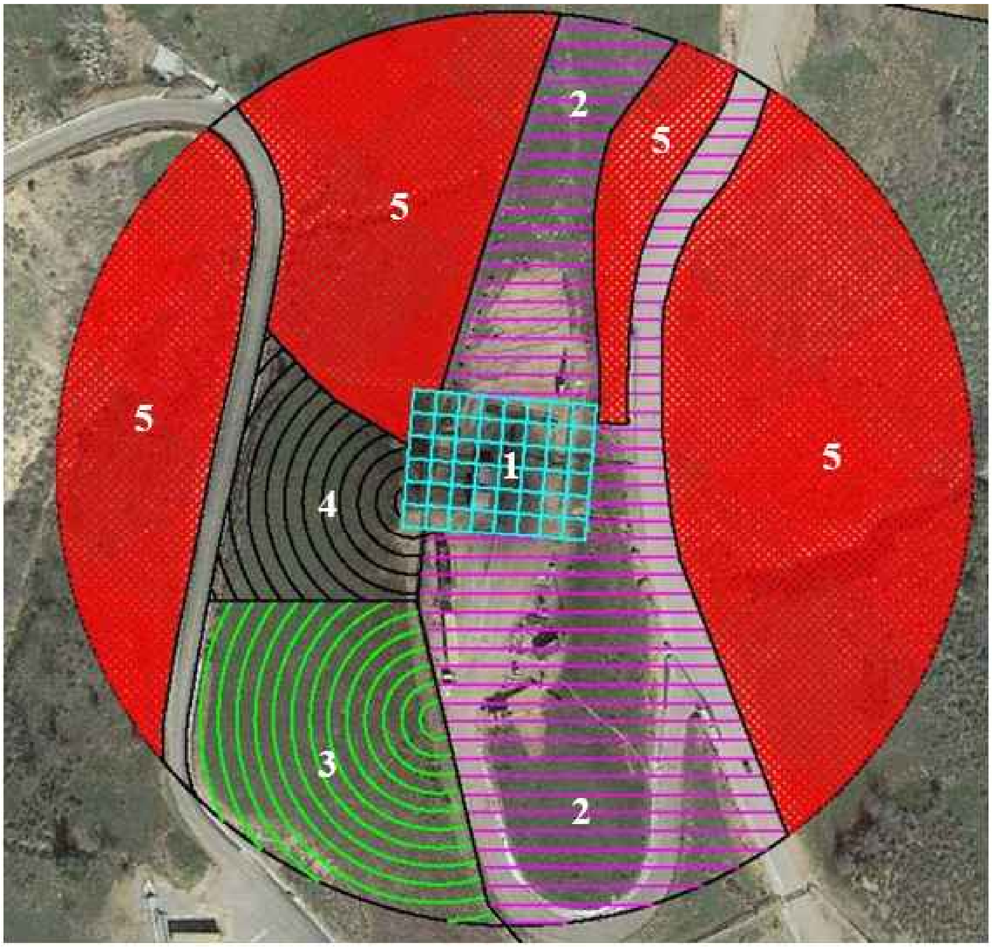

Figure 19: Evidence Search Zones

3.1.1 Zone 1

Zone 1 contained the SS-25, SS-25A, and SS-25B wellheads and all associated piping. Zone 1 extended just beyond the north and south ends of the temporary bridge placed over the crater and to the edges of the west and east slopes. Figure 20 (a) shows the boundary for Zone 1. A grid was developed for Zone 1 to facilitate a systematic approach for the evidence search. This was critical for Zone 1 due to the visual obstructions, debris, and contamination obscuring possible evidence. A grid system also ensured full coverage of Zone 1. The west side of Zone 1 was obstructed by piping running from the SS-25A and SS-25B wells. Figure 20 (b) and Figure 21 shows the SS-25A and SS-25B piping obstructing the west side of Zone 1. The intent for the Zone 1 search was to release sectors of the grid after an exhaustive surface search. A grid sector was not released until each square foot was documented and evidence found within it was removed and documented.

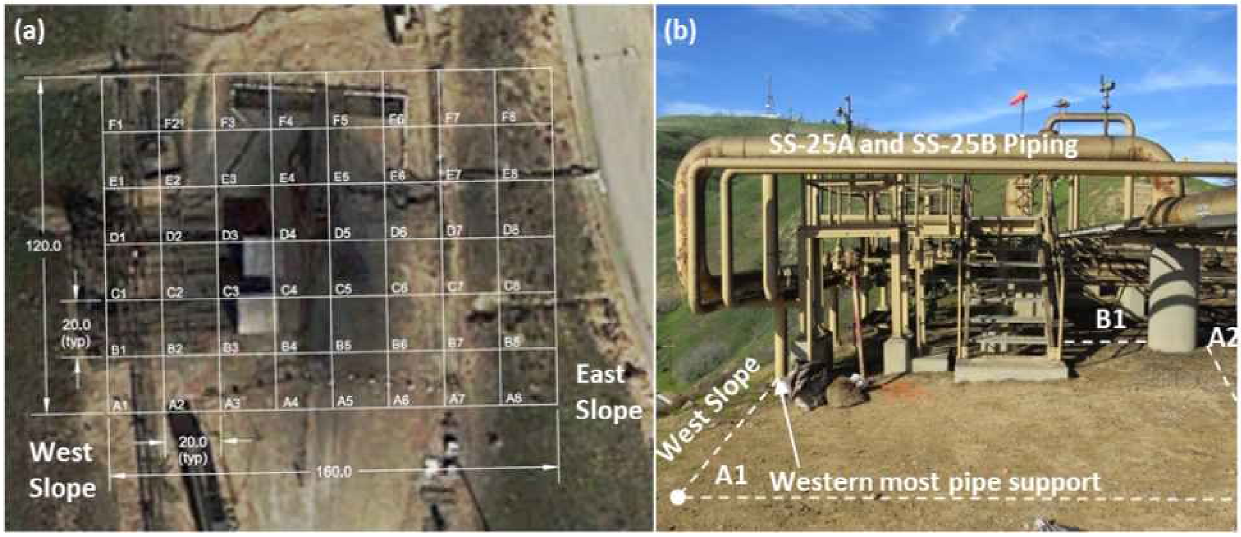

Figure 20: (a) Zone 1 Grid and (b) A1 Grid Location

Zone 1 was subdivided into 20 ft × 20 ft sectors. Gridlines running east and west were designated by letters A–F. Gridlines running north and south were designated by numbers 1–8. Grid A1 is shown in the lower left corner of Figure 20 (a). A stake was driven approximately 20 ft south from the westernmost pipe support. Figure 20 (b) shows the approximate location for grid A1. The A1 stake and the previously referenced pipe support are identified in Figure 20 (b).

The remaining grid sectors were laid out using tape measures, stakes, flags, and sandbags. Sandbags were used at locations where driving a stake was not possible. The sandbags were placed over the grid point, and a flag was inserted into the sandbag. Some grid points were not physically located due to accessibility or safety concerns. These locations included areas near and within the crater.

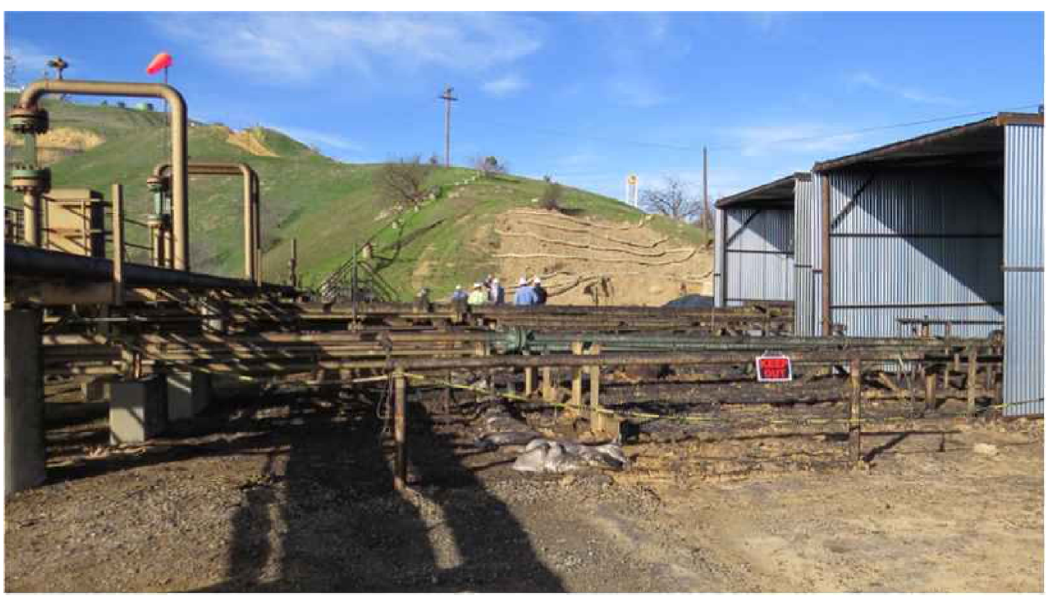

Figure 21: SS-25A and SS-25B Piping Obstructing the Zone 1 Search

Figure 22 is an aerial image of the SS-25 site with the layout of the Zone 1 grid. The solid white circles indicate gridline intersections marked with flagged sandbags. The dashed white circles indicate gridlines marked with stakes driven into the ground. The sandbags are visible in the aerial photo, unlike the stakes.

The red circles indicate gridline intersections that were not physically marked due to accessibility or safety concerns. These include areas near and within the crater. The bottom left corner of Figure 22 shows an example of a flagged sandbag used during the Zone 1 grid layout.

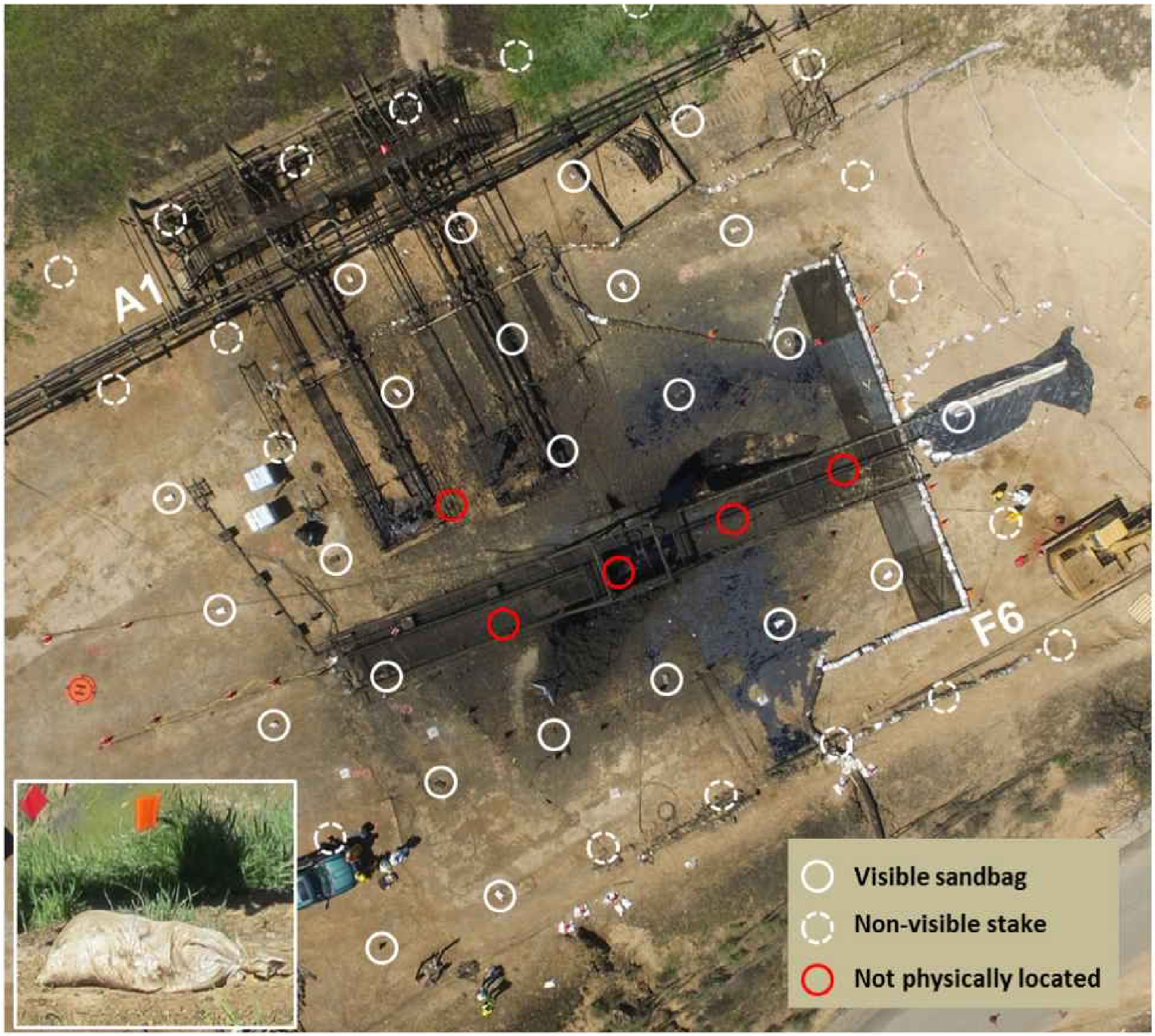

Figure 22: Physical Location of Zone 1 Grid Markers (Sandbags and Stakes)

3.1.2 Zones 2–4

Zones 2–4 were designed to divide the site into manageable search zones outside of the Zone 1 grid. Discussions with CPUC led to the decision to develop an outer grid. The intent of the outer grid was to communicate locations for evidence found outside of Zone 1. The outer grid was tied into the Zone 1 grid for continuity. Gridlines running east and west were designated by double letters AA–UU. Gridlines running north and south were designated by numbers 10–220 at intervals of 10. Figure 23 (a) shows the outer grid and the corresponding gridline designations. The outer grid was subdivided into 40 ft × 40 ft sectors.

Zone 2 consisted of areas that could easily be walked by Blade personnel. This zone was intended to represent areas that did not require special equipment, such as harnesses, to search. Zone 2 extended the full 400 ft radius of the outer boundary in the north and south directions. The east-west direction was bounded by the pipeline on the west side of the site and the east slope. Zone 2 was later extended to include the east slope. The east slope was originally designated as a no-go zone due to the steepness of the slope. Figure 23 shows the original area in Zone 2 that was designed as a no-go zone (red line). Zone 2 was extended to include the east slope after receiving confirmation from Capstone that the slope could safely be searched with harnesses. Therefore, Zone 2 included the east slope despite the need for a harness.

Zones 3 and 4 covered a majority of the west slope. Harnesses were required by Capstone[i] to search these zones. The west slope was originally divided into a southern (Zone 3) and northern (Zone 4) section. These zones were separated based on the assumption that two anchor points were required for harnesses. This is reflected by the search lines (Figure 19). The east road in Zone 2 and the west road in Zones 3 and 4 were walked by Blade personnel. Areas of the no-go zones were visually inspected from the road.

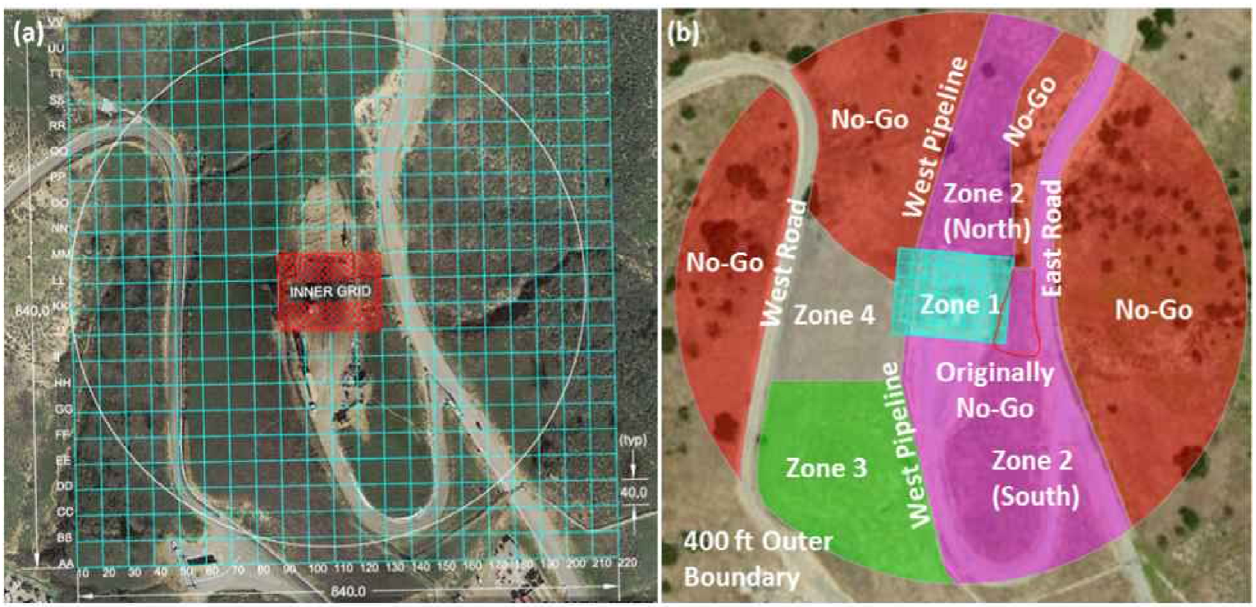

Figure 23: Aerial Images Showing the (a) Outer Grid and (b) Search Zones

3.2 Evidence Search

The goal for the evidence search was to identify and collect objects around the site that were related to or produced by the blowout. The search focused on metal objects due to the nature of the incident as all pressure-containing barriers or components within the SS-25 well were metal. A visual and geophysical search was conducted for each zone. Visual inspection was conducted by Blade personnel and focused on all objects with the potential to provide data associated with the SS-25 incident. A geophysical inspection was conducted by AECOM and focused on locating buried metal evidence that might have come from the well. The geophysical search used both the Geonics EM61-MK2 and handheld metal detectors.

[i] Capstone was contracted by SoCalGas to provide safety and rescue services at the SS-25 site.

The sequence for the evidence search was dictated by the Phase 1 schedule and other events occurring simultaneously on the SS-25 site. Efforts were made to release areas of the site requiring access from other parties. Heavy equipment and operations were not allowed in sectors not cleared by Blade. Metal objects were removed prior to the geophysical survey to minimize the number of anomalies detected by the equipment.

Items were separated into two categories during the search. The term ‘evidence’ was used to identify items possibly relevant to the incident, which required an evidence tag. The term ‘legacy and kill related’ (LKR) was used to identify items that needed to be removed but were not considered evidence. LKR and evidence are discussed in detail in Section 3.4.

3.2.1 Visual Search

A visual search was conducted by Blade at the SS-25 incident site between March 29, 2016 and April 04, 2016. The visual inspection included Zones 1–4. The site was searched up to the 400 ft perimeter in all areas deemed safely accessible. Zone 1 was searched in a grid pattern, as previously discussed. Grid sectors were entered by the Blade team and searched for evidence. Metal items were flagged and marked as either LKR or evidence. Table 2 is a timeline of events for visual inspection. The gap between March 31, 2016 and April 04, 2016 was due to other events occurring at the site. Efforts were made to manage resources and manpower to maintain progress with the schedule. For example, the east and west slope searches were postponed to April 04, 2016 to allow other activities to occur.

Table 2: Visual Inspection Timeline

Date	Description
March 29, 2016	Zone 2 North and South was searched and items were flagged
March 30, 2016	Zone 1 grid was laid out and part of Zone 1 was searched and flagged
March 31, 2016	Zone 1 completed
April 04, 2016	Searched east (Zone 2) and west (Zones 3 and 4) slopes for evidence

Markers were used to temporarily identify the locations of metal objects found during the search. Flags were numbered and a brief description and general location of each item was recorded. Photos and videos were used to document the collection of the items. Figure 24 shows an excerpt from the Blade Marker Log and an example of a numbered flag. No critical evidence was found.

Figure 24: Excerpt from Blade Marker Log

Zone 2 was searched in straight paths using search lines. Blade personnel walked approximately arm’s length apart in overlapping search paths. Zone 2 (excluding roads) was searched using mostly east-west search paths, with some areas using north-south paths when required. Boundaries of each search path were identified using flags and other temporary objects. Flags were placed by personnel on the leading edge of the search path. Personnel on the trailing end of the line removed flags that had previously been placed. This was repeated to ensure all areas were covered. Figure 25 is a schematic showing the evidence search method used for Zone 2.

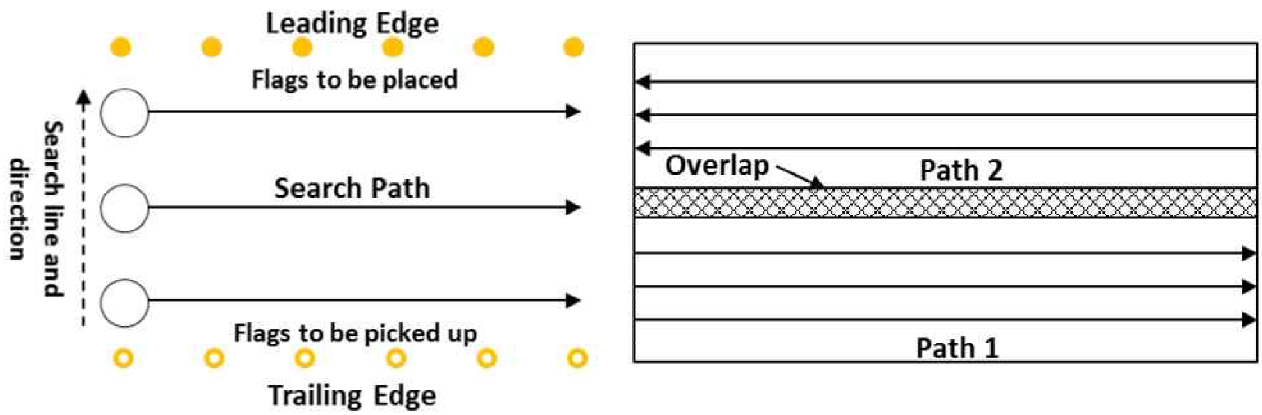

Figure 25: Evidence Search Method for Zone 2

Zone 3, Zone 4, and the east slope proved challenging for visual inspection due to the sloping terrain. Zones 3 and 4 covered the west slope. The east slope was an extended part of Zone 2 that was previously declared a no-go area. The west slope was shallower than the east. Blade personnel were harnessed by Capstone during the east and west slope visual inspections. The challenge with the west slope was the abundance of grass that had grown since the incident. Visual inspection was slow and ground visibility was low. The grass was moved and pushed to assist with visibility. The east slope had less grass but a much steeper grade. Climbing the east slope was more of a challenge but the visibility was higher than the west slope. Figure 26 shows the east slope search. A harness was used with a rope attached to an anchor point to allow a searcher to rappel. The lines were kept taut by Capstone for safety and assistance with climbing. The west slope could be walked without using a harness and rope, but the same search method was used.

Figure 26: East Slope Search

The roads leading up to and around the SS-25 site were walked and visually searched. Inaccessible portions of the slopes were critically-viewed from the east road (Figure 26). Observations from the road were limited but were the only means of inspecting some areas of the site. No critical evidence was found in any zone of the search in the preceding paragraphs.

3.2.2 Surface Geophysical Search

The geophysical search was conducted by AECOM between April 02 and April 21, 2016. The survey took 19 days to complete, including downtime due to equipment malfunctions. AECOM arrived with the Geonics EM61-MK2 and handheld metal detectors. A summary of the geophysical search timeline is shown in Table 3. The Geonics EM61-MK2 is a time-domain metal detector that transmits a time-varying electromagnetic pulse in the subsurface. The instrument can detect ferrous and non-ferrous metallic objects based on the time-decay rate of the response.

The geophysical search began on April 02, 2016 in the afternoon. The EM61-MK2 was taken to the north side of Zone 2 (north hill). AECOM personnel used the EM61-MK2 for a few hours before the brackets securing the handlebars began to break. New brackets had to be ordered before the equipment could be fixed. This caused a four-day delay with the geophysical search. From April 02 to April 05, 2016, Blade provided support as AECOM searched Zone 1 and part of Zone 2 using only the handheld metal detectors. Blade assisted by digging up located items and determining their significance. Figure 27 shows the collection of items dug up and collected on April 02 and April 03, 2016. Some of the typical items found were discarded welding rods, nails, bolts, washers, and other such irrelevant items. Figure 28 indicates the signals returned from the detector. The scale on the left is in millivolts with pink indicating a strong metal signal. The majority of the items appeared old and coated with a heavy rust layer indicating they were legacy items and unrelated to the incident.

Figure 27: Objects Found during the Geophysical Search on (a) April 02, 2016 and (b)–(d) April 03, 2016

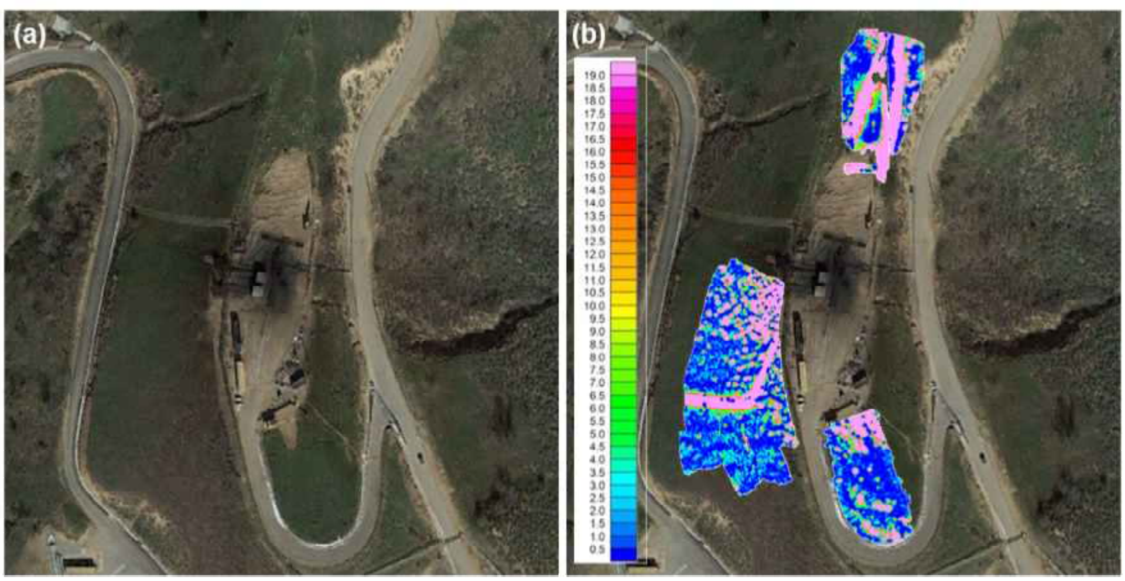

Figure 28: EM61-MK2 (a) Tracking and (b) Results

Figure 29 shows enlarged images of the millivolt colormap of Figure 28 (b). Areas colored pink and red are indications of buried metallic objects. The large, continuous indications in pink and red in Figure 29 (b) are confirmed pipes running down the slope. Portions of the pipes were uncovered and seen during the visual search. The pipeline in Figure 29 (a) was also visually confirmed. A total of 547 indications were detected by the EM61-MK2. There were 195 indications found in Zone 2 and 352 found in Zones 3 and 4. Some of the Zone 2 North indications were recovered to provide a sample of the types of items found by the technology. Additional items were recovered from Zone 2 South. All of the recovered indications were considered LKR. No evidence was found by the EM61-MK2.

Blade personnel could not investigate all indications due to the high quantity. Areas of the site such as Zone 2 South and North, as well as the west slope (Zones 3 and 4), were sectioned off to limit the amount of traffic disturbing the area. These areas remained inaccessible to heavy equipment until completion of Phase 3. The intent of Phase 3 was to recover as much of the tubing and casing from downhole as possible for visual and NDE inspection. Evidence and LKR from the geophysical search were to be further investigated if the visual inspection of the casing and tubing suggested missing metal fragments.

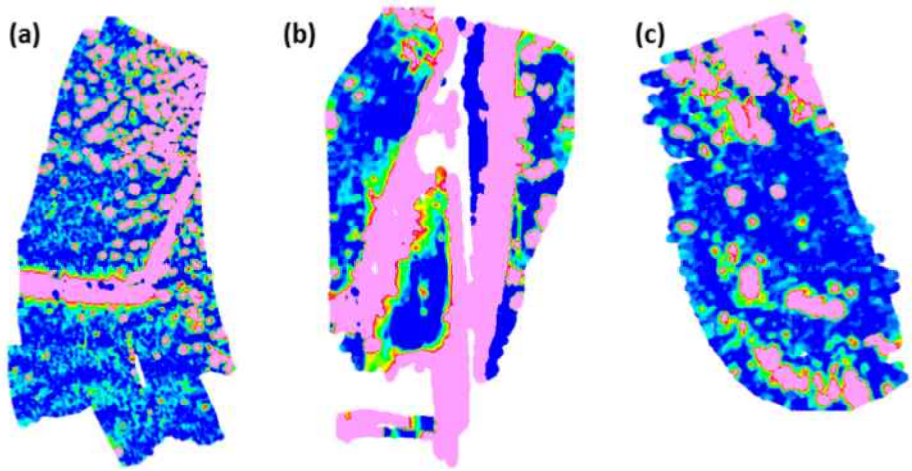

Figure 29: Colormaps for (a) West Slope, (b) Zone 2 North, and (c) Zone 2 South

3.3 Crater Search, Evacuation, and Excavation

The crater presented numerous problems. It was partially filled with a mixture of fluids that included rainwater, kill fluids, formation oil, etc. It was unclear if any items related to the failure were in the crater below the surface of the fluid. The SS-25 concrete cellar had disappeared into the crater and the 11 3/4 in. × 7 in. annulus valve that backed out during a kill attempt was assumed to be in the crater. Further, the wellhead was leaning to one side, indicating that it had become unstable at the initiation or during the blowout. To move forward with the investigation, the area within the crater had to be reclaimed, and potential evidence within the crater had to be preserved.

3.3.1 Fluid Tests

Throughout the RCA, samples of oil, kill fluids and brine (water) were collected from various origins and sent for detailed chemical analyses. The analyses were carried out by Texas Oil Tech Laboratories (TOL).

It was established that the hydrocarbons collected around the environment originated at the Sesnon formation. However, the samples were contaminated with various lighter fluids that are sometimes used for workover operations. The brine samples were dilute kill—or workover fluids. The soil analyses were later used in conjunction with additional sources to establish connections with the nature of the shallow formation surrounding this well.

Fluid samples were collected from ground-level from various points surrounding the SS-25 well using volatile organic chemical (VOC) bottles. Sample collection from within the crater is described in Appendix B and Appendix C.

3.3.2 Evacuation

The first attempt to empty the crater of oil was by vacuum. On April 23, 2016, fluid samples were obtained by lowering a thief on an extension stick into the fluid within the crater. The fluid was tar-like and too viscous to go naturally into the thief, so samples were scraped from its outside surfaces after retrieving it from the crater. An estimate of the viscosity was based on comparison to known heavy fluids and fell somewhere between honey and SAE 70 oil. This translates to viscosities from 1,760 cp to 17,600 cp. The volume of the fluid was roughly estimated at 255 ft^3 by taking the area of the fluid surface and multiplying by manual depth measurements obtained using a graduated stick.

Discussion with SoCalGas and their contractors, Argus and Doby, suggested that their vacuum equipment could deal with fluids in this viscosity range. The viscosities estimates were relayed to SoCalGas and their contractors. On April 24, 2016, the super sucker truck arrived as shown in Figure 30 (a). Accompanying it was a containment vessel big enough to hold the estimated volume, which is shown in Figure 30 (b). The vacuum hose was lowered by a boom into the crater, shown in Figure 30 (c) and (d). After a few minutes, it was obvious that this was not a viable method and the procedure was aborted. The fluid was far too viscous.

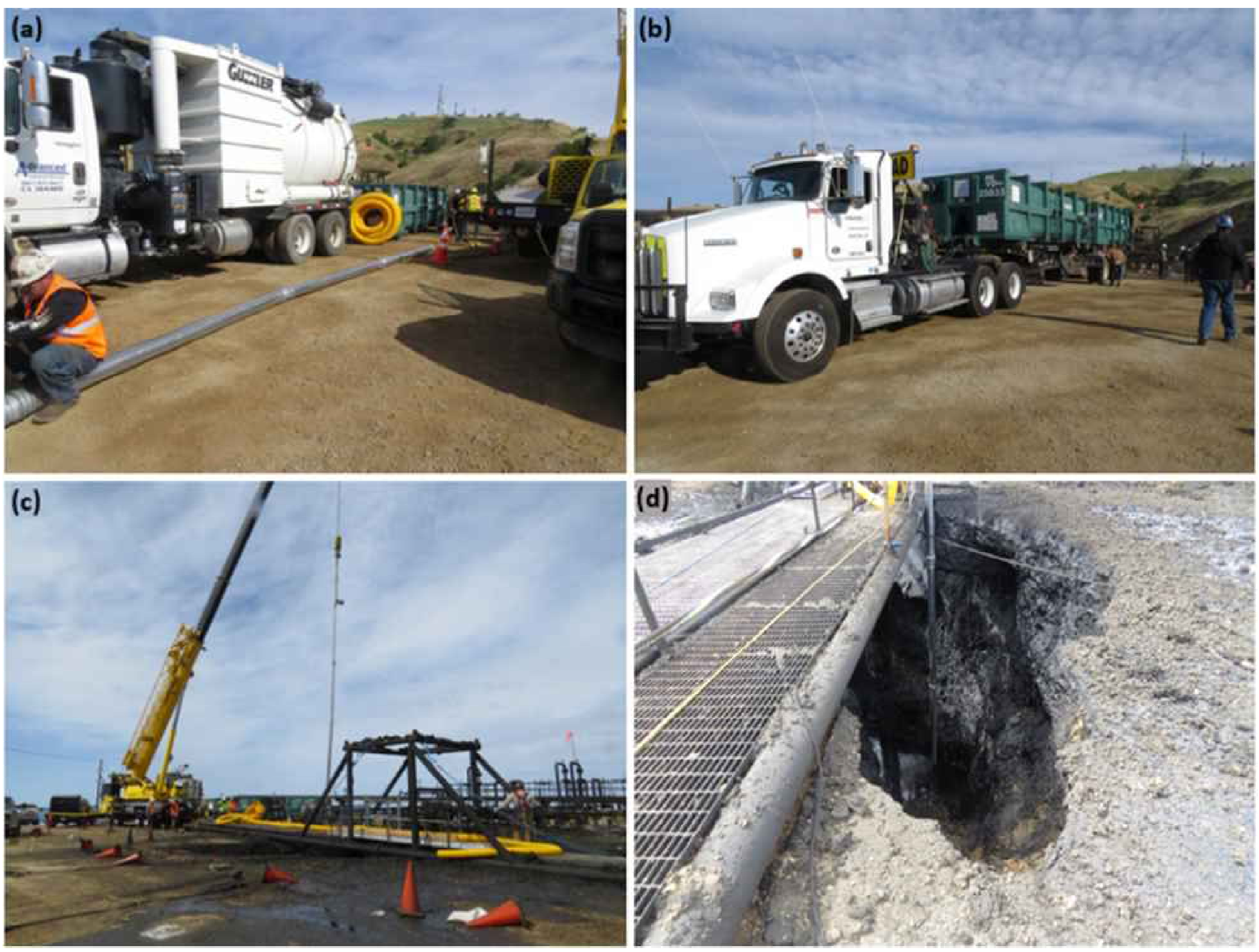

Figure 30: SS-25 Crater Evacuation Attempt

3.3.3 Excavation

Excavation was required to reclaim the crater. It was excavated on June 15, 2016. The fluids in the crater had pooled to the deepest location at the base of the wellhead (Figure 31). A backhoe removed sequential bucket-loads of fluid and contaminated soil (Figure 32 [a]), and the bucket contents were deposited on an observation platform for visual inspection (Figure 32 [b]). When they were deemed as not containing visible evidence, the contents were stored in adequate storage vessels at another location on the SoCalGas site.

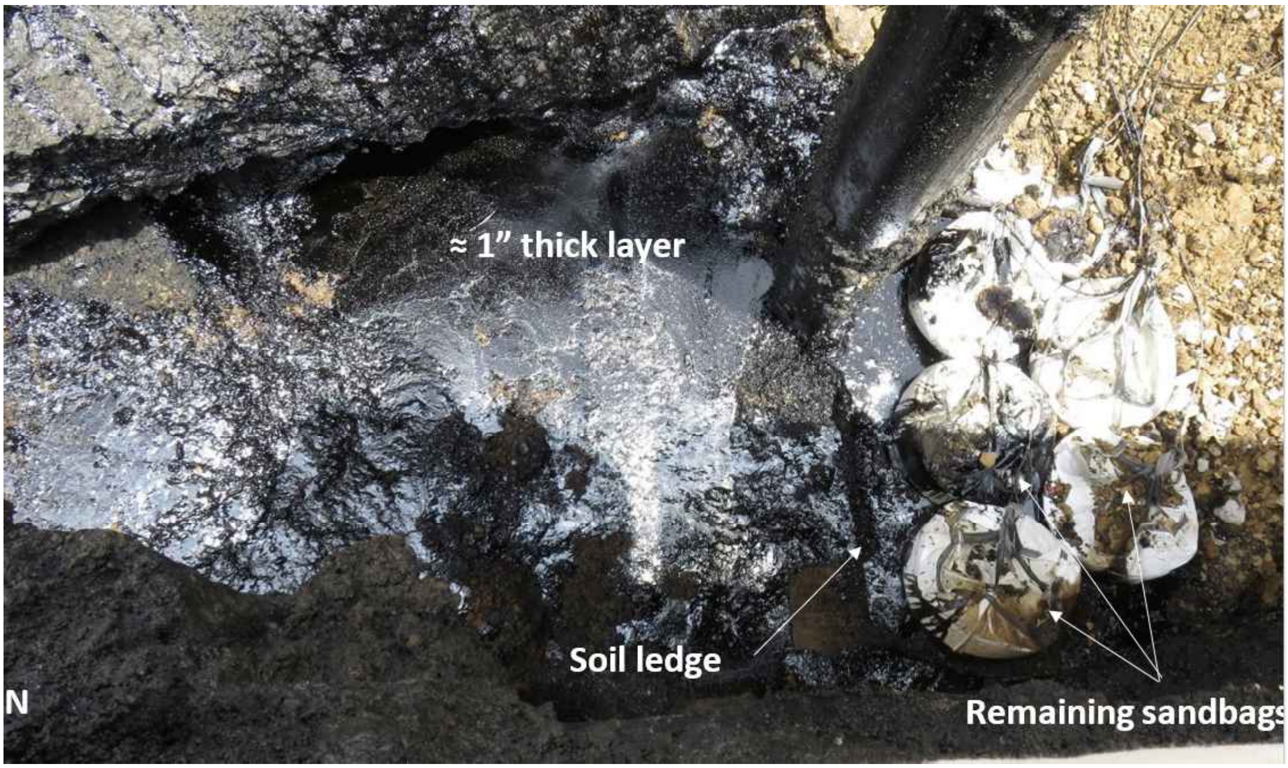

Figure 31: *In situ* Crater Fluids of SS-25

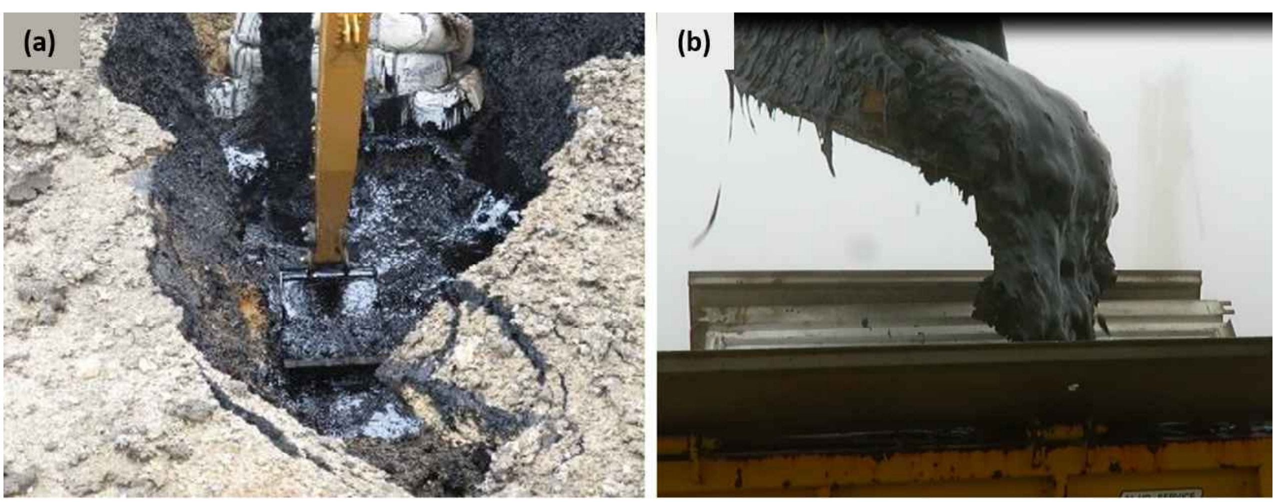

Figure 32: (a) Removal of Fluids From the Crater and (b) Content Inspection

3.4 Evidence Collection, Documentation, and Storage

3.4.1 Legacy and Kill Related

LKR items were identified during the visual and geophysical searches. Legacy items included items existing onsite before the failure, and kill-related items were added to the site during kill operations. Additional LKR items were found during the cleanout of SS-25A and SS-25B well cellars. The majority of LKR items were welding rods, bolts, nuts, washers, small plate, flow lines, and other objects unrelated to the SS-25 incident (Figure 33). The procedure for documenting LKR items was as follows:

1. Place a numbered marker near the LKR.
2. Photo-document the LKR item(s).
3. Collect all the LKR in preparation for the geophysical evidence search.

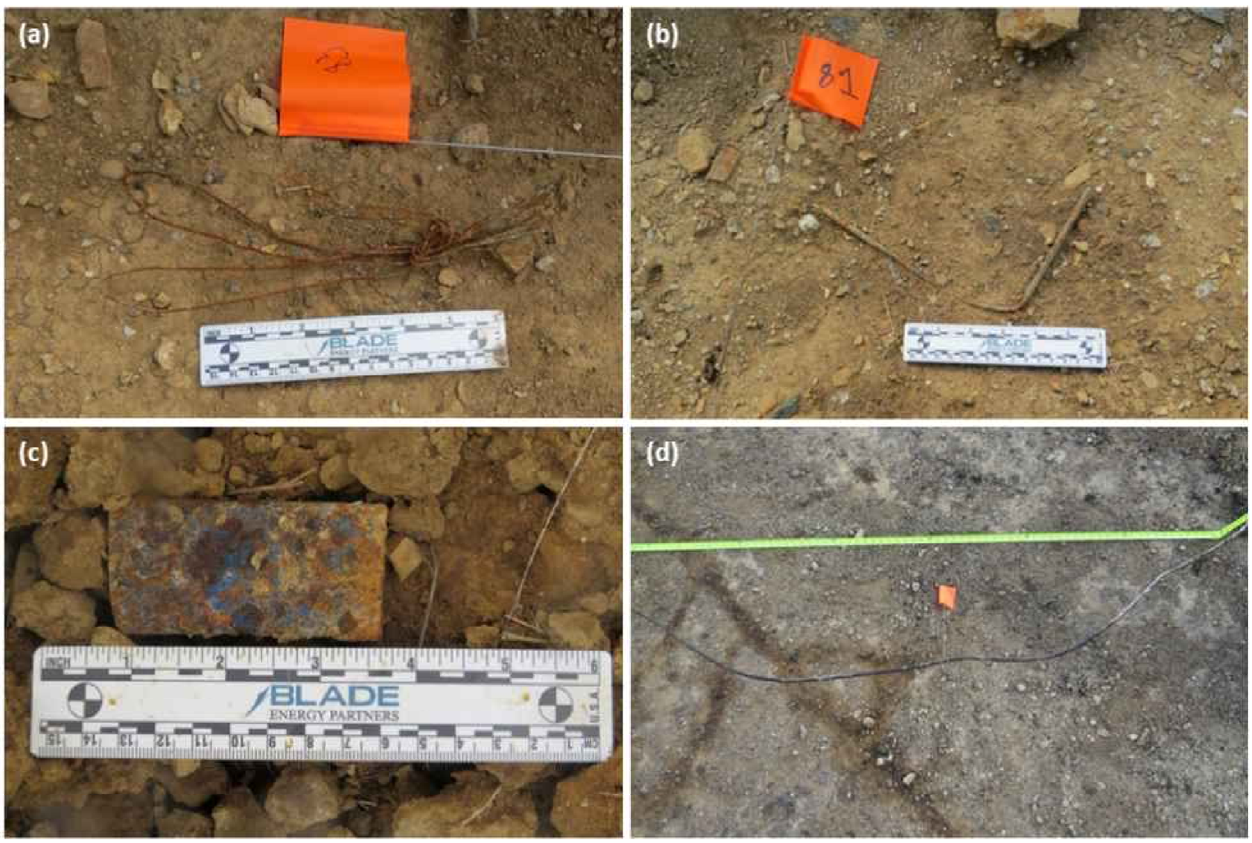

Figure 33: Legacy and Kill Related Items: (a) Wire, (b) Welding Rod, (c) Small Plate, and (d) Flow Line

3.5 Evidence

Any item found during the evidence search that was possibly related to the SS-25 incident or non-LKR was considered evidence. Any item identified as evidence was subject to the documentation protocol described in Blade's Phase I investigation protocol provided to and approved by SoCalGas, DOGGR and CPUC before executing the phase. A total of 59 items were identified and collected as evidence.

This included four large items, six metal items, 26 liquid samples, 21 soil samples, and two items identified as 'other'. The SS-25 incident site was visually searched between the dates of March 29, 2016 to April 04,

2016. The geophysical search occurred between the dates of April 02 and April 21, 2016. Table 3 is a summary of the days covering the evidence search and collection. Evidence was documented per the Phase 1 protocol [1]. Collected evidence was logged and stored into a secured trailer. The trailer was under 24 hour surveillance and could only be accessed by Blade.

Table 3: Evidence Search Timeline

Date	Description
March 16, 2016	Five pieces of evidence were collected from the SS-25A and B heat shields. (4) Metal (1) Soil
March 28, 2016	Phase 1 officially kicked-off. Fog caused a half day delay. Photo documentation of the site began in the afternoon.
March 29, 2016	Zone 2 North and Zone 2 South were searched. Items were flagged but no evidence was collected.
March 30, 2016	The grid for Zone 1 was laid out. Part of Zone 1 was searched and items were flagged.
March 31, 2016	Completed Zone 1 search. Collected LKR items for storage. Assisted with metal detection.
April 01, 2016	(2) Large (1) Metal (2) Other
April 02, 2016	Geophysical search using metal detectors (Blade personnel required).
April 03, 2016	Geophysical search using metal detectors (Blade personnel required).
April 04, 2016	Removed flowlines and handrails to search northwest corner of Zone 1. Searched east (Zone 2) and west (Zones 3 and 4) slopes for evidence.
April 06, 2016	(20) Liquid (10) Soil
April 07, 2016	(2) Large (1) Metal (10) Soil
April 08, 2016	(1) Liquid
April 23, 2016	(5) Liquid

4 Wellhead Cleaning and Inspection

Evaluation of the wellhead was performed by visual and nondestructive inspection (NDI) techniques. The wellhead was thickly coated with grime resulting from the massive gas release that carried with it kill fluids, sediment, oil, water, etc. Cleaning was required to remove all these debris and the underlying paint prior to inspection. Images of the wellhead prior to cleaning are given in Figure 49 (a) and (b).

To clean the wellhead, a combination of two procedures were recommended. These included chemical and hydroblast procedures. Argus, a local contractor, was suggested by SoCalGas to execute the wellhead cleaning. Argus had cleaned numerous wellheads and other oil and gas-related components at the Aliso Canyon site and brought years of experience to the project.

Cleaning was approached in a systematic way. The chemical and hydroblast procedures were first evaluated independently at the coupon level using the chemical and hydroblasting independently. Chemical cleaning was further evaluated on a flow line. A final combined test of chemical and hydroblasting was completed on an analog full-scale test article wellhead similar in design to the one at SS-25.

When the test article was successfully cleaned and Blade was convinced that there was no appreciable risk to the SS-25 wellhead, actual cleaning commenced. It must be noted that wellhead failure had not been eliminated as a possible cause to the SS-25 leak. This drove the following issues of serious concern:

- Mechanically removing, altering, or masking potential evidence on the surface of the wellhead
- Chemically eroding or pitting the surface to an unacceptable degree

There are two painting schemes used throughout the Aliso Canyon facility that were described to Blade. These include:

- Suntan yellow lead-based (old method)
- Lead abatement green urethane with white epoxy primer (new method)

SoCalGas confirmed that the SS-25 wellhead was painted using the newer lead abatement paint scheme. However, both paint schemes listed were considered in the tests.

Materials for coupon tests were obtained from Energy Alloys in Houston, TX. These were used to evaluate the surface effect of a chemical stripper and metal loss due to high-pressure water stream impingement. The materials selected were:

- Continuous cast, 1045 Carbon Steel, normalized (49 ksi yield stress [YS])
- Forged, 4130 Low Alloy Steel, quenched and tempered (70 ksi YS)

The materials are representative of 5,000 psi, API Type 1 and Type 2 steels. Type 2 was used in 1971 for 5,000 psi wellheads. For reference purposes, API type (1–4) mechanical properties are given in Table 4.

Table 4: API Spec 6A 14th Edition Minimum Mechanical Requirements for Wellheads

Property	Type 1	Type 2	Type 3	Type 4
Minimum Tensile Strength (psi)	70,000	90,00	100,000	70,000
Minimum Yield Strength (psi)	36,000	60,000	75,000	45,000
Minimum Elongation (%)	22	18	17	19

Property	Type 1	Type 2	Type 3	Type 4
Minimum Reduction in Area (%)	30	35	35	32

Since the governing API 6A specification in use when the wellhead was commissioned (1971) did not include specifics on microstructure, materials of lesser and greater hardness were selected to span the range of properties most likely to be exhibited by the SS-25 wellhead.

Once the individual tests were completed, two test articles were evaluated. The first article was the flow line at the SS-25 location painted with suntan yellow, lead-based paint. This was covered with the grime of the blowout. A chemical-only cleaning process was applied because the suntan yellow, lead-based paint is easier to remove. The surface was evaluated micrographically with a portable microscope after cleaning. The second test article was the Frew 8 wellhead analog to the SS-25 wellhead. It was of similar design but was painted with lead abatement green urethane with white epoxy. This was done to demonstrate the overall procedure of a representative wellhead of the same base material and design, painted with the same scheme as the SS-25 wellhead.

Once the preliminary cleaning tests were completed with satisfactory results and showed no appreciable alteration of the underlying base metal, the SS-25 wellhead was cleaned with a combination of chemical and hydroblast procedures using a 24 hour chemical soak and 20 ksi hydroblast pressure with 60 second, location-specific, maximum hydroblast exposure time.

Riccardelli Consulting Services (RCS) Inc. was hired for consultant inspection services. Based on the outdoor Southern California sunlight conditions, RCS Inc. suggested wet, black-and-white MPI. Prior to commencing MPI, on RCS' recommendation, light sandblasting was applied to the wellhead surface for improved inspection results. The procedures for the RCS inspections are described in Appendix D. RCS Inc. issued an independent inspection report regarding the results (Appendix E). Essentially, no leaking defect was found in the SS-25 wellhead.

4.1 Proposed Cleaning Procedures

Argus suggested the following cleaning methodologies:

- Use of SmartStripPRO™ only
- Use of SmartStripPRO™ with hydroblasting

After each application of SmartStripPRO™, the loosened debris and paint were removed with brass hand tools (brushes and scrapers). Brass was required to eliminate the chance of steel-to-steel contact sparks and to ensure no additional surface damage was introduced.

The basic protocol for using the SmartStripPRO™ solvent was to designate and demarcate a representative area with caution tape. Then, 6 mil thick, fire-retardant poly sheeting was placed under and around all surfaces to be cleaned. Loose dirt, oil, grime, debris, etc. were scraped away before applying the SmartStripPRO™ chemical. After the chemical paste was applied, the surface was wrapped with 2 to 4 mil poly sheeting. Wrapping the surfaces keeps the paste from drying out or washing off from rain or dripping. The chemical works best when allowed to soak into the surface materials under wrap over a 24 hour period with temperature excursions above 70°F. The wrap allows UV light to enter and traps heat of the chemical reaction. At lower temperatures, more scraping is required. After the soak time, the wrap was removed and hand tools (brass or plastic scrapers) were utilized to remove the remaining debris and residual paint from the surfaces. The SmartStripPRO™ container labels are shown in Figure 34. SmartStripPRO™ is a biodegradable chemical, however, once used, the spent chemical was impregnated with surface debris, gunk, and paint and was therefore discarded in accordance with local regulations.

Hydroblasting was an additional step. Argus had a portable blaster on a truck that could access any location on the Aliso Canyon site. Hydroblasting aided in removing the loosened debris and paint on articles that were cleaned around the site. Additional containment was required when this step was employed.

Figure 34: SmartStripPRO™ Chemical Cleaner Labels

4.2 Chemical Exposure Coupon Tests

4.2.1 Chemical Exposure Test Procedure

Sample coupons of 1045 carbon steel and 4130 low alloy steel were shipped to EAG Laboratories (formally, SEAL Laboratories) in El Segundo, CA for the chemical exposure tests. These samples were evaluated as per the test matrix as given in Table 5. The purpose of this study was to characterize any microstructural changes due to reactions between the solvent and the base metal. Figure 35 (a) shows a single sample with a chemical stripper applied to its micro-polished surface. Figure 35 (b) shows how the samples were loaded in a laboratory oven for sustained exposure. Figure 35 (c) demonstrates the temperature was held constant to the average temperature that would be expected for the surface of the wellhead during a chemical stripping procedure.

Table 5: Solvent Coupon Test Matrix

Sample ID	Material	Solvent Exposure Time (hours)
AC-MET-1045-24	1045 CS, 70 ksi yield strength, normalized, continuous cast	24
AC-MET-1045-48		48
AC-MET-1045-72		72
AC-MET-4130-24	4130, 70 ksi yield strength, forged	24
AC-MET-4130-48		48
AC-MET-4130-72		72

Figure 35: Controlled Exposure to SmartStripPRO™

4.2.2 Chemical Exposure Test Results

The metallographic images of the exposed 1045 annealed carbon steel sample surfaces are presented in Figure 36.

The exposed surfaces of the 4130 Q&T samples are presented in Figure 37. All images were taken at 500× using bright field optical microscopy.

After 24 hours of exposure, the formic acid within SmartStripPRO™ acts similar to an extremely mild metallographic reagent and reveals the microstructure, as shown in Figure 36 (b) and Figure 37 (b). Over extended periods, pitting can occur as demonstrated in Figure 36 (c) and Figure 36 (d) and Figure 37 (c) and Figure 37 (d). Pit depths estimated from the micrographs are less than 0.05 mm (0.002 in.) deep.

These results were found not to damage the surface. Most items on the Aliso Canyon site had already been cleaned, including the SS-25 wellhead, so this procedure was cleared for use.

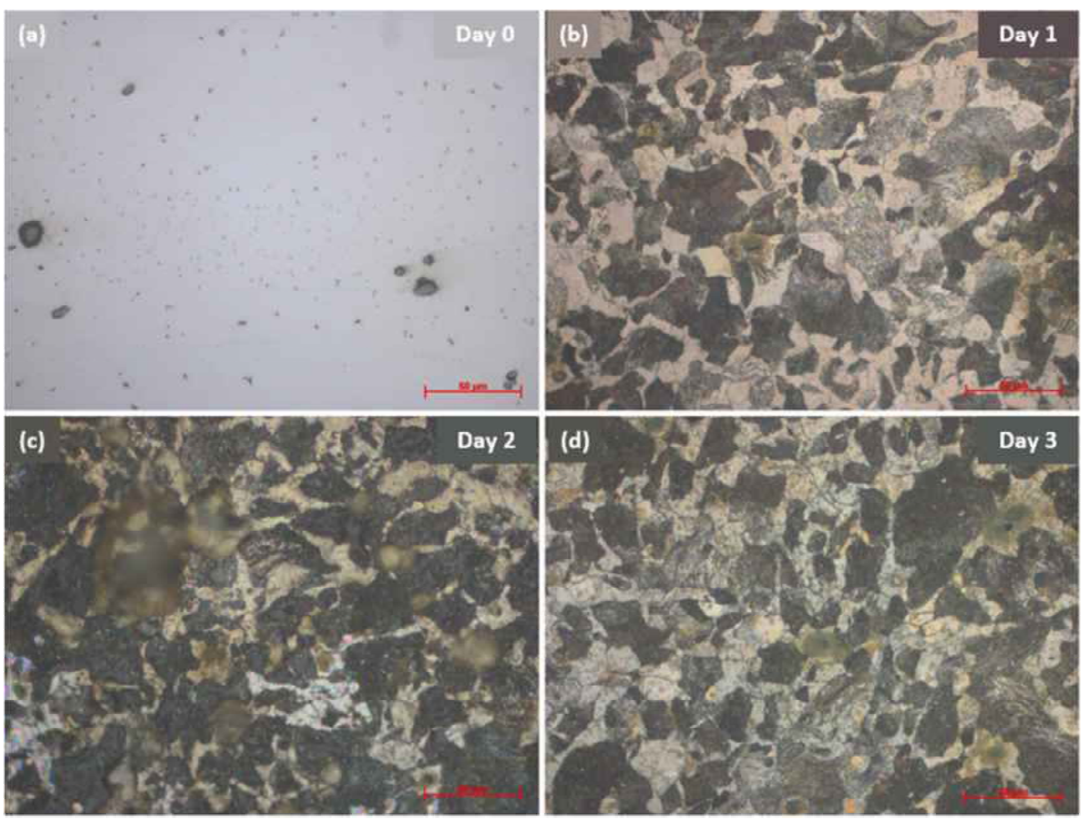

Figure 36: Effect of SmartStripPRO™ on 1045 Annealed Carbon Steel

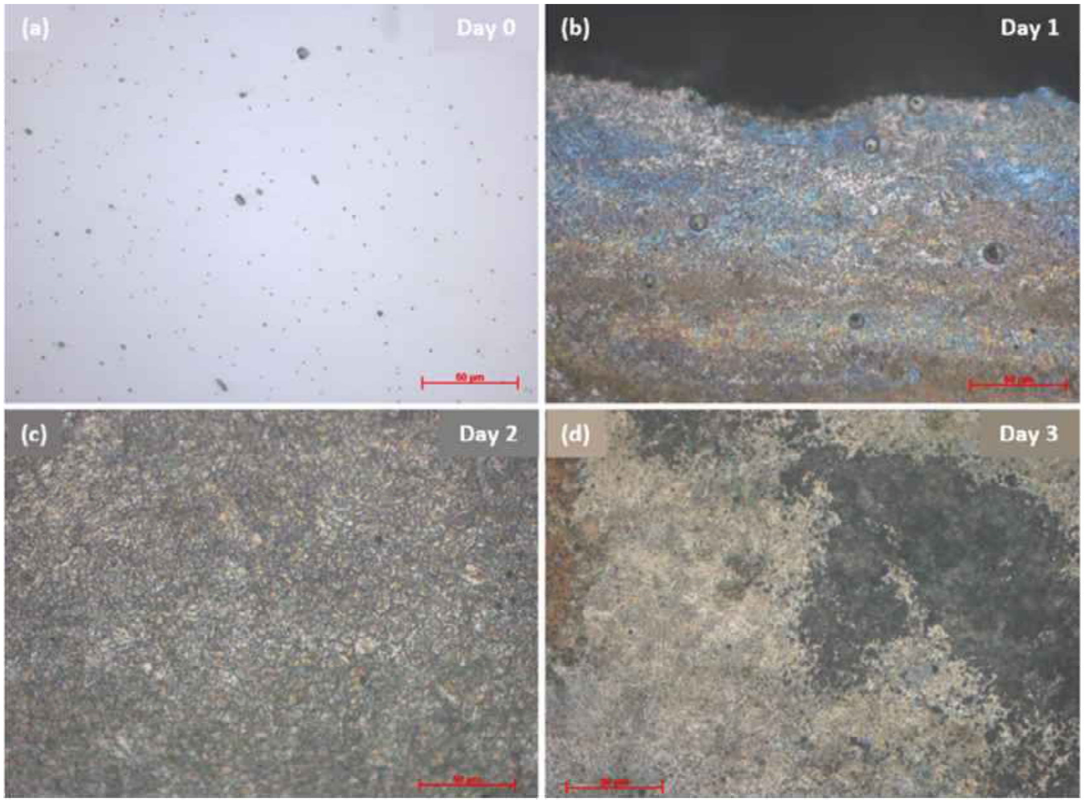

Figure 37: Effect of SmartStripPRO™ on 4130 Q&T Low Alloy Steel

4.3 Hydroblast (Waterblast, Pressure Washing) Evaluations

4.3.1 Hydroblast Testing Procedure

Plates were machined from the materials documented in Table 5 and were used as hydroblast targets to correlate material erosion with water pressure and time of exposure. A typical hydroblast target made of 1045 carbon steel in the annealed condition is shown in Figure 38. Here, four quadrants are defined to separate exposure time areas. For this particular target, the pressure was held at 20 ksi (a typical hydroblast pressure) and the times were varied as depicted. However, the effect was characterized over a range of pressures. Further, 4130 was identically evaluated. All of the targets were surface-ground to provide a consistent target flatness and roughness from which to measure the erosion depth.

Figure 38: Typical Waterblast Target with Impingement Time per Quadrant

4.3.2 Hydroblast Test Results

The plates were sent for high-resolution, optical profilometry to measure metal loss for each test pressure and time pair per material type. The results of the testing are given in Figure 39. The data shows that for 20 ksi of water pressure, there is no appreciable metal loss for the first 60 seconds, irrespective of material type.

Based on these tests, personnel were instructed to direct the water stream at any one area for a cumulative time not to exceed 60 seconds. Further, water pressure was to be limited to 20 ksi.

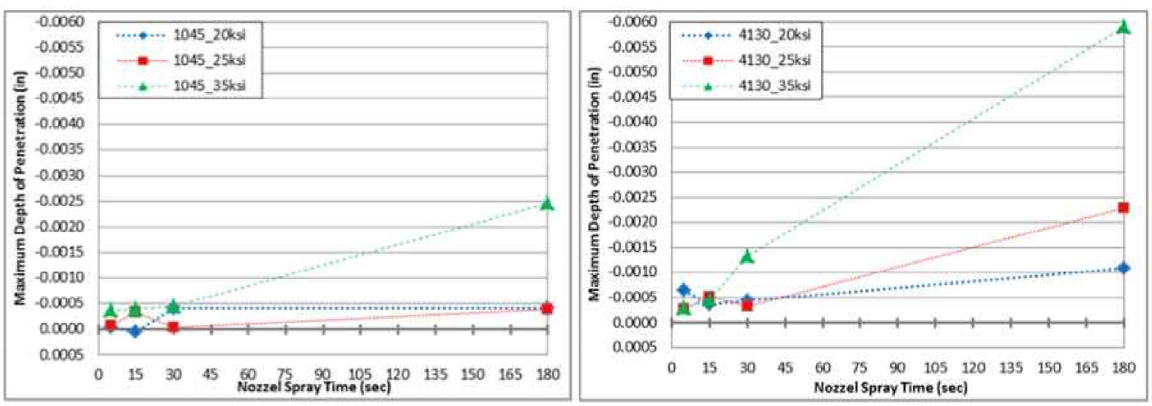

Figure 39: Erosion as a Function of Water Pressure and Exposure Time at 20 ksi

4.4 SmartStripPRO™ Full-Scale Evaluation on SS-25 Flow Line

A flow line was used to first demonstrate to Blade how the chemical stripper works on lead-based paint. This was intended as a quick demonstration that, if successful, would precipitate more interest and testing.

A test section of pipe leading away from SS-25 painted with suntan yellow, lead-based paint was selected as a chemical-only test article (Figure 40). The pipe was coated with SmartStripPRO™ and wrapped to allow the solvent to take effect. At 24 and 48 hour time intervals, sequential areas were unwrapped and evaluated for the effectiveness of the solvent as a function of time. The cleaned surfaces were evaluated by the naked eye and under a portable microscope to assess paint removal and base metal surface alteration, respectively.

Figure 40: Flow Line for SmartStripPRO™ Evaluation

After the chemical was applied to the pipe, the surface was wrapped with plastic, secured with tape, and allowed to dissolve the surface debris and paint for intervals of 24 hours. When the sequential sections were unwrapped, the surfaces were scraped, and the results were documented.

Figure 41 (a) is the test pipe surface before paint stripper application taken at approximately 6 AM. This shows the pipe surface covered with grime from the blowout. Figure 41 (b) shows an adjacent section of pipe after a minimum of 24 hours of chemical treatment. The photos demonstrate that the chemical stripper was effective in removing grime and the underlying lead-based paint in a 24 hour period. Figure 42 shows micrographs taken at 200× magnification with a ProScope™ portable digital microscope of the pipe surface (a) before stripping and (b) after stripping. No scale marker option is available with this software. However, when printed to pictures per width of 8.5 in. × 11 in., the 200× magnification is nearly correct. The findings were: there was minimal residual paint left after stripping and no apparent damage was inflicted to the base metal from using the chemical stripper.

This completed the effectiveness evaluation of removing lead-based paint with SmartStripPRO™. The conclusion was that using the paint stripper without hydroblasting was an option on smooth, easily accessible areas. Further, the lead-based paint responded well to the chemical and was readily removed in a 24 to 48 hour period with little residual paint remaining on the surface. Also, the formic acid in the paint stripper was mild and low enough in concentration as not to pit or corrode the surface of the material even after several days of exposure This proved to be a viable and non-detrimental method of cleaning.

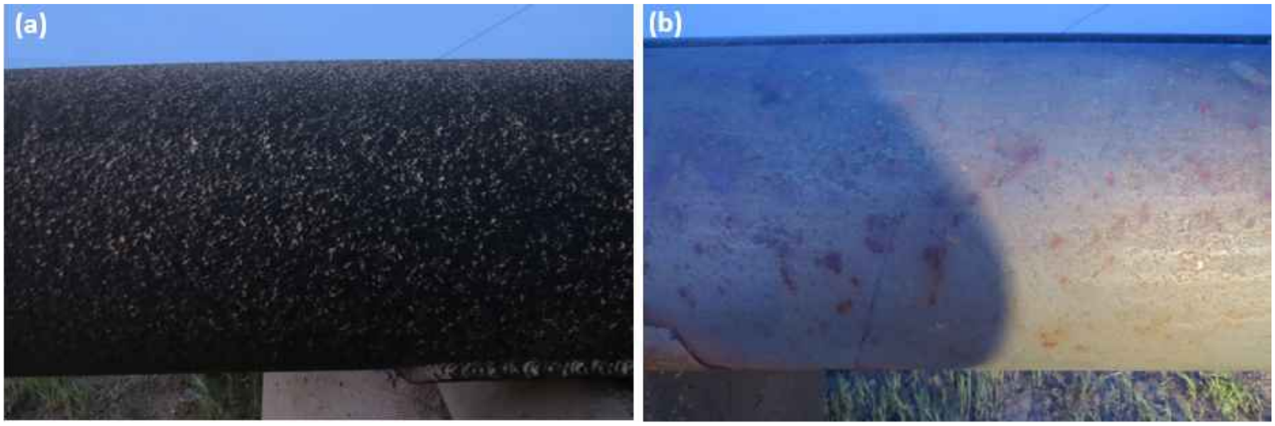

Figure 41: (a) Before and (b) After a 24 hr. Chemical Treatment

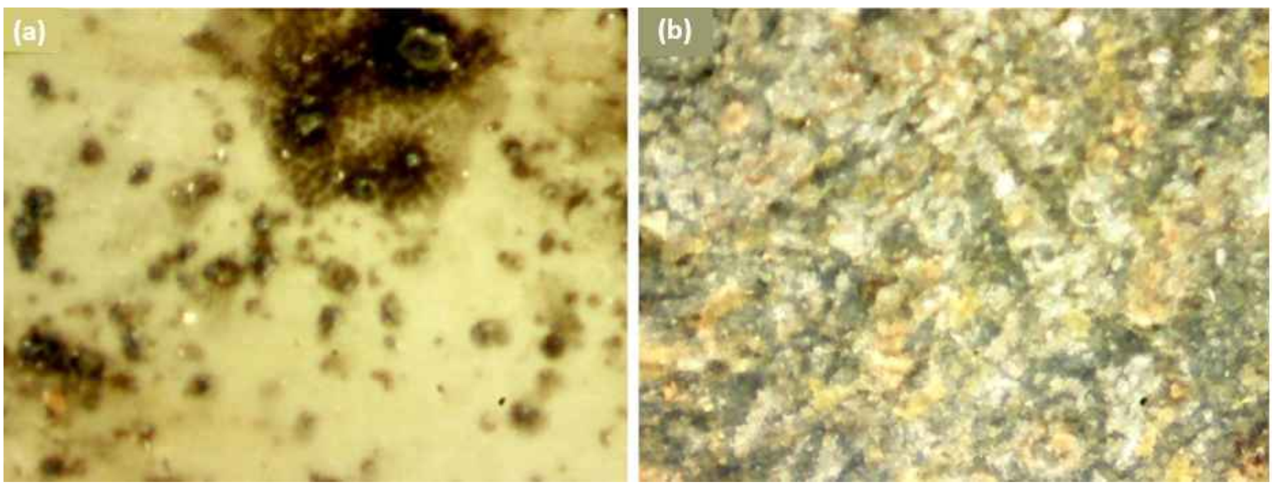

Figure 42: Micrographs taken at 200× (a) Before and (b) After Paint Stripper

4.5 SmartStripPRO™ Solvent with Hydroblasting on Frew 8 Analog Well

An analog well was identified by SoCalGas with a similar design, the same paint scheme, and same API Type 2 steel to serve as the final cleaning and paint stripping analog. This was the Frew 8 wellhead as shown in multiple views in Figure 43. Drawings comparing the wellheads of Frew 8 to SS-25 are depicted in Figure 44. Only select regions of Frew 8 that would present the greatest challenge on the SS-25 wellhead were chemically cleaned and hydroblasted. These included two sets of components. Component set 1 was the cap, crossover, casing spool, and casing head. Component set 2 was the wing, master, and gate valves. Chemical stripping was applied, wrapped, and allowed to soak for nearly 20 hours as shown in Figure 45. After the soak time, the wrapping was removed and the selected wellhead components were scraped as shown in Figure 46.

Post-cleaning criteria were set by RCS Inc. Photos were sent to RCS Inc. to evaluate if the surface condition was suitable for subsequent MPI. The results were evaluated qualitatively as follows: component set 1 required additional time, and component set 2 was completely clean. Component set 1 was chemically treated again for an additional 17 hours. After the extended period of time, all components were considered suitable for MPI based on high-resolution photographs. RCS Inc. did suggest to have sandblasting on site based on their experience. Frew 8 was hydroblasted (Figure 47) and repainted immediately to preserve its integrity. Final images comparing the starting and final conditions are presented (Figure 48).

Figure 43: The Frew 8 Wellhead Final Cleaning and Paint Stripping Full-Scale Test Article

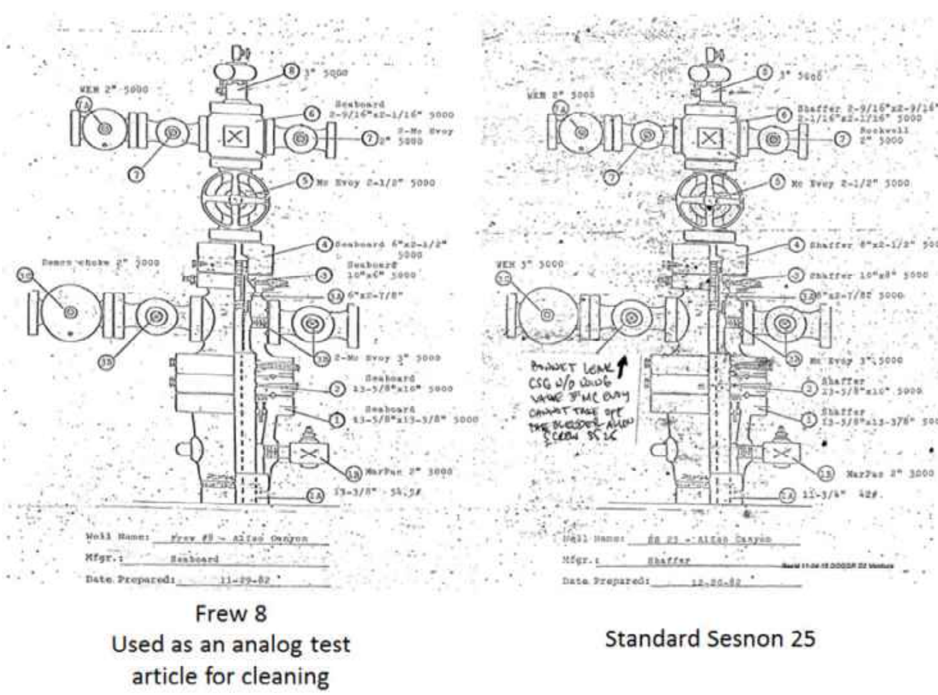

Figure 44: Frew 8 and Standard Sesnon 25 Wellhead Comparison

Figure 45: Applying Stripping and Wrapping to Frew 8 Wellhead

Plastic scrapers used

Typical debris created during scraping

Brass brush used to clean nuts & threads

Brass brushes used to clean crevices

Figure 46: Removal of Debris After a 20 Hour Chemical Soak of the Frew 8 Wellhead

Figure 47: Waterblasting of the Frew 8 Wellhead

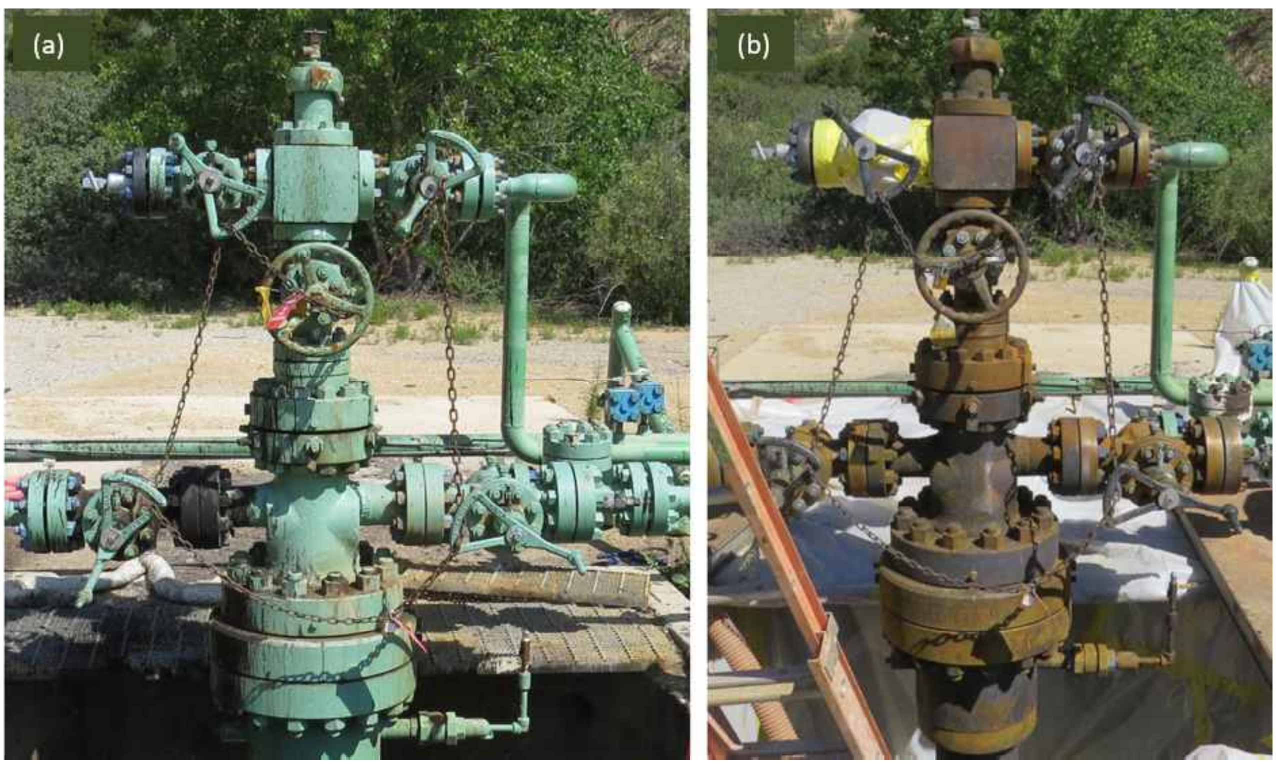

Figure 48: Photos of the Frew 8 Wellhead (a) Before and (b) After Cleaning

5 SS-25 Wellhead Cleaning

5.1 Preliminary work

The SS-25 wellhead was in a dangerous and precarious position. It was positioned within a crater partially filled will debris, rocks, broken concrete cellars, rebar, oil, and kill fluids. It was also leaning at an angle. There was a makeshift bridge spanning the crater caused by the blowout that gave investigators access to the wellhead. Before cleaning, safe access to the wellhead had to be ensured. Several methods were tried to evacuate the fluids from the craters. However, the tar-like viscosity made vacuum attempts impossible. It was decided to dig out the crater with a backhoe and remove the contaminated soil to reclaim the site. This is covered in detail in the Phase 2 report. For this document, only a brief discussion will be made. Once cleaned, the wellhead was inspected by MPI nondestructive mythology. The 11 3/4 in. surface casing circumferential welds were evaluated with phased array ultrasonic testing (PAUT) and radiographic nondestructive methods.

5.2 SS-25 Crater Evacuation and Wellhead Access

Until this point, limited access to the wellhead was made possible by a makeshift bridge spanned across the crater. It was dangerous on the bridge and each person had to be harnessed in case of a fall into the crater. This was an unacceptable situation for cleaning. (a) shows the condition of the wellhead as seen looking northwest with the bridge in place. (b) shows the wellhead in the crater with the bridge removed with steel tension cables (shoring lines) attached to straighten the wellhead. (c) shows how the backhoe was used to clear the site of contaminated soil. Finally, (d) shows the end result of readying the wellhead for cleaning. Scaffolding provided 180˚ access for cleaning and inspecting the entire exposed wellhead.

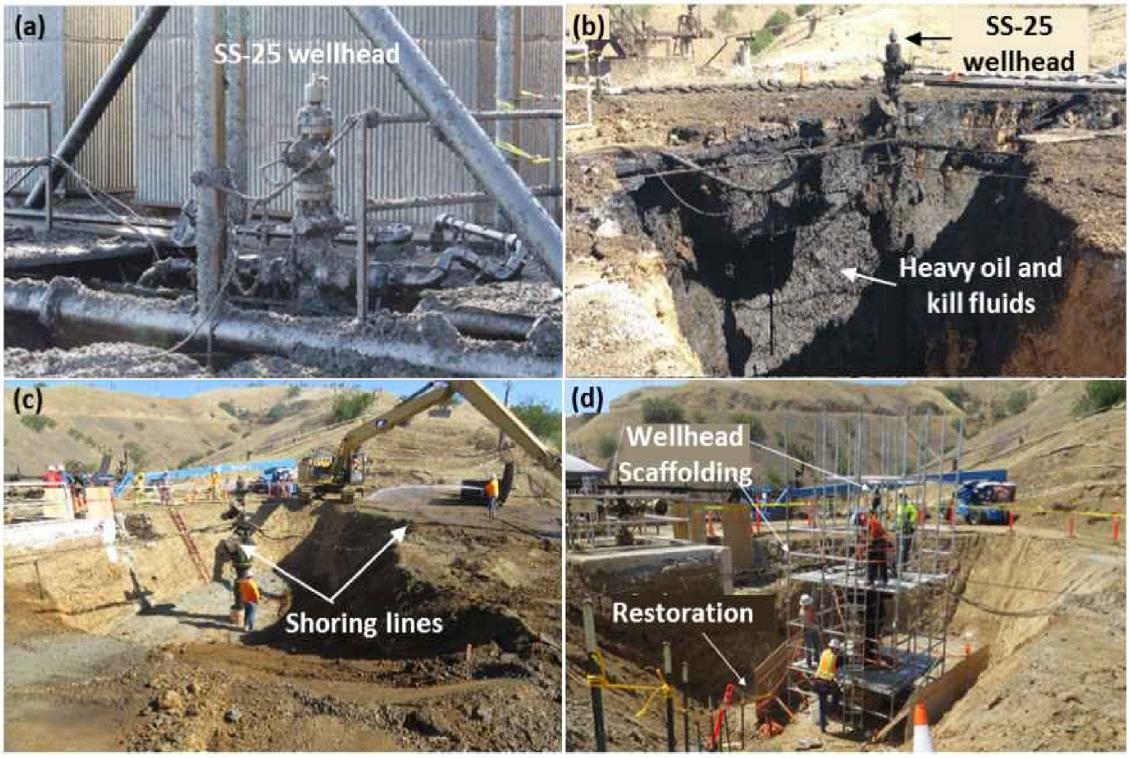

Figure 49: Steps to Access the Wellhead for Cleaning

5.3 SS-25 Wellhead Cleaning

The process developed by the cleaning of Frew 8 and test coupons was executed upon SS-25 with the scaffolding in place. The first step was to make a containment barrier with plastic sheeting as shown in Figure 50 (a) and (b). The wellhead was scraped with hand tools shown in Figure 50 (c) to remove all loose debris. Then the SmartStripPRO™ chemical was applied and wrapped for a 24 hour period. The stripper was then scraped along with all remaining debris (Figure 50 [d]). At this point, hydroblasting was employed as was done on Frew 8.

In Figure 51 (a), the same truck that performed the pressure washing on Frew 8 was requested. The water pressure came in at just over 21 ksi, as recorded by (Figure 51 [b]). This was considered high enough without any risk of damage. Final results are shown in Figure 51 (c) and (d). Photos were sent to RCS Inc. for evaluation. Light sandblasting was recommended to remove the flash rust that occurred immediately. Argus accommodated this request and the wellhead surfaces were considered clean enough for MPI.

5.4 Wellhead Inspection

The wellhead inspection was overseen by Blade and executed by RCS Inc. The procedure applied to the wellhead inspection is described in Appendix A. The details of RCS's general MPI procedures are given in Appendix D. This included wet, black-and-white contrast MPI of the wellhead and circumferential PAUT of the surface casing weld below the wellhead and above the conductor casing. Details of the inspection and specific findings are given in the RCS Inc. report (Appendix E). In short, no indications were found to suggest a leak. Eleven benign, crack-like indications were identified, but they were isolated to the surface. For the surface casing, small surface cracks were found. However, they were not leaks. These indications were of minor concern in terms of the integrity of the surface casing to support loads for extracting the tubing and casing. Radiography was scheduled but did not take place until after Phase 2. A full description of the indications found during the MPI and PAUT inspections of the wellhead and girth weld (GW), respectively are given in Appendix E.

Figure 50: SS-25 Chemical Cleaning and Containment

Figure 51: Hydroblasting of SS-25

6 Conclusions

This phase concluded with the completion of the wellhead inspection. The inspection showed that the wellhead was not the cause of the failure. No physical metallic evidence was found corresponding to a breach in pressure containment above ground. The cause of the failure was still unknown at the completion of this phase. Eleven small, benign defects and indications were found in the wellhead on MPI inspection. Also, crack-like indications were found in the girth weld connecting the wellhead to the surface casing. These defects are discussed in detail in the RCS report included herein.

Aerial photography was used to qualitatively document the as-found failure site and the extent of the incident. Wide-area laser scanning was then employed to quantitatively document the site's topography and the crater's internal dimensions.

No ejected metallic components or pieces of the wellhead or subsurface tubular sections were found after an exhaustive search. On determining the cause of the failure as a parting of the 7 in. casing, it was confirmed that no missing pieces existed. All SS-25 well components were completely accounted for.

Cleaning and inspection of the wellhead showed that it was not related to the failure. The leak came from below ground. Extraction of the tubular sections would be necessary to progress the investigation of a root cause.

Appendix A SS-25 MPI Inspection Procedure

The NDE inspector will give the final approval of the cleanliness of the wellhead such that inspections can be effectively executed.

A plan for inspecting wellhead SS-25 is given below. This plan will be refined based on the onsite evaluation of the wellhead and tree.

- The first step in the process is visual documentation following cleaning to confirm the cleanliness of the surface. It will be documented with photographs.
- The most likely NDI procedure to be utilized is MPI. Water-soluble contrast paint (black on white) will be used. If crack-like indications are found, UT may be used to determine depths. Alternatively, the indications may be marked and the indications opened at a later date.
- UT may be used to measure indication depth and wall thickness. However, MPI will be the primary inspection method.
- A bottom-up inspection approach will be engaged such that fluids are not continuously draining downwards and building up on lower wellhead components to be inspected later. Weld inspection is part of this exercise. For weld inspection sandblasting may be required.
- The inspection will be focused on the external surfaces of the wellhead at this point. Any and all anomalies will be identified and documented. If possible, the dimensions will be characterized. Following extraction of the wellhead and tree, the components will be further examined to assess if any of the anomalies are through-wall.
- The master valve housing is currently limited to visual inspection due to guy wire attachments that obscure access to its surface. This limits its inspection to visual methods.
- The wellhead will be removed before the tubing is pulled from the well.
- A decision will be made at that time if further inspection of the wellhead is necessary.

Appendix B Crater Fluid Sampling Protocol

A crater was formed during the blowout and kill operations of the SS-25 well. Fluids pooled at the bottom of the crater during the various events. Fluid samples are to be collected from the bottom of the crater for several reasons. This protocol describes the equipment, collection procedure, storage, and shipment of fluid samples obtained from the crater surrounding the wellhead. This protocol was subject to change as deemed necessary. Deviations will be documented in the final report.

Fluid sampling will be accomplished using a standard oil tank thief designed for fluids and semi-solids collection as shown in Figure 52.

Core-Type Sample Thief

Test Method

The K28100 Core-Type Sample Thief is used to manually obtain samples of a liquid, semi liquid or solid state whose vapor pressure at ambient conditions is below 101kPa (crude oil, etc.) in accordance to ASTM D4057.

Specifications

Conforms to the specifications of:
ASTM D4057
Capacity: 33 oz.
Empty Weight: 6.187 lbs
Sample Container Material: Polycarbonate
Markings: every inch from 3" to 14"
Distance from tank bottom to inlet valve: 1.729"
Max height: 21"
Max length: 4.7"
Max width: 4.2"

Ordering Information	
Catalog No.	
K28100	Core Type Sample Thief

Features

- Obtains bottom samples or samples from any level
- Butterfly valve on bottom for easy sampling
- Stainless steel and brass construction
- Three Petcocks for draining at different levels

Figure 52: Core-Type Thief

B.1 Containment Bottles

The fluid recovered from the crater will be transferred to suitable storage bottles. These will be similar to those shown in Figure 53, but may differ in size, color, or container lid.

(a) (b)

Figure 53: (a) 125mL VOA Glass Bottle with Teflon Seal and Expansion Port (b) 125mL Standard Glass Collection Bottle

The crater fluid depth will be measured at various locations with a 25 ft Jameson telescoping measurement pole as shown in Figure 54. The locations selected will be based on accessibility. Measurements will be made from the temporary bridge spanning the crater. A table of results will be constructed and populated with results. This will include location along the bridge and depth.

Figure 54: Jameson 25-ft telescoping measurement pole.

Appendix C Fluid Capture Procedure

The fluid will be manually removed from the crater by the Blade team. Blade personnel will be tethered to the bridge. Once at the wellhead, two Blade personnel will guide the thief down to the fluid using a drive pipe. The thief will be operated from the bridge using a rope, wire, chain, or other similar device. It is believed that the deepest part of the crater will be the area local to the conductor casing as shown in Figure 55.

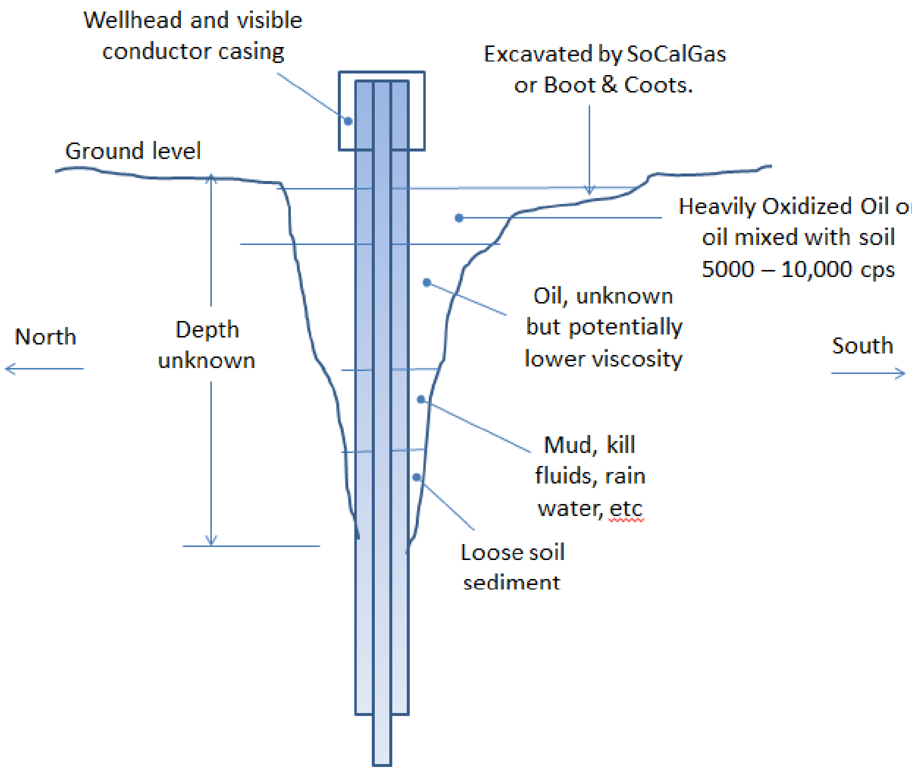

Figure 55: Conceptualization of the Soil surrounding the wellhead below the fluid level.

Blade will attach the fluid sampling thief to a 'drive' pipe as depicted in Figure 56. The reasoning for this is that the viscosity of the fluid may be too great for the thief to descend under its weight to collect fluid as originally designed. The drive pipe will positively locate the thief at the desired depth. Then, the thief will be actuated remotely using a rope, wire, chain, etc. This procedure will be empirically evaluated before it is deemed acceptable for actual fluid collection. Figure 56 depicts the proposed method of driving the thief and activating it at the desired depth. Various depths will be sampled. The total depth will drive the depth interval of the sample. Currently, it is proposed that fluid will be taken at 0, 10, and 20 ft, but this is subject to change based on the results of the depth measurement.

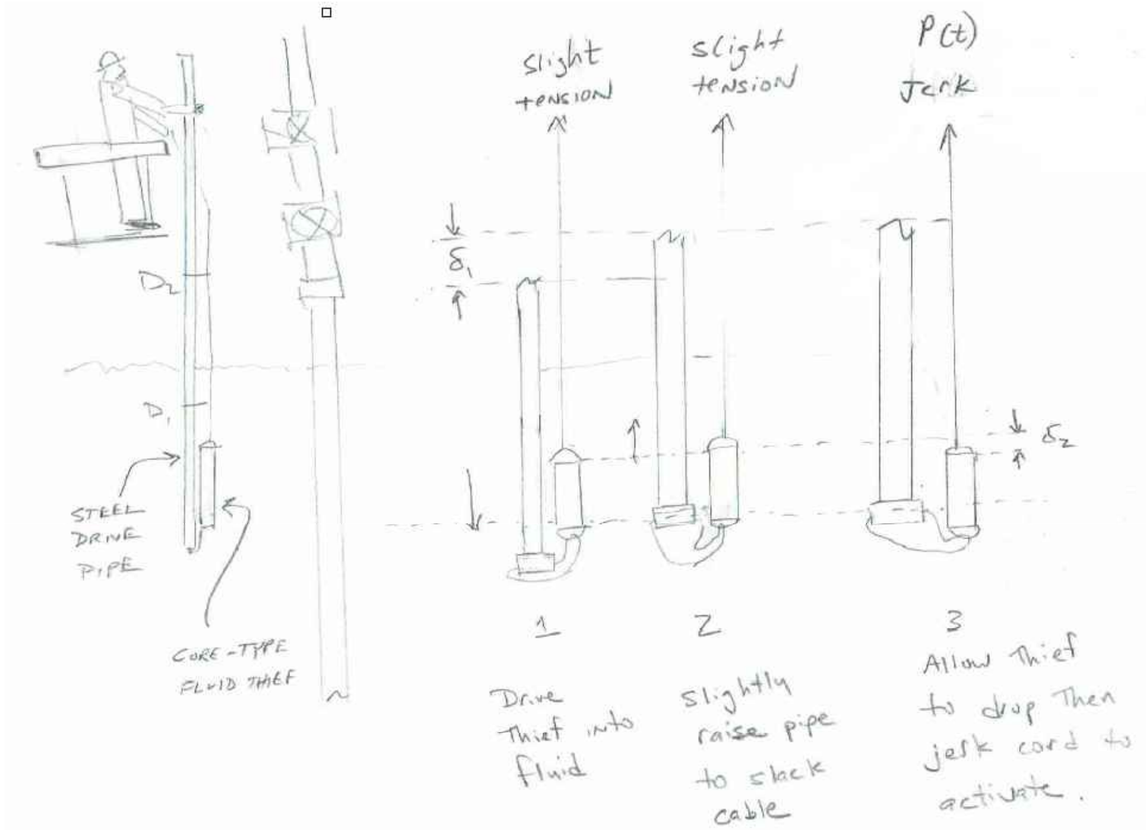

Figure 56: Proposed Thief-ing Procedure Utilizing a Drive Pipe

C.1 Sampling and Shipment

The amount of fluid captured at any one depth will vary and will be based on the effectiveness of the thief to capture samples as a function of the local viscosity. In some cases, multiple trips into the crater may be necessary. Five (5) sample bottles will be filled from the fluid at each depth. If non-volatile organic compound lids are used, the bottles will be filled to approximately 80% capacity. VOC bottles will be filled to approximately 100% capacity.

Once captured, the samples disposition will follow the evidence collection protocol stated in Aliso Canyon RCA SS25 Site Evidence Collection and Site Documentation Protocol Phase 1 Version 6. One sample from each depth will be retained by Blade. The other four (4) samples will be turned over to parties as instructed by SoCalGas, DOGGR, or CPUC. Blade will ship the bottles in sealed containers to Texas OilTech Laboratories (TOL) for analysis. The analyses to be performed are to be determined.

Appendix D RCS Inspection Method

Riccardelli Consulting Services

MAGNETIC PARTICLE INSPECTION
YOKE METHOD

RCS-MT-001
REVISION 0, 8-26-15

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1.0 PURPOSE

1.1 The purpose of this procedure is to provide detailed instructions for the performance of magnetic particle examination using the continuous yoke technique with either visible or fluorescent particles in accordance with ASME Section V, Article 7.

2.0 REFERENCE DOCUMENTS

2.1 ASME Section V, Article 7 2004 Edition with Addenda

2.2 ASME Section VIII, Division 1 Latest Edition with Addenda

2.3 ANSI/ASME B31.1, Latest Edition with Addenda

2.4 ANSI/ASME B31.3, Latest Edition with Addenda

2.5 ASTM E-709, Latest Edition

2.6 ASTM E2297

2.7 API Standards 5L, 510, 570, 650, 653, 1104 Latest Editions

2.8 CP-189, 2011 Edition

2.9

2.10 RCS-WP-001

3.0 PERSONNEL

3.1 RCS personnel performing work to this procedure shall be qualified and certified in accordance with the requirements of RCS Written Practice, RCS-WP-001.

3.2 Level I personnel shall be allowed to perform magnetic particle examinations under the direct supervision of Level II or III personnel.

3.3 Evaluation of indications and test results shall be performed by a Level II or III.

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4.0 EQUIPMENT AND MATERIALS

4.1 The following equipment and materials shall be available at the start of each magnetic particle examination

4.1.1 AC or DC electromagnetic yokes
4.1.2 10 lb. test plate for AC yokes and 40 lb. test plate for DC yokes
4.1.3 Medium for use in the examination
4.1.4 Solvent cleaners as necessary
4.1.5 UV & white lighting equipment when needed
4.1.6 UV & white light meters

5.0 METHOD OF EXAMINATION

5.1 The ferromagnetic particles used in an examination medium can be either wet or dry, and may be either fluorescent or non-fluorescent. Examination(s) shall be done with the continuous method.

5.2 Dry Particles

5.2.1 The magnetizing current shall remain on while the examination medium is being applied and while any excess of the examination medium is removed.

5.3 Wet Particles

5.3.1 The magnetizing current shall be turned on after the particles have been applied. Flow of particles shall stop with the application of current. Wet particles applied from aerosol spray cans may be applied before and/or after magnetizing current is applied. Wet particles may be applied during the application of magnetizing current if they are not applied directly to the examination area and are allowed to flow over the examination area or are applied directly to the examination area with low velocities insufficient to remove accumulated particles.

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6.0 MATERIAL CHARACTERISTICS

6.1 General

6.1.1 Magnetic Particles must have high permeability

6.1.2 Particle size and shape must be uniform

6.1.3 Particles should be free of rust, grease, paint, dirt and other foreign materials

6.1.4 Color selection to be based on what will provide adequate contrast with the surface being examined

6.2 Dry Particles

6.2.1 Dry particles are not to be used on surfaces with temperatures exceeding 600 °F.

6.3 Wet Particles

6.3.1 The temperature of a wet particle suspension shall not be used on surfaces with temperatures exceeding 125 °F, unless otherwise specified by manufacturer.

6.4 Wet Suspension vehicle (oil)

6.4.1 Minimum flash point of 200 °F.

6.4.2 Low inherent fluorescence

6.5 Wet Suspension vehicle (water)

6.5.1 If water is used as a vehicle, the solution shall be mixed in proportions to ensure no flaw may be missed. Application shall be with a suitable pump or sprayer. Manufacturer recommendations shall be followed except when using alternate techniques that have been validated.

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7.0 LIGHTING

7.1 Non-fluorescent examinations

7.1.1 A minimum of 100 fc (1000 Lx) is required on the surface to be examined to ensure adequate sensitivity during the examination and evaluation of indications. The light source, technique used and light level verification is required to be demonstrated one time, documented, and maintained on file.

7.2 Fluorescent examinations

7.2.1 The examination must be performed in a darkened area.

7.2.2 The examiner shall be in the darkened area for at least 5 minutes prior to performing the examination to enable their eyes to adapt to dark viewing. If the examiner wears glasses or lenses, they shall not be photosensitive.

7.2.3 The black light shall be allowed to warm up for a minimum of 5 minutes prior to use or measurement of the intensity of the ultraviolet light emitted. Reflectors and filters shall be checked daily when in use. Cracked or broken filters shall be immediately replaced. Newer LED type lights may not require warmup. For these types follow manufacturer's recommendations for use.

7.2.4 The black light intensity shall be measured with a black light meter. A minimum of 1000 $\mu W/cm^2$ on the surface to be examined is required. The black light intensity shall be verified at least once every 8 hours, whenever the work station is changed, or whenever the bulb is changed.

7.2.5 The intensity of the visible ambient light in the darkened area shall not be more than 2 fc (20 Lx).

8.0 SURFACE PREPARATION

8.1 The surface to be examined and any adjacent areas within at least (1) inch shall be dry and free from oil, grease, sand, loose rust, or loose scale and paint. As-cast, as-rolled, as- forged, or as-welded surfaces are generally satisfactory if clean and if the weld contour blends into the base metal without undercutting. If the surface is unusually rough, such as with burned-in sand or a very rough weld

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bead, interpretation may be difficult because the powder is mechanically trapped. Cleaning may be accomplished using detergents, organic solvents, de-scaling solutions, paint removers, vapor de-greasing, sand or grit blasting or ultrasonic cleaning methods.

8.2 If coatings are left on the part in the area being examined, it must be demonstrated that indications can be detected through the maximum coating thickness.

9.0 EQUIPMENT CALIBRATION

9.1 Yokes

9.1.1 Prior to use, the magnetizing power of electromagnetic yokes shall be checked daily. The magnetizing power of the electromagnetic yoke shall be documented annually. The magnetizing power of all yokes shall be checked whenever the yoke has been damaged or repaired.

9.1.2 Each alternating current electromagnetic yoke shall have a lifting power of at least 10 lbs at the maximum pole spacing that will be used.

9.1.3 Each direct current electromagnetic yoke shall have a lifting power of at least 40 lbs at the maximum pole spacing that will be used.

9.1.4 Each weight shall be weighed with a scale from a reputable manufacturer and stenciled with the applicable nominal weight prior to first use. A weight needs only be verified again if damaged in a manner that could have caused potential loss of material.

9.1.5 Light meters, both visible and fluorescent (black) light meters, shall be calibrated at least once a year or whenever the meter has been repaired. If meters have not been in use for one year or more, calibration shall be done before being used.

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10.0 EXAMINATION TECHNIQUE

10.1 Examinations shall be carried out by the continuous method. For examinations utilizing dry particles method, the application shall be done in accordance with section 5.3 of this procedure; for examinations utilizing the wet particle method, the application shall be done in accordance with section 5.4.

10.2 At least two separate examinations shall be performed, the second at approximately 90° to the first.

10.3 Overlap shall be sufficient to assure 100% coverage.

10.4 Yoke method procedure

10.4.1 Application – This method shall be used only to detect discontinuities open to the surface.

10.4.2 Application – This method shall be used only to detect discontinuities open to the surface.

10.4.3 Examination medium – Magnetic particles in either dry or wet form shall be used with the yoke method.

10.4.4 AC or DC yokes shall be used.

10.4.4.1 Except for materials ¼ inches or less in thickness, AC yokes are superior to DC yokes of equal lifting power for the detection of surface discontinuities

10.4.5 When it is necessary to verify the direction of the magnetizing field, the Magnetic Particle Field Indicator (Attachment I) shall be used by positioning the indicator on the surface to be examined.

10.4.6 The yoke is positioned on the surface to be examined and the magnetizing current turned on. The dry or wet particles are then applied to the area to be examined in accordance with section 5.0. Indications of defects are noted and the second examination of the area at approximately 90° to the first is made. All indications shall be evaluated in accordance with the applicable code and addendum specified. Examination shall be conducted with sufficient overlap to assure 100% coverage at the established test sensitivity.

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11.0 EVALUATION OF INDICATIONS

11.1 All indications shall be evaluated in accordance with the specified acceptance standards.

11.2 Discontinuities at the surface will be indicated by retention of the examination particles. However,localized surface irregularities due to machining marks or other surface conditions may produce false indications.

11.3 Broad area of particle accumulation which could mask indications of discontinuities is unacceptable and such areas shall be cleaned and re-examined.

11.4 Any indication which is believed to be non-relevant shall be regarded as a defect and shall be re- examined to verify whether or not actual defects are present. Surface conditioning may precede the re-examination.

11.5 A relevant indication is one which results from a mechanical discontinuity and which produces an indication whose major dimensions are greater than 1/16th of an inch.

11.6 A linear indication is one having a length greater than three times the width.

11.7 A rounded indication is one of circular or elliptical shape with the length equal to or less than three times the width.

11.8 Three or more indications are considered aligned when a line drawn between the centers of the two outermost indications touches any part of those indications between.

12.0 MARKING OF INDICATIONS

12.1 All indications shall be marked and located in regards to the “0” datum point location. The location of the indication shall be marked per customer requirements, in the downstream, clockwise direction from the “0” datum location. The datum location shall be as follows for each piece of equipment.

12.1.1 Piping

For all vertical runs of pipe the datum point will be on the North

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side of the pipe. For all horizontal runs of pipe the top of the pipe will be the datum point.

12.1.2 Heat Exchangers

For all vertical heat exchangers, the datum point will be North side of the heat exchanger. For all horizontal heat exchangers, the top of the heat exchanger will be the datum point.

12.1.3 Columns and Vessels

For all vertical columns and vessels, the datum point will be the North side of the column or vessel. For all horizontal vessels, the datum point will be the top of the vessel.

13.0 ACCEPTANCE CRITERIA

13.1 API-1104

Relevant indications shall be considered defects should any of the following conditions exist:

13.1.1 Linear Indications evaluated as crater cracks or star cracks exceeding 5/32 in. (4mm) in length.

13.1.2 Linear indications are evaluated as cracks other than crater cracks or star cracks.

13.1.3 Linear indications are evaluated as IF and exceed 1 in. (25mm) in total length in a continuous 12 in. (300mm) length of weld or 8% of the weld length.

Rounded indications shall be evaluated according to the criteria of API-1104-Section 9.3.9.2 and 9.3.9.3, as applicable. For evaluation purposes, the maximum dimension of a rounded indication shall be considered its size.

13.2 ASME Section VIII, Division 1

Only indications with major dimensions greater than 1/16 inches shall be considered relevant. All surfaces to be examined shall be free of:

13.2.1 Relevant linear indications

13.2.2 Relevant rounded indications greater than 3/16 inches

13.2.3 Four or more rounded indications in a line separated by 1/16 inches or less (edge to edge)

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An indication of an imperfection may be larger than the imperfection that caused it; however the size of the indication is the basis for acceptance evaluation

13.3 ASME B31.1, Power Piping

The following relevant indications will be unacceptable:

13.3.1 Any crack or linear indication

13.3.2 Rounded indications with dimensions greater than 3/16 inches

13.3.3 Four or more rounded indication in a line separated by 1/16 inches or less (edge to edge)

13.3.4 Ten or more rounded indications in any 6 square inches of surface area with the major dimension of this area not to exceed 6 inches with the area taken in the most unfavorable location relative to the indications being evaluated.

13.4 ASME B31.3, Chemical Plant and Petroleum Refinery Piping

Each examined surface shall be free of cracks

13.4.1 API 510, 570, 650 and 653

Indications will be revealed by retention of magnetic particles. All such indications are not necessarily imperfections, however, since excessive surface roughness, magnetic permeability variations (such as at the edge of a heat affected zones), etc., may produce similar indications.

An indication of an imperfection may be larger than the imperfection that causes it; however, the size of the indication is the basis for acceptance evaluation. Only indications which have any dimensions greater than 1/16 inches shall be considered relevant.

13.4.2 A linear indication is one having a length greater than 3 times the width

13.4.3 A rounded indication is one of circular or elliptical shape with a length equal to or less than three times its width.

13.4.4 Any questionable or doubtful indications shall be re-examined to determine whether or not they are relevant.

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14.0 REPORTING

14.1 A suitable report of the NDE results shall be completed for each required examination. Content of the report shall include pertinent data to the exam such as

14.1.1 Procedure Identification and Revision (code required only)

14.1.2 Magnetic particle equipment and type of current Magnetic particles (visible or fluorescent, wet or dry)

14.1.3 Qualification of personnel

14.1.4 Map and record of indications, if any found

14.1.5 Material and thickness (if applicable)

14.1.6 Lighting equipment, i.e. flashlight, black light, etc.

14.1.7 Date and time of examination

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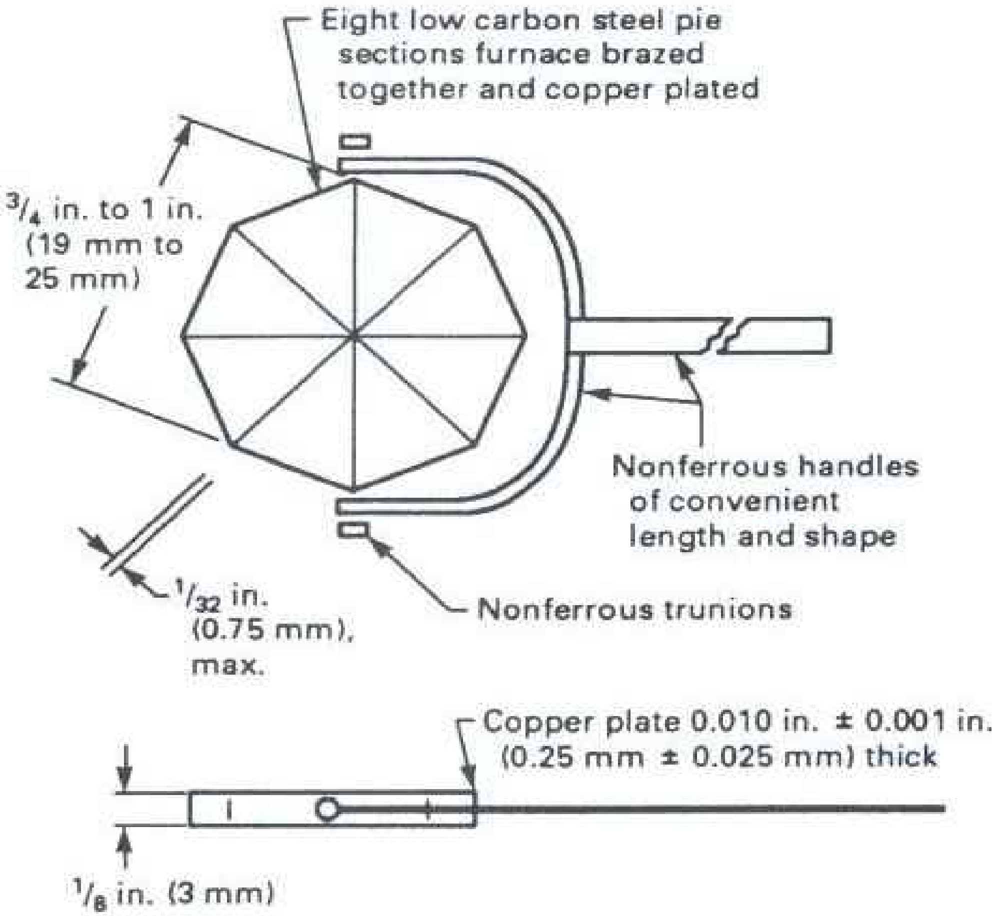

Attachment 1

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Appendix E RCS Inspection Report

Riccardelli Consulting Services, Inc.

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Executive Summary

Project: Magnetic Particle Inspection, Wellhead SS-25
Dates: July 15-18, 2016

Riccardelli Consulting Services (RCS), Inc, at the request of Blade Energy, was contracted to assist in the development of an NDE inspection procedure, execution plan, and comprehensive magnetic particle inspection (MPI) of an existing, out-of-service, subterranean gas storage wellhead identified as Wellhead SS-25. RCS' Sean Riccardelli, an ASNT NDT Level III, was selected to provide the on-site MPI inspection of select components at SS-25.

June 15
Arrived on site at Blade Energy main office, Aliso Canyon, and met with Ken George of Blade Energy to discuss details regarding the current status of the project and the day's objective. Shortly thereafter, traveled to wellhead site SS-25. After a crew safety meeting, identifying potential hazards and mandatory safety protocol, an introduction was made of key personnel supporting the inspection. Blade and RCS decided that a Visual Inspection of the components to be non-destructively evaluated would be performed. It was immediately observed that the steel pipe protruding out of the ground to the surface casing had significant flash rust and surface scale, above and below the girth weld, up through and including the surface casing flange. It was communicated that a confident MPI inspection would require additional preparation of the surfaces to be inspected. As the visual inspection continued, it was identified that additional areas contained surface residue that may interfere with the MPI. It was agreed upon that additional hydroblasting and sandblasting of the surface casing would be conducted. RCS proceeded to set up for MPI equipment calibrations and solution ratios.

Electricity was provided through 120ft of industrial grade 110V cord and the MPI lift test conducted at the maximum length to be used during inspection. Once the surface preparation of the wellhead was completed, a second visual inspection was conducted and found to be acceptable for MPI the following day.

June 16

Arrived at wellhead site SS-25 at 7am to meet with Blade Energy and site personnel for safety briefing. The contractor proceeded to clean up and prepare the platform for inspection. It was requested that all debris be blown off the wellhead components and the components be allowed to dry completely prior to the application of MPI white contrast paint. RCS conducted MPI strength tests, magnetic field indicator, sensitivity, and solution evaluation at the point of inspection. An ambient light meter test was also conducted to validate ambient light was in compliance with industry standard and adequate for MPI inspection without artificial lighting. The remainder of the day was spent photographing, evaluating and labeling all relevant MPI indications detected from the surface casing to the tubing head adapter. A total of 5 MPI indications were recorded and photographed. Please refer to RCS photo reports and Blade Energy MPI Inspection Summary.

June 17 a.m.

Arrived at wellhead site SS-25 at 7am to meet with Blade Energy and site personnel for safety briefing. RCS conducted MPI strength tests, magnetic field indicator, sensitivity, and solution evaluation at the point of inspection. The first part of the day was spent photographing, evaluating and labeling all relevant MPI indications detected on the wellhead tree cross, wing valves, and main valve. A total of 6 MPI indications were recorded and photographed. Please refer to RCS photo reports and Blade Energy MPI Inspection Summary.

June 17 p.m.

Proceeded to calibrate for Ultrasonic Thickness Testing (UTT) of the wellhead surface casing to identify component thickness intersecting piping components above and below the horizontal girth weld. Once thicknesses were identified, RCS proceeded to calibrate for Phased Array Ultrasonic Testing (PAUT) and depth sizing of linear surface-breaking indications detected on the surface casing piping below the horizontal girth weld. These indications were clearly identified surface indications having shallow depth less than 10% of pipe wall thickness.

Blade Energy representative requested a screening of the girth weld. At the reluctance of RCS to provide any screening of this weld due to poor surface conditions (gouges, corrosion, uneven contour), the unknown weld configuration, inadequate time to prepare a qualified procedure, and proper equipment on hand to deliver a preferred inspection, RCS proceeded to provide a manual, *for information only*, phased array ultrasonic examination as an unofficial screening of weld soundness. It was determined, through manual inspection and imaging, that multiple ultrasonic reflectors were identified within the weld cross section. It is suspected that both linear indications at the weld root and volumetric indications within the weld body are present. Most indications appear sporadic and intermittent across the length of the weld. Given the results of the ultrasonic screening, it was advised that the weld be radiographed or allow time and preparation to provide a more advanced level of fully-encoded ultrasonic testing using fixed automation with multi-probe/multi-group phased array.

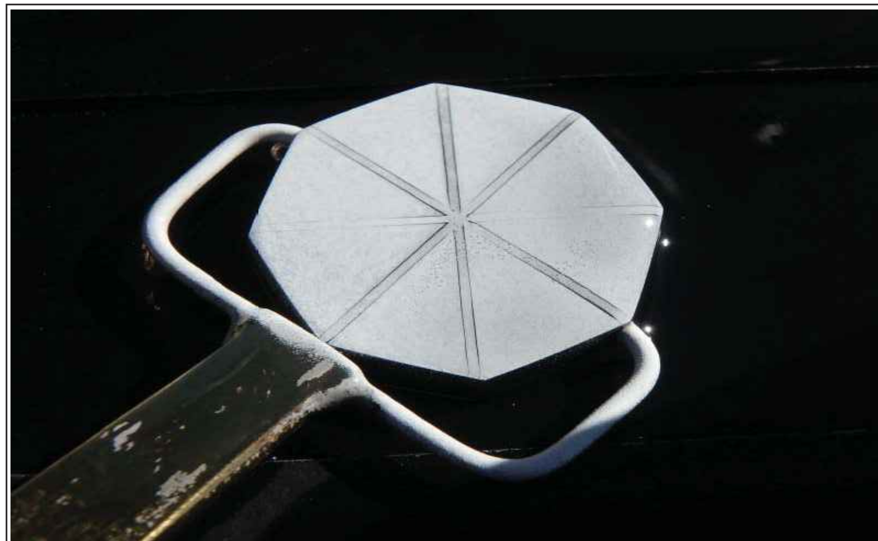
Photo Report

Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	SS-25 Wellhead/Christmas Tree

Description : New AC Yoke and New 10lb lift block

Description : Lift test

Description : Magnetic field indicator



Description : Magnetic field indicator +90 degrees

Photo Report

Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	

Description : GW located at lower end of wellhead surface casing

Description : Surface lamination detected at 292.5 degrees below girth weld

Description : close-up of surface lamination continuing downward

Description : macro of surface lamination

Photo Report

Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	SS-25 Wellhead/Christmas Tree

Description : Wellhead flanges after MPI contrast paint application

Description : Wellhead flanges after MPI contrast paint application

Description : Ambient light meter placed in shaded area. Typical reading

Description : Ambient light meter placed in sunlit area. Typical reading

Photo Report

Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	SS-25 Wellhead/Christmas Tree

Description : Surface preparation of wellhead tree prior to MPI contrast paint

Description : Surface preparation of wellhead tree prior to MPI contrast paint

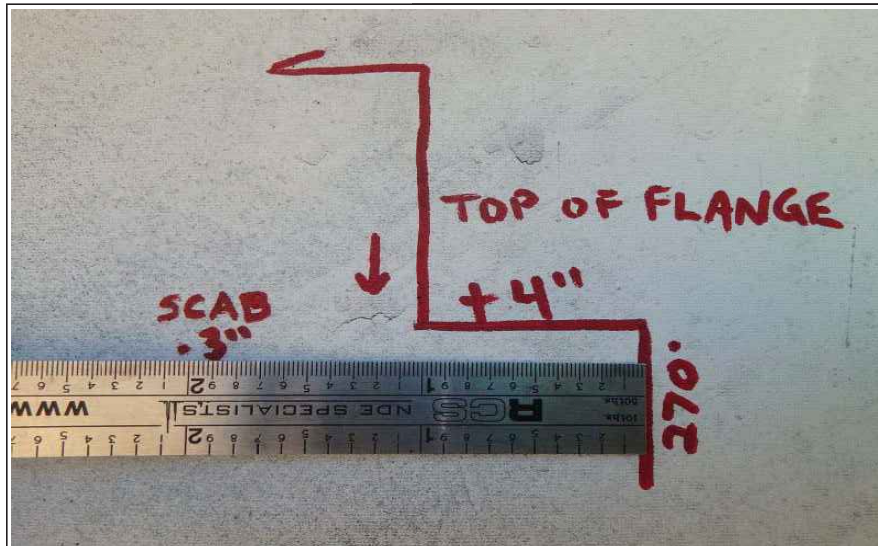
Description : Surface preparation of wellhead tree prior to MPI contrast paint

Description : Surface preparation of wellhead tree prior to MPI contrast paint

Photo Report

Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	SS-25 Wellhead/Christmas Tree

Description : General location of surface scab on upper flange



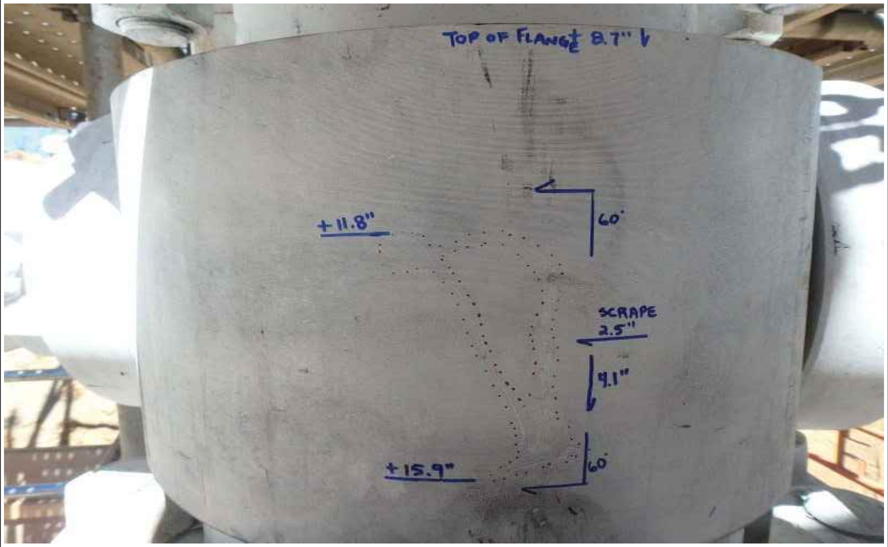
Description : General location of surface scab on upper flange

Description : Macro of surface scab: Horizontal measurement

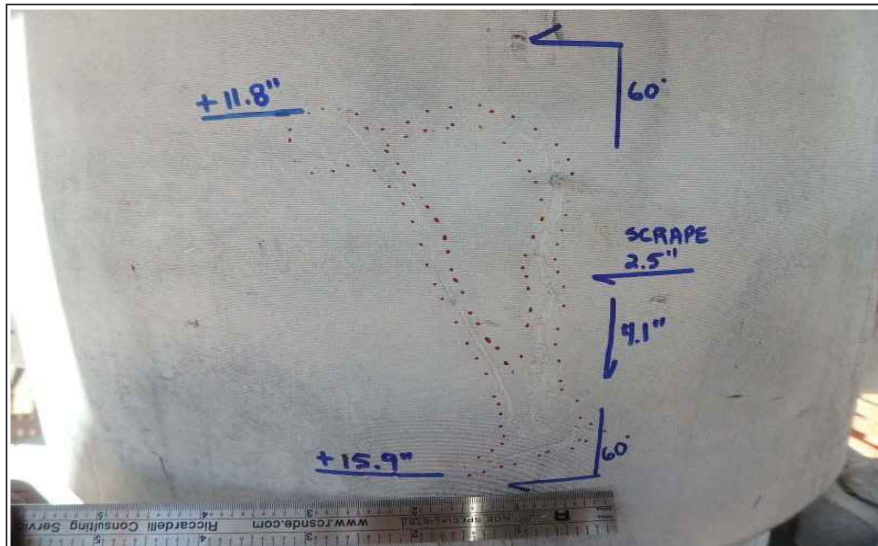
Description : Surface scab: Vertical measurement

Photo Report

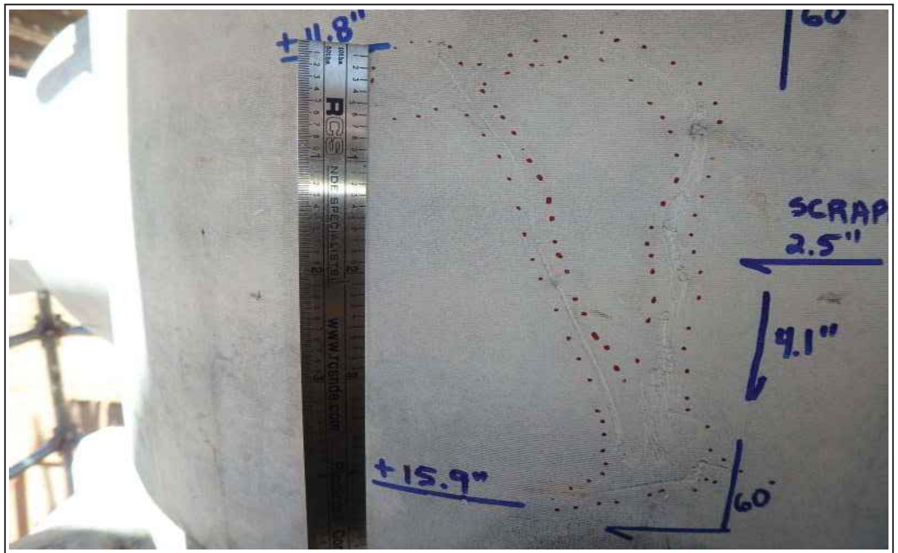
Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	SS-25 Wellhead/Christmas Tree



Description : General location of mechanical surface anomaly: scrapes/gouge



Description : Mechanical surface anomaly: horizontal measurement



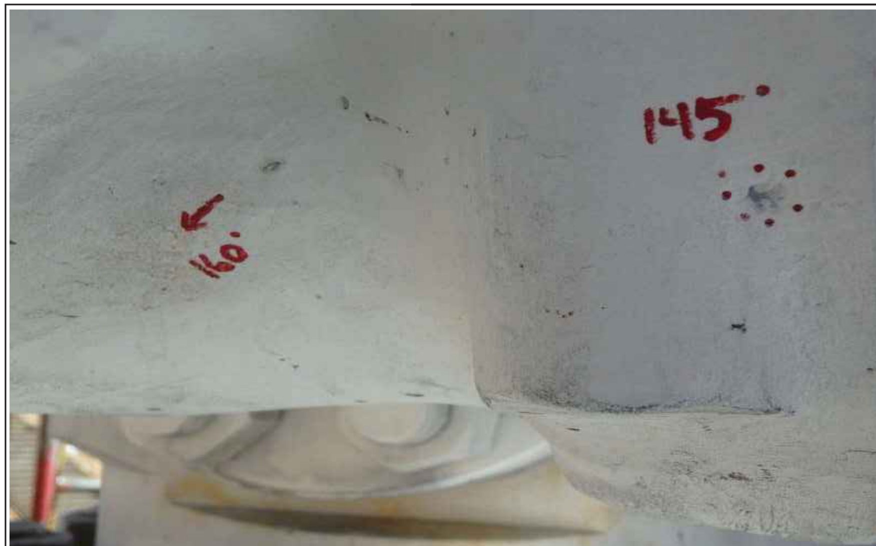
Description : Mechanical surface anomaly: vertical measurement

Description : Macro of surface gouge; material displacement

Photo Report

Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	SS-25 Wellhead/Christmas Tree

Description : General location of surface anomalies



Description : General location of surface anomalies

Description : Macro of surface anomaly at 145 degrees: pit

Description : Macro of surface anomaly at 160 degrees: scab

Photo Report

Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	SS-25 Wellhead/Christmas Tree

Description : Top of tree prior to application of MPI contrast paint

Description : Top of tree prior to application of MPI contrast paint

Description : Top of tree after application of MPI contrast paint

Description : Top of tree after application of MPI contrast paint

Photo Report

Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	SS-25 Wellhead/Christmas Tree

Description : General location of crack-like anomaly found during MPI

Description : Location of crack-like anomaly

Description : Close-up of crack-like anomaly: horizontal measurement

Description : Macro of crack-like anomaly plus adjacent hole

Photo Report

Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	SS-25 Wellhead/Christmas Tree

Description : General location of crack-like anomaly

Description : 2.2" crack-like anomaly found

Description : close-up of crack-like within 1st inch

Description : close-up of crack-like within 1st inch

Photo Report

Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	SS-25 Wellhead/Christmas Tree

Description : General location of surface anomalies

Description : Two surface anomalies just above stamped alpha/numerals

Description : Close-up of surface anomalies: vertical measurement

Description : Macro of lower surface anomaly

Photo Report

Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	SS-25 Wellhead/Christmas Tree

Description : General location of surface anomalies

Description : General location of surface anomalies

Description : Close-up of surface anomalies: horizontal measurement

Description : Close-up of surface anomalies: vertcal measurement

Photo Report

Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	SS-25 Wellhead/Christmas Tree

Description : General location of surface anomaly

Description : General location of surface anomaly: horizontal measurement

Description : General location of surface anomaly: vertical measurement

Description : Close-up of surface anomaly

Photo Report

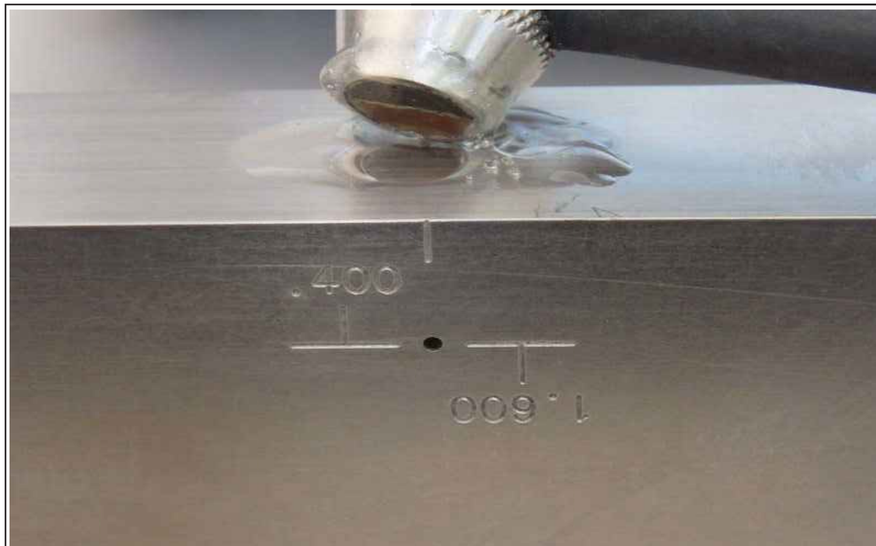
Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	SS-25 Wellhead/Christmas Tree

Description : SS-25 Wellhead MPI Complete

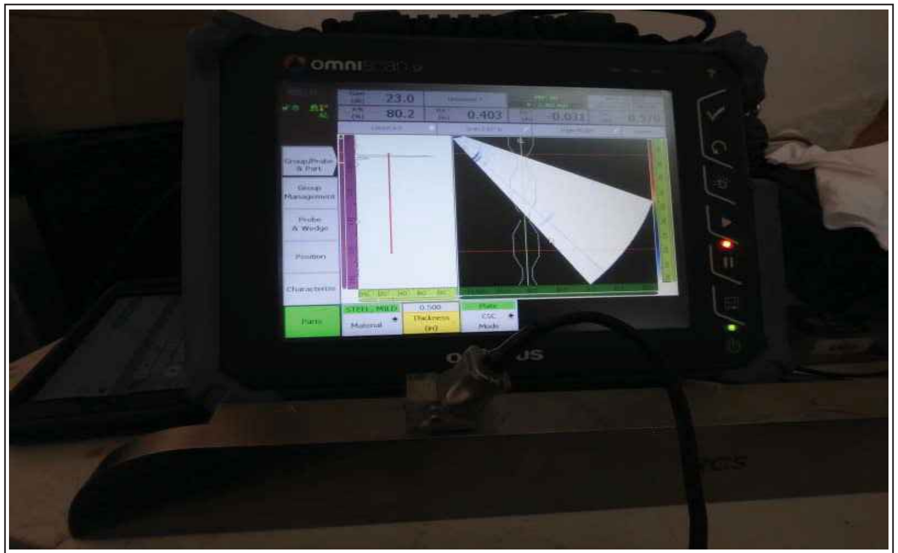
Photo Report

Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	SS-25 Wellhead/Christmas Tree

Description : UTT equipment and depth verification prior to crack sizing



Description : .400" deep SDH and dual element transducer



Description : PAUT post-calibration showing .403" depth measurement

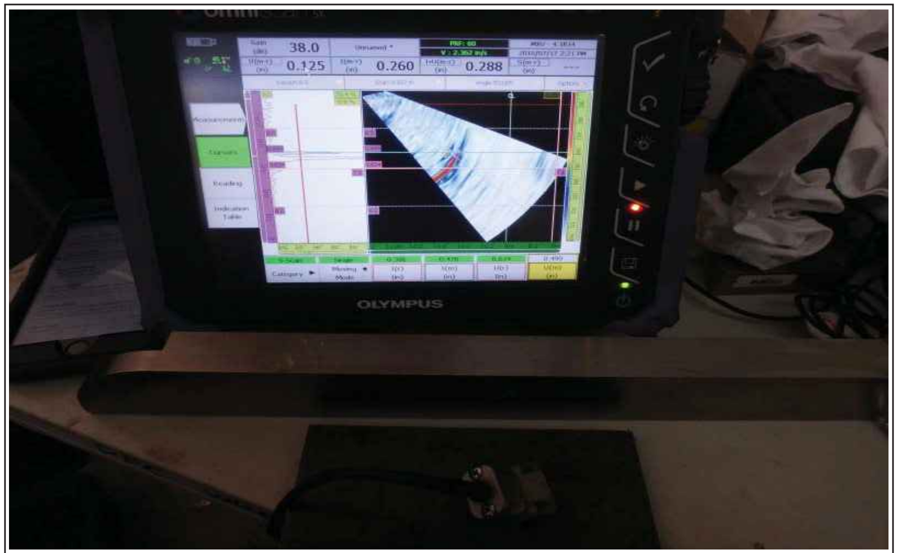
Description : .400" deep SDH and 10L16 PAUT transducer with N55S wedge

Photo Report

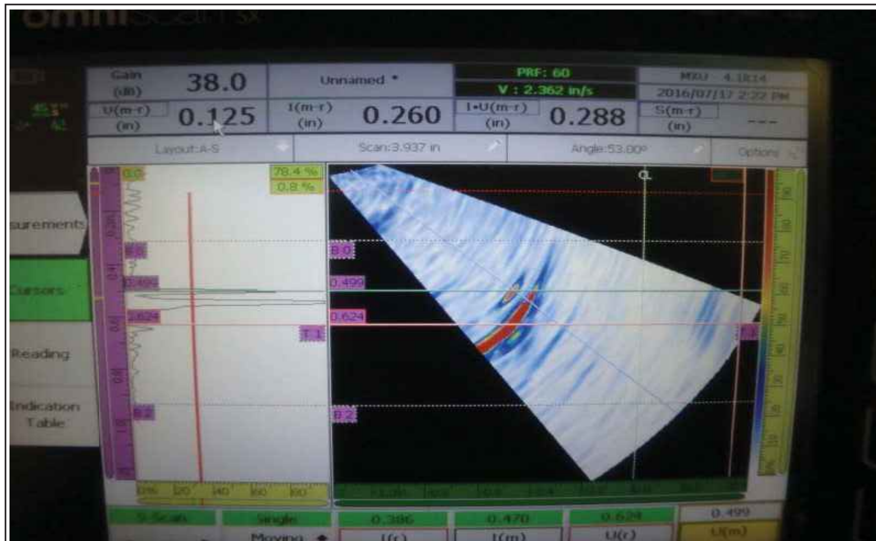
Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	SS-25 Wellhead/Christmas Tree

Description : Custom calibration standard with .125" deep EDM notch

Description : 10L-16 PAUT Transducer on EDM notch for depth cal check



Description : Omniscan SX screenshot: validation of .125" measurement



Description : Close-up of depth verification and tip-diffracted signal in Sscan

Photo Report

Line ID:	SS-25
AFE / WO / PO:	Blade Energy
Project:	Wellhead MPI
Line Description:	SS-25 Wellhead/Christmas Tree

Description : Post-UT and GW (approximately north facing)

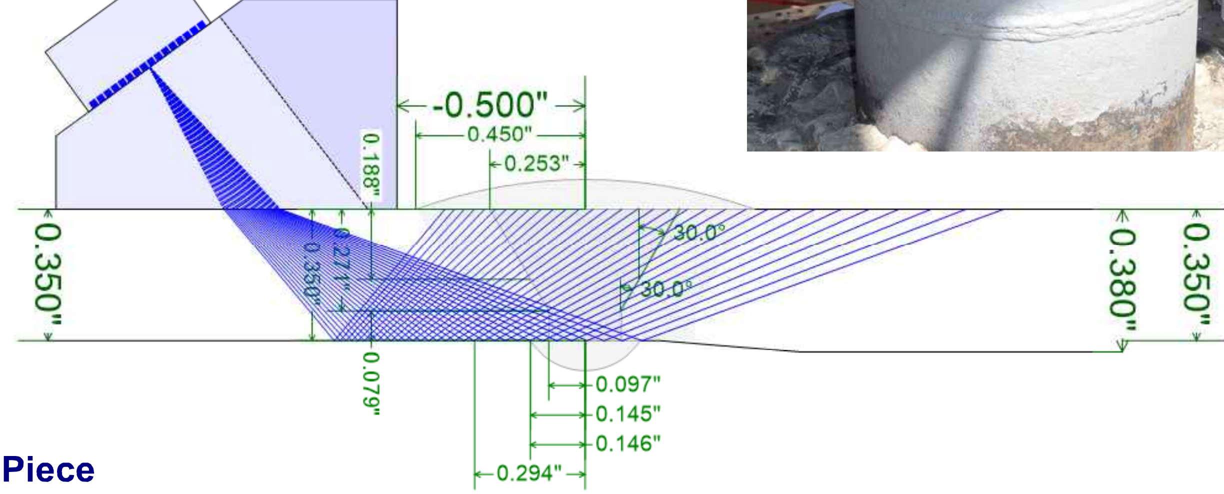
Description : Post-UT and GW (approximately east facing)

Description : Post-UT and GW (approximately south facing)

Description : Post-UT and GW (approximately west facing)

RCS Scan Plan

Inspection Layout



Piece

Thickness	Index Offset	Material	Shear Velocity	Compression Velocity
0.35"-0.375"	.5"	Steel 1020	0.13IN/s	0.23IN/s

HAZ Width: 0.375"

Phased Array Probe: PA Probe

Index Offset: -0.5" **Scan Offset:** 0"

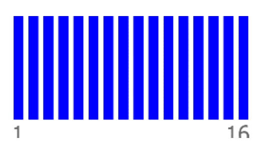
Sectorial Beamset 1 Beamset

Law Config.: Sectorial **Wave Type:** Shear

Element Qty	First Element	Min Angle	Max Angle	Angle Steps	Focus
16	1	40°	70°	0.97°	.6"

Wedge: SA10-N55S 5L16-A10

Velocity	Primary Offset	Height 1st Element	Length	Width	Angle
0.09in/s	0.8"	0.27"	0.91"	0.91"	36.1°

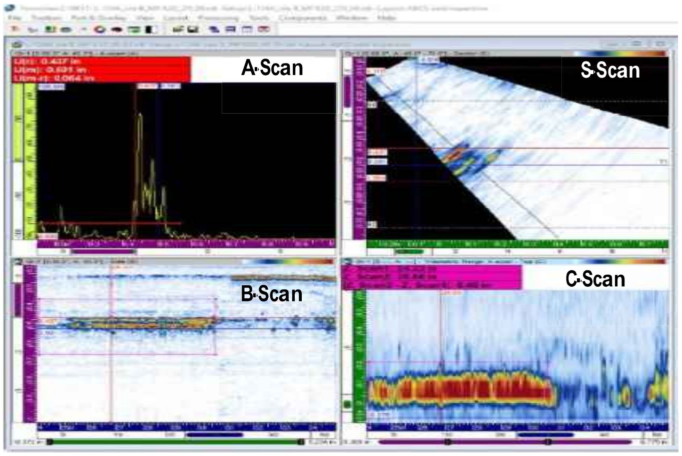


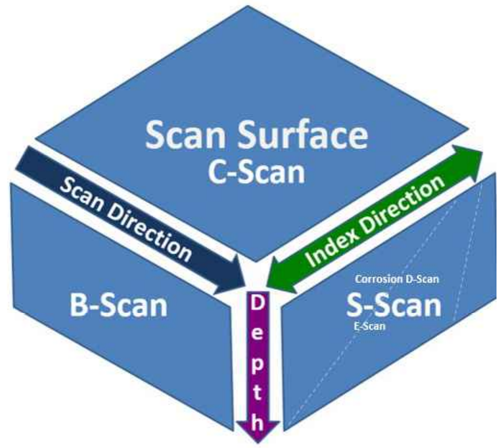
Transducer: 10L16-A10

Total Aperture: 0.38" **Number of Elements:** 16 **Element Pitch:** 0.02"

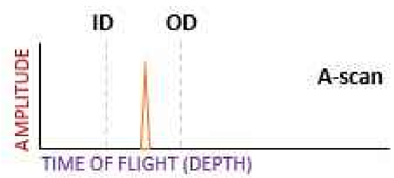
Document Date: Sunday, July 17, 2016

Phased Array Views





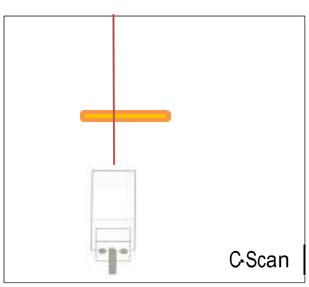
A-scan is the basis for all Ultrasonics.
-It represents travel and return intensity of sound within a part.
-The time of travel (**time of flight**) is calibrated to show representation as depth. (horizontal plane.
-The returning intensity of the sound energy is represented by the height of a peak (**amplitude** in vertical plane)

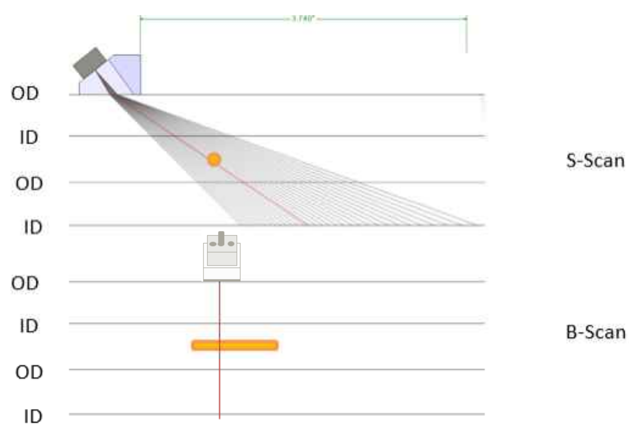


Deconstructed 3D representation

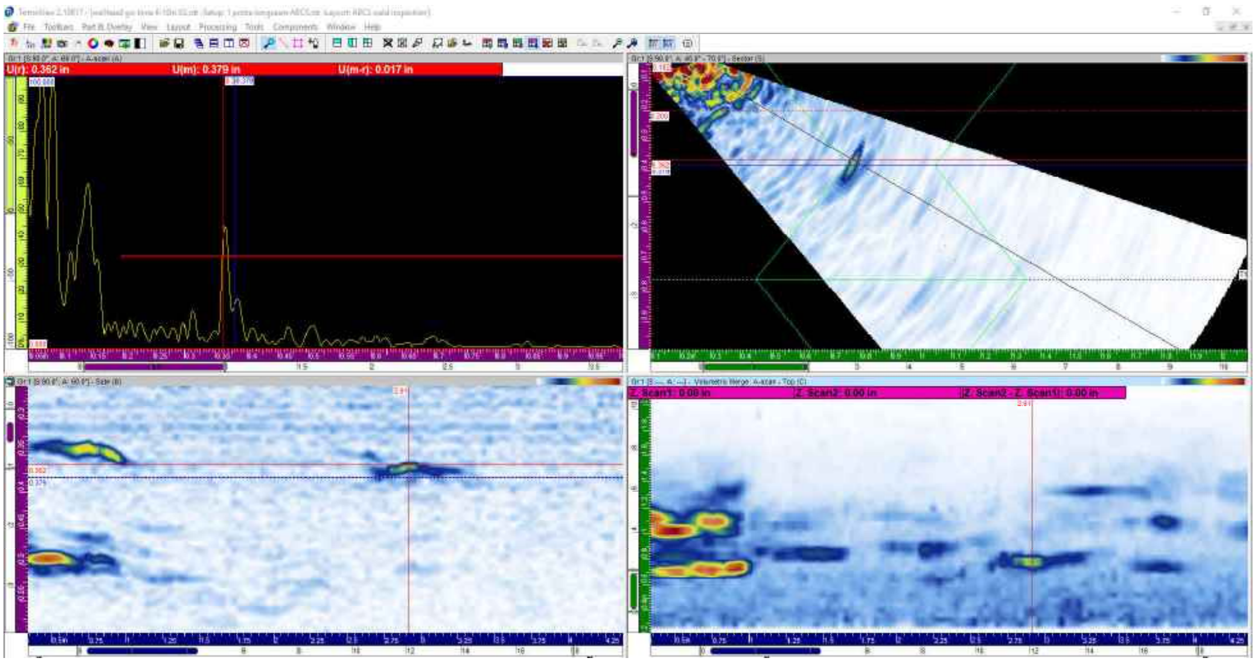
Sound Propagation in a part

How the same reflector is represented in Phased Array views.





Phased array imaging of typical indications within horizontal Girthweld at surface casing.



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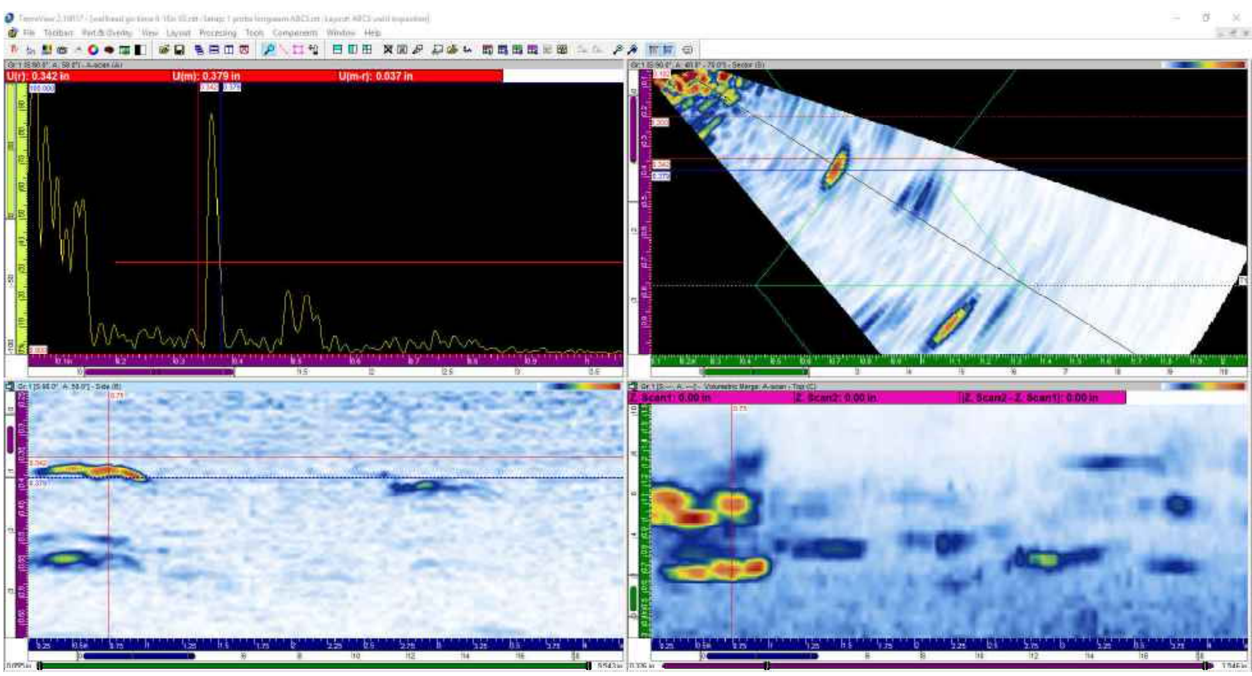

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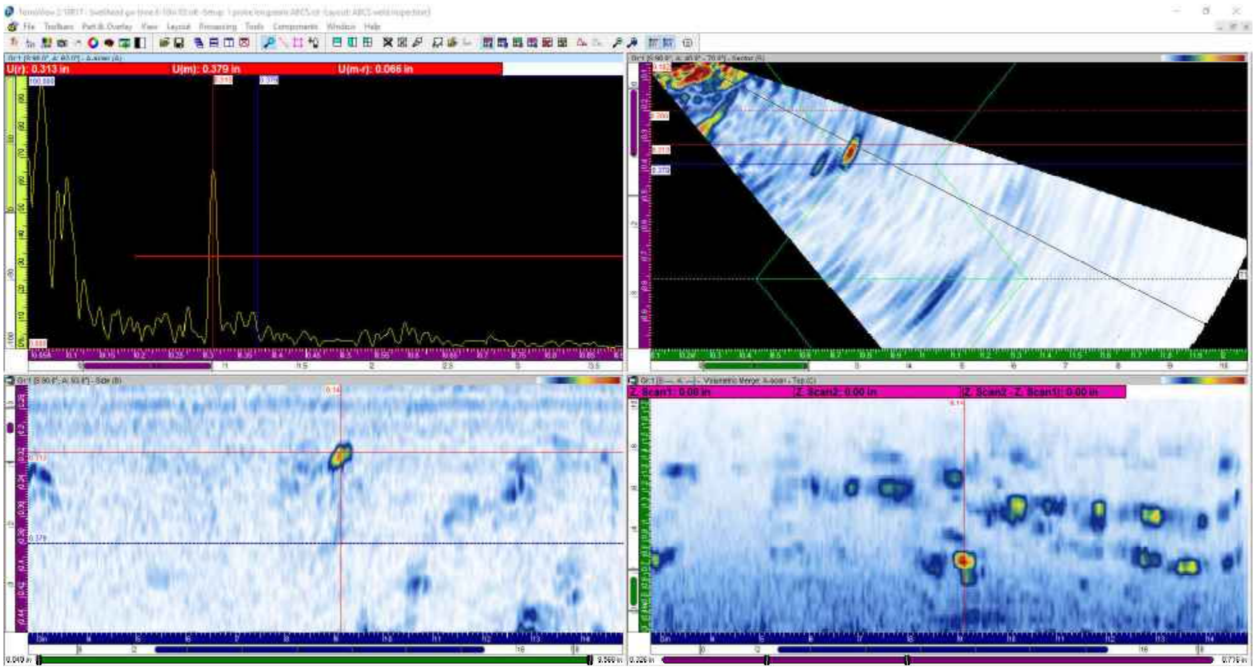

Porosity

Respectfully submitted,

C. Sean Riccardelli
Riccardelli Consulting Services, Inc
"Integrity Delivers Quality"

SS-25 RCA Supplementary Report

Phase 2 Summary

Purpose:
This report describes the remediation activities on the crater and surrounding site of well Standard Sesnon 25 (SS-25) witnessed by Blade. This work returned the site to a safe condition for future rig operations.

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May 31, 2019

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Abstract

The gas storage well Standard Sesnon 25 (SS-25) in the Aliso Canyon Gas Storage Field located in Los Angeles County, California started leaking gas in October 2015. A relief well was drilled, and SS-25 was brought under control. The leak stopped in February 2016.

In January 2016, as part of their investigation of the leak, the California Public Utilities Commission (CPUC) and the Division of Oil, Gas, and Geothermal Resources (DOGGR) selected and gave provisional authority to Blade Energy Partners (Blade) to perform an independent Root Cause Analysis (RCA). The Blade Team and parties under Blade's direction were responsible for directing the work of subcontractors who performed the extraction of the SS-25's wellhead and tubing and casing and the preservation and protection of associated evidence. Blade RCA Reports, including this report, document and describe the key activities undertaken in support of the RCA effort.

The RCA work scope consisted of several phases — from Phase 0 (data collection) to Phase 5 (final report). This document covers Phase 2 — site restoration to rig readiness — in preparation for Phase 3 of the RCA during which a rig is utilized to perform wellbore operations.

The second attempted well kill operation, which occurred on November 13, 2015, initiated the formation of a crater on the SS-25 well site with the following characteristics:

- It had an area of approximately 20×65 ft on the surface of well's site and was 30 ft deep below site elevation.
- It was of unknown stability and represented a hazard to health and safety of all on-site personnel and to preserving the post-blowout condition of SS-25 and wellhead components.
  - Preserving as many post-blowout aspects of the SS-25 well was central to the RCA in order to not obscure potentially important pieces of evidence.
- It limited personnel access to the SS-25 well and access of heavy equipment (such as a drilling rig) to the site.

Thus, it was deemed necessary to infill the crater and clean the remainder of the site to allow safe access needed for future aspects of the RCA, such as wellhead cleaning and inspection and retrieving SS-25 tubulars.

The work undertaken to return the site to a rig-ready condition was named Phase 2, whose execution was the responsibility of SoCalGas and their subcontractors, whereas Blade maintained provisional authority status to approve work proposed, witness work activities, and maintain unencumbered access to the site. This document is written as a third-party witness report and aims to summarize the facts of the planned Phase 2 work, document its execution, and report the results while framing it as part of the overall Root Cause Analysis (RCA).

Phase 2 was successfully completed without injury to personnel and without any apparent damage to the SS-25's conductor casing or wellhead.

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1 Introduction

The gas leak and subsequent broaching of gas to surface resulted in a large crater that formed around the wellhead of SS-25. This phase included removing well fluids and contaminated soil from the crater and the surface location surrounding the well pad. The crater was then filled in, a new cellar was added for work around the well head, and a concrete pad was poured in preparation for moving a rig over the well for the Phase 3 work. Phase 2 was coordinated by SoCalGas for the purpose of preparing the site for Phase 3. The Phase 2 timeframe was from June 2016–October 2016.

A crater of approximately 20×65 ft in areal extent and 30 ft in depth formed around SS-25 during the blowout event, between October 2015 and February 2016. The crater walls were caked with an unknown thickness of oily solids deposited throughout the blowout, and the bottom was filled with highly viscous oily liquids ranging from 1 to 9 ft in depth according to numerous soundings collected through vibracoring. The SS-25 Conductor and/or Surface casing were destabilized; the wellhead, observed to be swaying, was anchored and later determined to be out of plumb.

To allow rig access for extracting well tubulars for examination, the site needed to be rehabilitated. This work was completed by AECOM and their subcontractors on behalf of SoCalGas in accordance with the site restoration plan [1].

This report is a factual summary of the observations made throughout the execution of the planned site remediation work scope. The key activities observed include:

- Removal of failed concrete slab overhanging crater wall.
- Bridge removal.
- SS-25’s pipe trench cleaning and removal.
- Crater excavation.
- Backfilling of crater to 12 ft below site grade elevation, which entailed:
  - Protecting Conductor with silica sand-filled Sonotube® form.
  - Preparing slurry foundation with layers of crushed gravel, geogrid, and concrete mat.
  - Placing Controlled Low Strength Material (CLSM) slurry backfill.
- Wellhead cleaning access, which entailed:
  - Installing a scaffold.
  - Cleaning the wellhead—not detailed here because it falls under the RCA Phase 1 [2].
- Backfilling of crater to site grade elevation, which entailed:
  - Installing a 10 ft diameter well cellar.
  - Placing CLSM to site grade elevation.
  - Placing concrete well pad.

Throughout the time period covered in this report, some activities on the SS-25's site were performed as part of Phase 1 (Well Site Documentation) and others as part of Phase 2 (Site Remediation to Rig Readiness) and were not easily distinguishable at times. For instance, excavation activities were performed as part of Phase 1 to locate materials directly related to the root cause of the SS-25's failure (e.g., the B-annulus valve, metal pieces potentially ejected during the blowout, or similarly meaningful pieces of debris). Phase 2 excavation involved removing additional soil and other wellsite infrastructure to grade the crater for subsequent remediation of the SS-25's site.

1.1 Abbreviations and Acronyms

Term	Definition
Blade	Blade Energy Partners
CLSM	Controlled Low Strength Material (otherwise known as a *2-sack slurry*)
CPUC	California Public Utilities Commission
DOGGR	Division of Oil, Gas, and Geothermal Resources
H&M	Henkels & McCoy
NDE	Nondestructive Evaluation
RCA	Root Cause Analysis
SCAQMD	South Coast Air Quality Management District
SoCalGas	Southern California Gas Company
SS-25	Standard Sesnon 25
VOC	Volatile Organic Compound

2 SS-25 Site Remediation Activities

This section presents the key details that make up the Phase 2 scope of work covered in this report associated with the following major intermediate work plans:

- Removal of the failed concrete slab overhanging the crater wall
- Removal of bridge (for wellhead access)
- Cleaning and removal of SS-25's pipe trench
- Excavation of crater
- Backfilling of crater to 12 ft below site grade elevation
- Access to wellhead for cleaning
- Backfilling of crater to site grade elevation

2.1 Removal of Failed Concrete Slab Overhanging Crater Wall

Observation of the crater revealed a slab of concrete overhanging the crater's edge suspended just to the south of SS-25. The concrete slab was ruptured near the crater's edge and was being held by a number of rebars; the amount and types of rebars were obscured by the soil and oil ejected during the blowout.

The concrete slab was perceived as a safety hazard and, if destabilized, a potential threat to cause damage to SS-25. SoCalGas assisted Henkels & McCoy (H&M) in developing a plan to stabilize and safely remove the concrete slab from the crater.

Figure 1 through Figure 3 show the crater, concrete slab, and evidence of rebar.

Figure 1: Crater Surrounding SS-25

Figure 2: Concrete Slab Suspended from South Edge of Crater

Figure 3: Visual Indications of Rebar

2.1.1 Work Plan to Safely Remove Concrete Slab

As a prerequisite to any of this Phase 2 work, large (35×35×38 in. tall) sand-filled woven polypropylene (Super Sack) containers were lowered into the crater and stacked around the conductor casing to prevent any damage during removal of the concrete slab, bridge, or while excavating the crater. The work plan [3] for the placement of the Super Sack containers consisted of:

1. Positioning and setting up of a crane for installation of Super Sack containers.
2. Receiving of the Super Sack containers in a temporary staging area on-site.
3. Disconnecting the non-tension bearing wellhead anchor located at the south-west anchor point.
4. Pre-installing a lifting strap on each Super Sack container.
5. Picking and placing a Super Sack container into crater using a crane.
    a. A pre-installed lifting strap on each Super Sack was disconnected by hand and anchored at site grade elevation for later retrieval from the crater.
6. Pivoting the crane for picking and placing another Super Sack.

Figure 4 through Figure 7 show the placement of the Super Sack containers.

.

Figure 4: Placement of the First Super Sack Container

Figure 5: Continued Placement of Super Sack Containers in Crater, South of SS-25 Conductor

Figure 6: Complete Placement of Super Sack Containers, Five Layers Tall

Figure 7: Super Sack Containers Toppled Overnight; Three-Layers Remained

With the Super Sack containers in place, the removal of the overhanging concrete slab was then addressed. The concrete slab removal work plan [4] had 28 distinct steps–not detailed here. The major stages of the work plan entailed:

1. Slab stabilization to give structural support and stability to the concrete slab, which was achieved by looping three cable sets longitudinally around the concrete slab. The support loop cables were tied to crane #2.
2. Installation of a netting support system to catch any large chunks of concrete that could have become dislodged during removal and further secure the concrete slab. Seven cables were fed around the slab and fixed on one end to a pre-fabricated steel cable netting and on the other end to a spreader bar. Netting and cables were tied to a spreader bar tied to crane #1.
3. Removal of concrete slab from crater by excavating a trench along the south face of the crater. Rebar suspending the concrete slab were cut, and a sequence of smooth crane movements with load hand-offs between cranes #1 and #2 were completed to successfully remove the concrete slab. This slab was then demolished on-site, placed in roll-off bins along with excavated soil, and stored at Aliso Canyon.

Figure 8 through Figure 17 show the three safety straps installed, net support installed, excavation, slab removal, and slab storage.

Figure 8: Three Safety Straps Were Tightened around Slab

Figure 9: Net Support Unrolled from Header Bar, Support Lines Tightened to Header Bar

Figure 10: Trench Excavated in Crater South Wall for Slab Removal

Figure 11: Concrete Slab Jackhammered to Expose Rebar

Figure 12: Reinforcing Bars are Cut (Weight of Slab Supported by Crane)

Figure 13: Concrete Slab Removed from Crater by Crane

Figure 14: Safety Straps and Net Support Wrapped Around Slab; View of Bottom of Slab

Figure 15: Concrete Slab Jackhammered into Pieces

Figure 16: Slab Placed in Bins with Excavator

Figure 17: Excavated Crater Soil Placed in Bins with Front Loader

Removal of the overhanging concrete slab was safely completed as planned.

2.2 Bridge Removal

Further clean-up of the SS-25's site and remediation of the crater required access, which was being obstructed by the wellhead access bridge placed over the crater (Figure 18). R&D Technical Services developed a plan [5] to remove the wellhead access bridge.

Figure 18: Wellhead Access Bridge On-Site – Obstructing Crater Remediation Access

2.2.1 Work Plan to Safely Remove Bridge

Figure 19 shows the bridge being lifted clear of the crater. The bridge was then disassembled, placed on trailers, and transported off-site for decontamination. Details of the crane used, lift capacity calculations, and safety considerations are found in the work plan [5].

Figure 19: Wellhead Access Bridge – Crane Lifted from Crater

Figure 20 shows SS-25's site with the bridge removed.

Figure 20: SS-25's Site with Bridge Removed, Looking East

2.3 SS-25 Pipe Trench Cleaning and Removal

The crater was immediately adjacent to well site infrastructure, which included piping, concrete pipe trenches, and cellars for the adjacent SS-25A and SS-25B wells along with two concrete pipe trenches, which previously serviced SS-25, overhanging the west crater wall. In order to complete the crater excavation, the pipe trenches and their contents had to be safely removed. Figure 21 shows the area of the site prior to clean-up containing pipe trenches and the SS-25A and SS-25B's cellars.

Figure 21: As-found Pipe Trenches Filled with Blowout and Kill-Related Debris

2.3.1 Work Plan to Clean and Remove Pipe Trenches

The trenches were filled with debris ejected during the blowout and subsequent kill attempts and contained legacy and kill-related piping parts and tools. Thus, prior to removing the trenches, their contents had to be removed. The details of the trench cleaning and removal process are contained in a stand-alone work plan [6] and are summarized as:

1. Clean the SS-25's pipe trenches.
2. Saw-cut and remove the SS-25's pipe trenches.

Some aspects of the SS-25's pipe trench cleaning operation seen in Figure 22 through Figure 25 are:

- Removal of grating over trenches using a crane.
- Transportation of grating for on-site decontamination area.
- Removal of solids using a Supersucker vacuum loader.
- Solids pumped into 20 yd^3 bins.
- Use of hand-tools to assist dislodging and breaking up large chunks of debris.
- Storage of all retrieved materials from Aliso Canyon for later disposal.

Figure 22: SS-25A and SS-25B's Cellars Filled with Debris

Figure 23: Debris in Pipe Trenches at Site Grade Elevation – Seen Upon Removal of Grating

Figure 24: Cleaning of Pipe Trenches Using Supersucker® Vacuum Loader

Figure 25: Cleaned Condition of Pipe Trenches and SS-25A and SS-25B Cellars

The cleaned SS-25's pipe trenches were ready for removal. Figure 26 through Figure 28 show cutting and removal of the SS-25's pipe trench. Additional work execution details are given as follows:

1. Lifting and placement of additional Super Sack containers, using a crane, into the crater to prevent any debris from contacting the Conductor
2. Excavation around trenches using a Supersucker vacuum loader to provide access for lifting points around trenches
3. Securing the portions of each trench to be removed is done by cables attached to a crane
4. Cutting of the trenches on-site using a concrete saw
5. Lifting of trenches with the crane to a flatbed trailer for disposal off-site

Figure 26: SS-25 Pipe Trench Segment Affixed to Crane

Figure 27: Insitu Saw-Cutting of SS-25 Pipe Trenches

Figure 28: Another SS-25 Pipe Trench Segment Removed with Crane

SS-25’s pipe trenches and SS-25A and SS-25B’s cellars were successfully cleaned. SS-25’s pipe trenches were subsequently removed according to the work plan with no problems or safety incidents.

2.4 Crater Excavation

Figure 29 shows the condition of the SS-25 crater prior to excavation. Unsafe site conditions and *visually impacted* soils are readily apparent. The term visually impacted indicates soil readily identifiable as having been exposed to liquids expelled during the SS-25 blowout. Crater excavation was carried out to collect visually impacted soils and increase SS-25 site safety.

Figure 29: Condition of SS-25 Crater Before Excavation

2.4.1 Work Plan for Crater Excavation

The crater surrounding SS-25 was excavated for a number of reasons, but namely to:

- Remove, collect, and store for later disposition visually impacted soil. This activity is part of Phase 1 efforts.
- Remove disturbed and structurally unsound soils from the SS-25's bore.
- Remove and properly dispose of *Volatile Organic Compound (VOC) Contaminated* soils not visually impacted. VOC contamination was determined in accordance with Rule 1166 of the South Coast Air Quality Management District (SCAQMD) [7].
- Provide a cut angle that would improve slope stability while workers are in the interior of the crater to perform wellhead cleaning and Non-Destructive Examination (NDE) activities. Note that the wellhead NDE activity is part of Phase 1 efforts.

This crater excavation portion of the work plan also required validating the plumbness of the wellhead prior to backfilling the crater with slurry. Because of the large amount of excavating required and the close proximity of wellsite infrastructure, cutting and removal of the nearby concrete well pad and several old and abandoned flow lines was also required. Figure 30 through Figure 37 show the progression of work on the SS-25's site during the crater excavation work activities.

Figure 30: Exposed Abandoned and Buried Flow Lines Uncut (Left), Cut and Plugged (Right)

Figure 31: Concrete Well Pad Cut with Saw

Figure 32: Concrete Well Pad Removed with Excavator

Figure 33 demonstrates that Super Sack containers successfully protected the Conductor from large falling debris and cuttings from the excavation activity. Super Sack containers were removed after completing the 1:3 slope grading of the crater walls.

Figure 33: Conductor Appearance Before (Left) and After (Right) Excavation

Figure 34: Crater Appearance Looking East Before (Left) and After (Right) Excavation

Figure 35: Crater Appearance Looking North Before (Left) and After (Right) Excavation

Figure 36: AECOM Sniff Testing for Isobutylene (Correlated to Hexane for SCAQMD Rule 1166)

Figure 37: AECOM Tester – RAE Brand, MiniRAE3000 Model

The plumbing of the wellhead was vitally important to future well operations by preventing wear and ensuring easy retrieval of inner strings or any foreseeable downhole debris or evidence that could inform the RCA.

Figure 38 through Figure 41 show the wellhead plumbing work activities, which were completed by:

- Adjusting the tension of three cables fixed on one end around the wellhead and anchored on-site by the other end.
- Using surveying equipment for measuring plumbness of the wellhead with five benchmarked locations around the SS-25's site. Note that the sighting surface was the top bevel of the SS-25 Bradenhead.

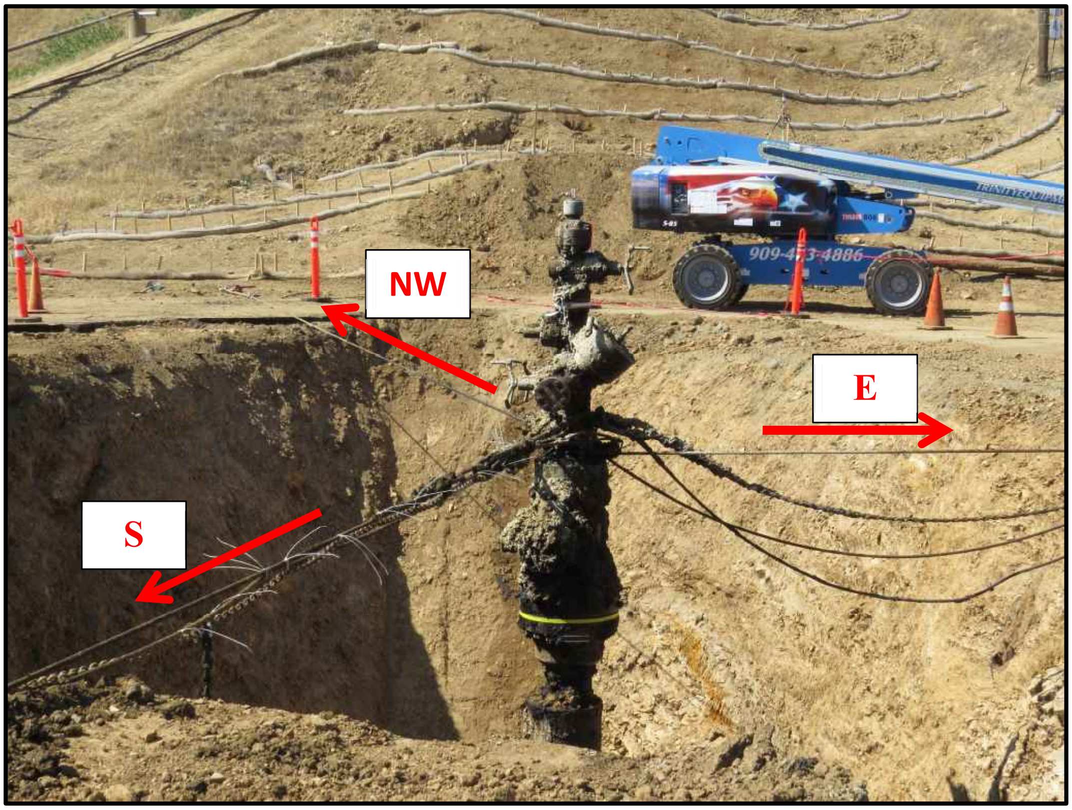

Figure 38: Tensioned Lines for Plumbing the Wellhead

Figure 39: Cleaning the Top Bevel of Bradenhead for Surveyor Sighting Surface

Figure 40: Level Affixed to Bottom of Bradenhead for Visual Confirmation of Surveyed Plumbness

Figure 41: Site Benchmarked Vantage Points (Top), Picture of *Obscured* Points (Bottom)

The crater was safely and successfully excavated, the wellhead adequately plumbed, and the SS-25 site cleaned of cuttings and prepared for the slurry backfilling portion of the Phase 2 activities.

2.5 Backfill Crater to 12 Ft Below Site Grade Elevation

With the crater base and walls excavated to solid and structurally sound foundation soils, the backfilling work plan was executed according to the steps detailed in the stabilization drawings [8] and work plans [9] and is summarized here:

- Installation of a segment of Sonotube form [10] filled with silica sand around the Conductor pipe for load transfer isolation. Leveling of the crater floor with 3/4 in. crushed gravel.
- Safe lowering of a sheet of TriAx® Geogrid [11] by tagline.
- Placement of an 8 in. lift of 3/4 in. crushed gravel over the geogrid using the excavator.
  - Addition of two more layers of TriAx Geogrid with 8 in. lifts of 3/4 in. crushed gravel.
  - Approximate lift height with surveying equipment.
- Placement of 3×8 in. lifts (total 24 in.) of 5 ksi compressive strength concrete.
  - On cold joints after a minimum of three hours set time.
  - On-site QA of delivered concrete was performed and 6 in. compressive strength cylinders created.
  - Approximate lift height with surveying equipment.
  - Installed another segment of Sonotube form filled with silica sand.
- Placement of 3×3 ft lifts (total 9 ft) of CLSM.
  - Lifts were placed on cold joints after a minimum of three hours set time.
  - On-site QA of delivered CLSM was performed and 6 in. compressive strength cylinders created.
  - Approximate lift height with surveying equipment.
  - Installed additional segments of Sonotube form filled with silica sand.
- NOTE: Suspended backfilling after slurry reached 12 ft below site grade for wellhead cleaning and NDE (a Phase 1 work activity).
- Other reference documents that were part of the work plan include, [12], [13], [14], [15], and [16].

Figure 42 through Figure 45 demonstrate the Sonotube form installation and crater floor leveling process. Later, additional segments of Sonotube form were installed into the crater as demonstrated in Figure 48.

Figure 42: Placement and Mounding of Silica Sand on Crater Bottom

Figure 43: Installation of Sonotube Form around Conductor

Figure 44: Settling Sonotube Form into Sand and Spacing it Concentric to Conductor

Figure 45: Placement of Gravel into Crater

Figure 46 and Figure 47 show the lowering of the TriAx Geogrid into the crater and condition of the crater bottom after installation of 24 in. of 3/4 in. crushed gravel and geogrid layers, respectively.

Figure 46: Geogrid Slid into Crater Bottom with Ropes Tied to Corners and Directed from Surface

Figure 47: Top of Gravel & Geogrid Layers for Crater Bottom Stabilization

Figure 48: Filling Conductor-to-Sonotube-Form Annulus with Silica Sand Using PVC Pipe Delivery

Figure 49 shows the crater being backfilled with concrete using a pump truck. Subsequent lifts of CLSM and additional segments of Sonotube form were placed. Figure 50 through Figure 52 show the backfilling process.

Figure 49: Concrete Truck and Concrete Pumping Unit on SS-25 Site to Fill Crater

Figure 50: Begin Placing Concrete in Crater with Pumping Unit

Figure 51: Crater Before (Left) and After (Right) First Concrete 24 in. Placement, Looking South

Figure 52: Crater After CLSM Placement to 12 ft Below Site Grade, Looking South

Backfilling of the crater was suspended to allow for wellhead cleaning and NDE of the Conductor and wellhead components. The wellhead NDE activities fall under Phase 1 activities (SS-25 site documentation [2]) and are not documented here.

This portion of the SS-25's crater backfilling for remediating the site was successfully executed according to the plan.

2.6 Wellhead Cleaning Access

It is clear from Figure 53 that access for personnel to the wellhead for cleaning and NDE was difficult and hazardous. This portion of work in Phase 2 provided safe access to the wellhead and ensured safety of workers while inside the partially backfilled crater.

Figure 53: Hazardous Site Conditions for Personnel Needing Access to the Wellhead

2.6.1 Work Plan for Wellhead Cleaning Access

Personnel needed to safely enter the partially filled crater to perform the wellhead cleaning and NDE. The required safety measures included:

- A compacted earth ramp with 3:1 (33.3%) slope with metal grating for improved footing and rope hand rail.
- Temporary bollards supporting a retaining wall, placed at the intersection of an influence line of 1:1 slope from the crater top and the crater-backfilled floor (at 12 ft below site grade) to mitigate the danger of a sudden slope failure of the crater wall(s).

The earth slope and retaining walls are detailed in cut sheet C102 and C103 of the SS-25's site stabilization drawings [8]. Figure 54 and Figure 55 show the compacted earth slope and the temporary retaining walls being constructed, respectively.

Figure 54: Excavator Used to Construct and Compact Earth Ramp with 3:1 Slope

Figure 55: Construction of Temporary Retaining Walls

Figure 56 shows the grated earth slope, rope handrail, and temporary retaining walls as workers assemble scaffolding around the SS-25's wellhead.

Figure 56: Egress to Crater and Temporary Retaining Walls Constructed, Looking North

Safe access to the wellhead was successfully constructed as planned. The wellhead cleaning and NDE activities were then executed for Phase 1.

2.7 Backfill Crater to Site Grade Elevation

The wellhead was cleaned and examined using non-destructive techniques in accordance with Phase 1, and the site control was returned to SoCalGas to complete Phase 2–Site Remediation to Rig Readiness. The remaining work items entailed installing a cellar, backfilling the crater to site grade elevation, and placing a concrete well pad over the backfilled crater.

2.7.1 Work Plan to Backfill Crater to Site Grade Elevation

The final series of steps to complete Phase 2 were specified in the Slurry Backfill work plan [9] and the associated detailed drawings [8]. The major remaining work items were:

- Placement of a 1 ft thick concrete mat of 14 ft square, centered on the Conductor.
- Installation of a 10 ft diameter and 10 ft deep SS-25 cellar.
- Placement of CLSM around the SS-25's cellar and filling the crater to site grade elevation.
- Placement of a 1 ft thick concrete mat over the site with a minimum of 4 ft past the slurry-filled crater area on finish grade.

Figure 57 through Figure 63 show these work items.

Figure 57: Cleaned Wellhead, Completed Non-Destructive Evaluation

Figure 58: Fiber Reinforced Concrete Mat to Support SS-25's Cellar

Figure 59: Two of Four 10 ft Diameter SS-25's Cellar Cylinder Segments of 2.5 ft Height Were Installed

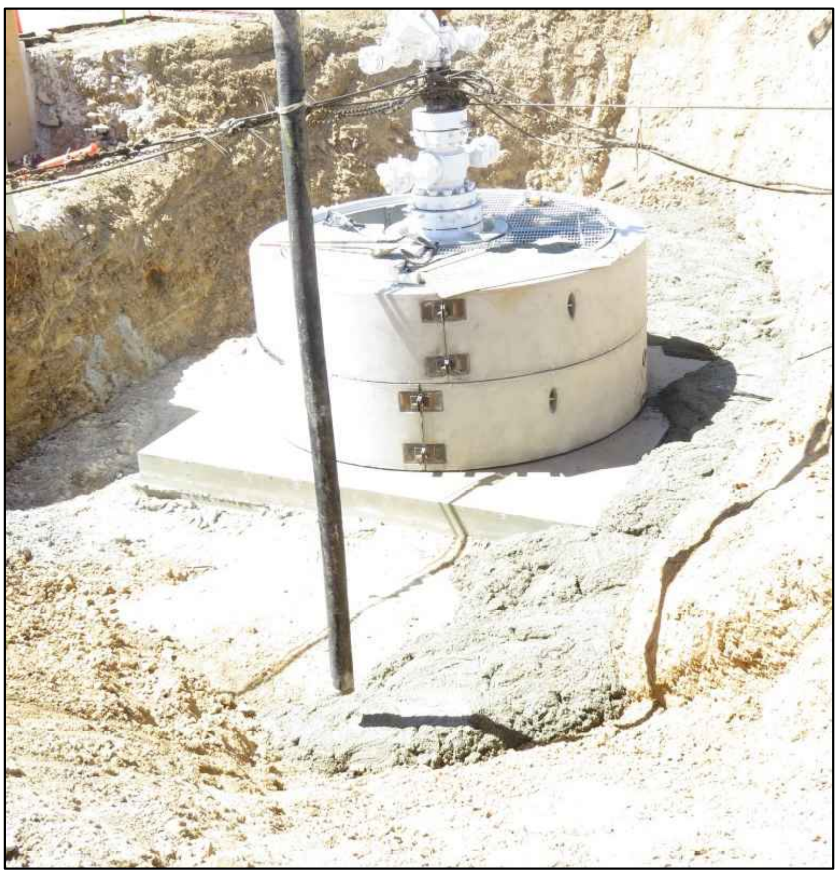

Figure 60: Backfilling Crater with CLSM Slurry Resumes

Figure 61: SS-25's Cellar Fully Installed

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Figure 63: SS-25's Concrete Mat Installed, Expansion Control Joints Being Cut

3 Conclusions

The crater that developed around SS-25 during the blowout event was cleaned, stabilized, and subsequently backfilled. The cleaning efforts included removing the wellhead access bridge over the crater and debris from the SS-25’s pipe trenches and the SS-25A and SS-25B’s cellars. Stabilization of the site was achieved by removing the failed concrete slab overhanging the crater wall and then excavating structurally unsound soils and blowout debris from the crater. Backfilling was completed through installation of layers of several engineering materials: sand, gravel, geogrids, fiber reinforced concrete, and CLSM. These work activities were completed in accordance with the plan, in a safe manner, without observed damage or detrimental alteration to the SS-25’s Conductor or wellhead and were witnessed by Blade’s representatives.

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SS-25 RCA Supplementary Report

Phase 3 Summary

Purpose:

Summarize the planning, field, and rig activities for Phase 3 of the Root Cause Analysis for SS-25.

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Abstract

The gas storage well Standard Sesnon 25 (SS-25) in the Aliso Canyon Gas Storage Field located in Los Angeles County, California started leaking gas in October 2015. A relief well was drilled, and SS-25 was brought under control. The leak stopped in February 2016.

In January 2016, as part of their investigation of the leak, the California Public Utilities Commission (CPUC) and the Division of Oil, Gas, and Geothermal Resources (DOGGR) selected and gave provisional authority to Blade Energy Partners (Blade) to perform an independent Root Cause Analysis (RCA). The Blade Team and parties under Blade's direction were responsible for directing the work of subcontractors who performed the extraction of the SS-25's wellhead, tubing, and casings and the preservation and protection of associated evidence. Blade's RCA Reports, including this report, document and describe the key activities undertaken in support of the RCA effort.

This document summarizes the planning that Blade did and the field operations for Phase 3 of the RCA for SS-25 and other downhole-related activities conducted for the RCA. Phase 3 included the extraction of the tubing, casing, and wellhead equipment and preservation of the equipment for the RCA. The scope of the RCA was expanded to include evaluation of offset wells with similarities to SS-25. Rig operations were conducted on two wells, SS-25A and SS-25. The two wells are located on the same well site. The SS-25 planning and field operations took approximately 820 days from when the Phase 3 concept overview was first presented to the DOGGR District in June 2016, through the start of field operations in July 2017, and until SS-25 was plugged and abandoned (P&A'd) in September 2018.

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1 Introduction

This document summarizes the planning and field activities for Phase 3 of the SS-25 Root Cause Analysis (RCA). An overview of the RCA phases is included. Initially, the main focus of Phase 3 was the extraction of the tubing, casing, and wellhead and preservation of the equipment for the RCA. This included working with Southern California Gas Company (SoCalGas) and the regulatory agencies to obtain approval and permits to perform the rig and field work necessary to extract the well equipment, evaluate the casing left in the well, and P&A the well.

SS-25 started leaking gas in October 2015 and was killed in February 2016. The SS-25 planning and field operations took approximately 820 days from when the Phase 3 concept overview was first presented to the DOGGR District in June 2016, through the start of field operations in July 2017, and until SS-25 was P&A'd in September 2018.

A key requirement for the RCA was to understand the downhole environment that the SS-25 tubulars were exposed to. As new information and opportunities became available, Blade expanded the Phase 3 scope to include the evaluation of several offset wells similar to SS-25, conducting a shallow geophysical investigation of the SS-25 well site and operations on well SS-25A, which is located on the same well site as SS-25. The SS-25A tubing was extracted and stored for the RCA. The casing was evaluated using wireline logs run in the 8 5/8 in. casing, and the lower part of the well was P&A'd. The Phase 3 operations discussed cover all of the downhole-related operations conducted for the RCA.

1.1 Abbreviations and Acronyms

Term	Definition
ADT	Dielectric Scanner
AIT	Array Induction Imager Tool
ALARP	As Low as Reasonably Practicable
Blade	Blade Energy Partners
BOPE	Blowout Preventer Equipment
CBL	Cement Bond Log
CHDT	Cased-Hole Dynamic Tester
CIBP	Cast Iron Bridge Plug
COC	Change of Custody
CPET	Corrosion and Protection Evaluation Tool
CPUC	California Public Utilities Commission
DE	Diatomaceous Earth
DOGGR	Division of Oil, Gas, and Geothermal Resources
DOGGR-IT	Division of Oil, Gas, and Geothermal Resources – Investigation Team
DTS	Distributed Temperature Sensing
EDS	Evidence Data Sheet
EOT	End of Tubing

Term	Definition
ERT	Electric Resistance Tomography
ETOP	Extract Tubulars on Paper
FMI	Formation Microimager
GR-JB	Gamma Ray Junk Basket
HAZid	Hazard Identification
HCAL	Hotwell Caliper
HNGS	Spectral Gamma Ray
HPT	High-Precision Temperature
HRVRT	High-Resolution Vertilog
IBC	Isolation Scanner
ICAL	Imaging Caliper
ID	Internal Diameter
IntEx	Integrity Explorer
JSN	Joint Sequence Number
MASW	Multichannel Analysis of Surface Waves
MDT	Modular Formation Dynamics Tester
MID	Magnetic Imaging Defectoscope
MPI	Magnetic Particle Inspection
MSCT	Mechanical Sidewall Coring Tool
MSIP	Modular Sonic Imaging Platform
MVRT	Micro Vertilog Tool
NDE	Nondestructive Evaluation
NEXT	Litho Scanner High-Definition Spectroscopy Service
NMR	Nuclear Magnetic Resonance
NOI	Notice of Intent
NTU	Nephelometric Turbidity Unit
OD	Outside Diameter
P&A	Plug and Abandon
PBTD	Plugback Total Depth
PNX	Pulsed Neutron Extreme
RAP	Resist-All Packaging
RBP	Retrievable Bridge Plug
RCA	Root Cause Analysis
RIH	Run in Hole
SCAQMD	South Coast Air Quality Management District
SNL	Spectral Noise Log
SoCalGas	Southern California Gas Company

Term	Definition
SS	Standard Sesnon (Lease Name)
SSCAN	Sonic Scanner
TD	Total Depth
TOC	Top of Cement
TP&A	Temporary Plug and Abandon
TVD	Total Vertical Depth
UCI	Ultrasonic Corrosion Imager
UT	Ultrasonic
VCI	Volatile Corrosion Inhibitor
VDL	Variable Density Log
VOC	Volatile Organic Compound
WBM	Water Based Mud

2 Root Cause Analysis Phases Descriptions

The RCA was conducted in phases on the basis of the scope of the work activity. Brief descriptions of the phases selected for this RCA with the approximate timeframes for each phase are as follows:

- **Phase 0—Well and Field Data Collection, Collation, and Analyses**

  February 2016–May 2019

  Well and field records were collected through data requests and public access through the DOGGR website. Data were reviewed and catalogued in a secure database with controlled access. Data analysis of the field and wells provided background and historical information for the RCA.

- **Phase 1—SS-25 Well Site Evidence Collection and Documentation**

  February 2016–May 2016

  This phase included a physical search of the area surrounding the well site to locate and document any physical evidence that may have been associated with the leak.

  A total of 13 liquid and soil samples were collected and analyzed in Phase 1. Details of the samples and analysis are included in the latest version of the RCA sample tracking document [1].

- **Phase 2—Well Site Restoration to Rig Readiness**

  June 2016–October 2016

  The gas leak and subsequent flow of gas to surface resulted in a large crater that formed around the wellhead of SS-25. Phase 2 included removing well fluids and contaminated soil from the crater and the surface location surrounding the well site. The crater was then filled in, a new cellar was added for work around the wellhead, and a concrete pad was poured in preparation for moving a rig over the well for the Phase 3 work. Phase 2 was coordinated by SoCalGas for the purpose of preparing the well site for Phase 3.

- **Phase 3—Tubing, Casing, and Wellhead Extraction**

  April 2016–December 2018

  Phase 3 covered all of the downhole-related operations conducted for the RCA. It included working with SoCalGas and the regulatory agencies to obtain approval and permits to extract and collect well equipment from SS-25 for the RCA. This consisted of extracting the tubing, casing, and wellhead; preserving the equipment; and properly P&A the well. After the equipment was extracted, the casing left in the well was evaluated using wireline logs. Finally, the well was P&A'd. Care was taken to handle the extracted equipment in a manner to preserve the as-recovered condition. Protecting critical pieces included wrapping, coating, and bolstering the tubing and casing and crating as required. All equipment extracted was treated as *evidence* and required special handling and documentation. Additional Phase 3 activities included the evaluation of several offset wells similar to SS-25, conducting a shallow geophysical investigation of the SS-25 well site, and operations on well SS-25A.

- **Phase 4— Nondestructive Evaluation and Laboratory Metallurgical Examination**

  February 2018–April 2019

Nondestructive Evaluation (NDE) and laboratory metallurgical examination were used to evaluate appropriate samples of the equipment extracted. This included visual examination, physical measurements, micro-fractographic and metallographic examination, mechanical and chemical testing, and corrosion and cracking evaluation.

- **Phase 5—Integration, Interpretation, and Final Report**

  October 2018–May 2019

  Data collected and results from the previous phases were integrated and interpreted to determine the root cause of the leak and failure. The data and analysis were compiled into a final report to document and present the RCA work.

Appendix A has timelines showing the RCA work that was done at Aliso Canyon during 2016, 2017, and 2018.

3 Tubulars and Wellhead Extraction Preparation

Figure 1 shows the status of SS-25 after it had been killed during the P-39 relief well operation. The key intent of Phase 3 was to move a rig onto SS-25, re-enter the well, and extract the 2 7/8 in. tubing and 7 in. casing. The removal of the tubulars from SS-25 for detailed examination and metallurgical testing was a fundamental part of the RCA to determine the mode of downhole failure and the root cause. At the same time, the needs of the RCA had to be balanced against the need to safely abandon the well at the conclusion of the operations. The main objectives of Phase 3 were therefore to:

- Permanently abandon the well in a manner that met all SoCalGas requirements, all DOGGR regulatory requirements, and industry best practices.
- Recover as much of the downhole equipment as possible, including, but not limited to, the production tubing, production casing, and the wellhead while maintaining the primary objective of safely plugging and abandoning the well.

Extensive preparation work was done to get ready for extracting the downhole equipment. This preparation involved a complex process of protocol development and review, operational planning, and work plan development. It required close coordination and cooperation among all the stakeholders—Blade, SoCalGas, CPUC, DOGGR, the DOGGR Investigation Team (DOGGR-IT), and the various service companies that provided the necessary equipment and services. The Phase 3 preparation effort started in April 2016 and continued through July 2017 when well site operations commenced. Highlights of this preparation work include the following:

- Blade's first steps were to research, collect, and analyze all the available data about SS-25 well history and status, relevant offset well history, and the geologic setting and conditions and to identify potential operational risks and problem areas. This was done by researching the publicly-available information on the DOGGR website and through a series of formal data requests sent by Blade to SoCalGas, who would then gather data and send them to Blade with copies to CPUC and DOGGR-IT. This information was compiled into the *Phase 3 Tubing, Casing, Wellhead Extraction Protocol* [2], which served as a design basis document and provided the foundation on which the detailed operational work plans would later be developed. This document, discussed in more detail in Section 3.1, went through several revisions as new information was collected and after reviews by CPUC, DOGGR, DOGGR-IT, and SoCalGas.
- From April 04 to April 22, 2016, Blade ran a series of logs in the 2 7/8 in. tubing in SS-25 to gather as much information as possible about the condition of the tubing and the 7 in. and 11 3/4 in. casing strings in the event that the tubulars ultimately could not be recovered or were damaged during the extraction work. Baker Hughes ran their caliper and Micro Vertilog (MVRT) tools, and Versa-Line ran their High-Performance Temperature (HPT), Spectral Noise Log (SNL), and Magnetic Imaging Defectoscope MID-2 and MID-3 tools. The MVRT and MID-2 results showed an area of metal loss in the 7 in. casing at approximately 895 ft, and the HPT results showed low-temperature anomalies at 140 and 340 ft where the temperature at each depth was measured at 46°F. The MID-3 results showed metal loss areas at 151 and 192 ft in the 11 3/4 in. casing. As a follow up, the HPT, SNL, MID-2, and MID-3 logs were run through the tubing in the SS-25A and SS-25B wells from May 17 to June 08, 2016.

- Blade met with DOGGR on June 15, 2016, to provide an update on the status of RCA work, provide a concept overview of the proposed extraction operations, and get clarity on the DOGGR requirements for permitting and well abandonment.

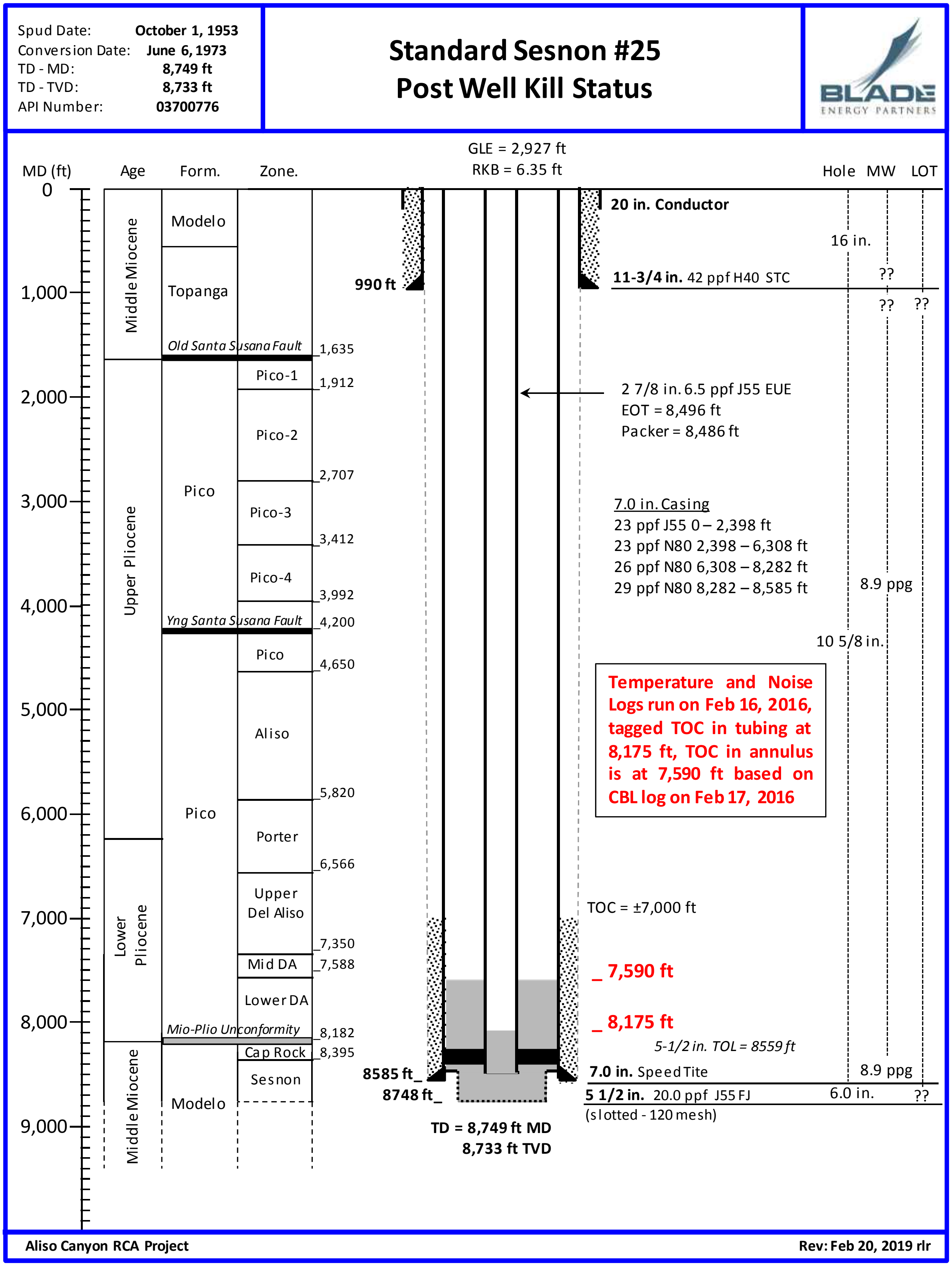

Figure 1: SS-25 Well Status at the Start of Phase 3

- In July 2016, Blade ran HPT logs in four surrounding wells, SS-1, SS-5, SS-9, and P-71, to determine the areal extent of the temperature anomaly seen earlier while logging SS-25.
- Blade had Schlumberger install their Distributed Temperature Sensing (DTS) fiber-optic survey tools in SS-25A and SS-25B in August 2016. Downhole temperature measurements from the surface to just below 1,000 ft were taken weekly through September 2018. In October 2016, DTS equipment was moved to SS-25, and weekly temperature measurements were recorded until July 2017.
- Blade hosted two task-based Hazard Identification (HAZid) risk assessment meetings. The first was held on August 11, 2016, and second follow-up meeting was held on September 23, 2016. As discussed in Section 3.2, the objective of these meetings was to conduct a formal risk assessment and evaluate the operational plans for Phase 3 to determine whether the risks were suitably managed with safeguards.
- Blade began a shallow geophysical investigation in August 2016 to provide information on the shallow geology around the SS-25 location down to approximately 1,312 ft below ground level. The intent was to characterize the geological and hydrogeological features including the depth and location of faults and other geological structures, the depth and extent of aquifers, overburden thickness, bedrock delineation, and shallow void mapping. The work was done by Advisian using the following surveying technologies:
  - Nuclear Magnetic Resonance (NMR)
  - Electric Resistance Tomography (ERT)
  - Seismic refraction
  - High-resolution seismic reflection
  - Multichannel Analysis of Surface Waves (MASW)

  The survey lines were run at various orientations across the SS-25 well site and were as much as 5,900 ft long with different electrode or geophone spacing, which influenced the depth of investigation and the resolution of the data. Figure 2 shows the multiple survey lines used for the 1.5 m spacing ERT survey.

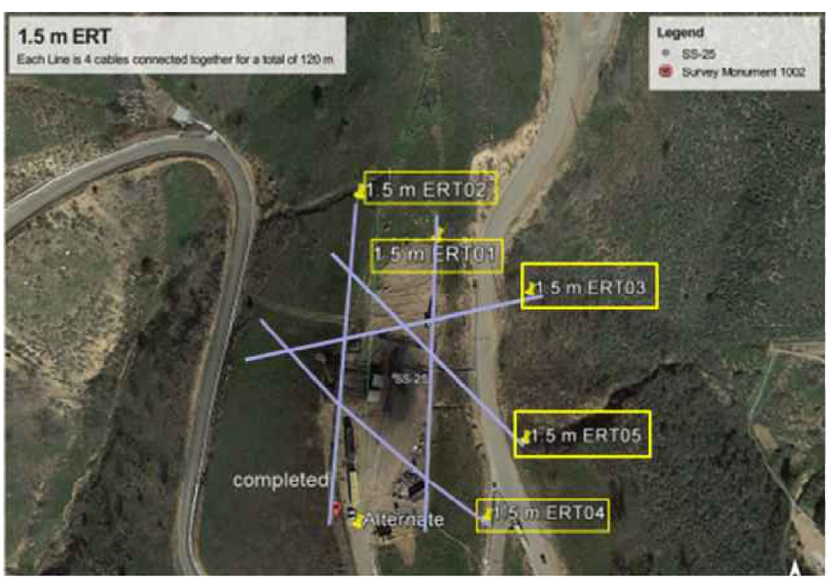

Figure 2: Survey Line Orientation Example—1.5 m Spacing Electric Resistance Tomography Survey

After this survey work was completed, Geosyntec drilled four shallow boreholes on the SS-25 well site to depths between 120 and 150 ft and collected core samples to further aid in characterizing the composition and strength of subsurface materials. After drilling, Advisian ran their temperature, gamma ray, conductivity, NMR, and optical televiewer wireline logs in each hole. The shallow geophysical investigation work was completed on September 23, 2016.

- Blade began developing the processes and procedures that would be used for handling the extracted tubulars in October 2016, which culminated in the protocol document *SS-25A Wellsite Tubulars Handling Protocol* [3]. As discussed in detail in Section 3.3, the objective was to ensure preservation of the tubulars removed from the well by describing the various steps, procedures, and requirements from the point of removal from the well, through on-site examination and cleaning, and then preparation for transport and storage. Because the extracted tubulars were considered to be evidence, the protocol also addressed documentation, traceability, and chain of custody procedures. It went through several revisions after reviews from CPUC, DOGGR-IT, the National Labs, and SoCalGas.
- Blade began a weekly fluid level monitoring program in December 2016, which involved measuring the fluid levels and recording the pressures in the tubing and in the A and B annuli in the SS-25A, SS-25B, and SS-25 wells.
- SoCalGas sent a draft Notice of Intent (NOI) to DOGGR on December 08, 2016, to get feedback on the proposed RCA-related extraction and logging operations and the final abandonment operations. The NOI was developed with input from Blade.
- DOGGR sent SoCalGas a letter describing the requirements for a SS-25 NOI on February 10, 2017. SoCalGas was instructed to submit an NOI only for operations to isolate and then pull the tubing and investigate the condition of the 7 in. casing. A supplemental NOI would be required for the next steps based on the well conditions observed. Because of uncertainties around the condition of the wellbore, operations were therefore to be done in stages with periodic hard stops to evaluate the latest information before determining the next steps. SoCalGas submitted the revised NOI on February 24, 2017.
- DOGGR sent SoCalGas a letter on March 29, 2017, requesting an NOI for work on SS-25A. Due to operational scheduling requirements related to the field-wide Safety Review directives (State Oil and Gas Supervisor Order 1109) [4], well work on SS-25A needed to be completed prior to the Phase 3 work on SS-25. The SS-25A work included tubing extraction, running casing and formation evaluation logs, and the P&A of the lower wellbore. The SS-25A operations took 83 days, starting on May 08, 2017, and finishing on July 29, 2017, and are discussed in the *SS-25A TP&A and RCA Operations Report* [5].
- DOGGR sent SoCalGas a permit for the first stage of the SS-25 work on June 06, 2017.
- Blade expanded the summary steps from the *Phase 3 Tubing, Casing, Wellhead Extraction Protocol* [2] into a detailed work plan for the Phase 3 field work. The work plan was updated for each stage of the operation and detailed the step-by-step operational tasks that would be carried out after the NOI was approved.
- Blade hosted an Extract Tubulars on Paper (ETOP) exercise on July 06, 2017, to introduce the plans and objectives to the people who would be doing the work in the field. Blade presented the work plan, and the participants were divided into groups to provide feedback on the work plan steps and procedures.

Participants represented the various stakeholders involved with the Phase 3 work, including the rig and service company personnel, SoCalGas, CPUC, and DOGGR-IT. Blade personnel were facilitators to the process and were not assigned to a group. Participants were assigned to groups based on their expertise and area of interest and to ensure each group included the right mix of people to review the work plan and identify issues for presentation to the entire group. Each group was asked to identify operational conflicts and safety issues and develop recommendations for improvement. The work plan was reviewed and updated based on feedback from the ETOP.

- Blade developed a comprehensive diagnostic logging program to gather as much information as possible about the condition of the 7 in. and 11 3/4 in. casing strings and to evaluate the annulus region around the strings and the surrounding formation. Table 1 lists the logs that were run and their function.

Table 1: Wireline Logging Program Description

Log Description	Purpose	Provider	Tool Name	Abbreviation
Junk basket, gauge ring, gamma ray, casing collar locator	Internal Diameter (ID) restriction detection, depth correlation	Baker Hughes	---	JB-GR/GR/CCL
Mechanical caliper	ID measurements (remaining wall, deformation), corrosion indications	Baker Hughes	ICAL Multifinger Caliper	ICAL
Defect detection, magnetic imaging	Metal loss detection, defect identification	Baker Hughes	High-Resolution Vertilog	HRVRT
Cement bond evaluation	Cement bond quality	Baker Hughes	Integrity Explorer	IntEx
Defect detection, magnetic imaging	Metal loss detection, defect identification through two strings of casing	Versa-Line	Magnetic Defectoscope-2	MID-2
Defect detection, magnetic imaging	Metal loss detection, defect identification through three strings of casing	Versa-Line	Magnetic Defectoscope-3	MID-3
Formation evaluation	Porosity, total organic content, presence of gas, formation pressure and temperature	Schlumberger	3D Pulsed Neutron Extreme	PNX
Cement bond evaluation, annulus evaluation	Cement bond quality, casing ID and wall thickness, condition of the annulus (fault analysis, hole enlargement), solid-liquid-gas map of annulus material, casing centralization	Schlumberger	Isolation Scanner, Sonic Scanner, Cement Bond Log, Variable Density Log	IBC-SSCAN-CBL-VDL
Formation evaluation	Gamma ray, neutron, and porosity log for quantitative mineralogy, matrix properties for petrophysical evaluation, elemental weight fractions	Schlumberger	NEXT-Litho Scanner	NEXT

Log Description	Purpose	Provider	Tool Name	Abbreviation
Casing condition, defect detection, acoustic imaging	High-resolution ultrasonic casing ID and Outside Diameter (OD) imaging (metal loss detection, defect identification)	Schlumberger	Ultrasonic Corrosion Imager	UCI
Active corrosion detection	Identification of anodic/cathodic cells indicating active corrosion	Schlumberger	Corrosion and Protection Evaluation Tool	CPET
Formation evaluation	Downhole pressure measurements and collect formation fluid samples	Schlumberger	Cased-Hole Dynamic Tester	CHDT
Formation evaluation	Collect formation cores	Schlumberger	Mechanical Sidewall Coring Tool	MSCT
Formation evaluation	Measurement of porosity, mineralogy, lithology, fluid content	Schlumberger	Pulsar Multifunction Spectroscopy Service	Pulsar
Openhole formation evaluation	Measure the gamma ray spectra and resolve into the three most common components in sands and shales—potassium, thorium, and uranium	Schlumberger	Spectral Gamma Ray	HNGS
Openhole formation evaluation	Identify water zones, estimate water volume and salinity, and measure temperature	Schlumberger	Dielectric Scanner	ADT
Openhole formation evaluation	Identify water zones, estimate permeability and porosity	Schlumberger	Combinable Magnetic Resonance	CMR
Openhole formation evaluation	Measures formation conductivity	Schlumberger	Array Induction Imager Tool	AIT
Openhole formation evaluation	Borehole image; borehole azimuth and inclination; identify joints, fractures, bedding planes	Schlumberger	Formation Microimager	FMI
Openhole formation evaluation	Collect fluid samples and measure formation pressure and temperature	Schlumberger	Modular Formation Dynamics Tester	MDT
Downhole video camera	Visual inspection of ID for defects and anomalies	EV	EV Downhole Video	MK2
Openhole formation evaluation	Borehole image, borehole azimuth and inclination, identify joints, fractures, bedding planes	Advisian	Acoustic Televiewer	---

Log Description	Purpose	Provider	Tool Name	Abbreviation
Openhole formation evaluation	Movement of water in the borehole, fluid temperature	Advisian	Fluid Temperature and Conductivity	---
Openhole formation evaluation	Correlation of stratigraphy	Advisian	Formation Conductivity and Natural Gamma	---
Openhole formation evaluation	Identify water zones and water content, mobile and bound water	Advisian	Nuclear Magnetic Resonance	NMR
Openhole formation evaluation	Identify sand, shale, and clay sequences	Advisian	Natural Gamma	---
Openhole formation evaluation	Photographic borehole image, borehole azimuth and inclination, identify joints, fractures, bedding planes	Advisian	Optical Televiewer	---

3.1 Phase 3 Extraction Protocol Document Discussion

The *SS-25 Phase 3 Tubing, Casing, Wellhead Extraction Protocol* [2], was drafted to document the planning for Phase 3. It includes a summary of the SS-25 well history, geologic information, offset well data, expected equipment and services requirements, summary steps for the proposed work, contingency steps to cover operations with unknown outcomes, and the overall operational concept for the tubular extraction effort and the P&A process. The document served as a design basis and provided the foundation on which the detailed operational work plans would later be developed.

Roles and responsibilities and working relationships were also addressed because Blade was responsible for the RCA-related work and SoCalGas was responsible for the safe P&A of the well. Therefore, the operational needs of the RCA had to accommodate the requirements for the P&A and vice versa. The roles and responsibilities are discussed in the following excerpt from Section 1 of the protocol:

> During Phase 3, the Blade Team and those parties under Blade's direction are responsible for directing the work of contractors retained to perform the extraction of Well SS-25 tubing, casing, and wellhead and protection of associated evidence. The person in charge (PIC) of the extraction activities and protection of evidence on-site is the Blade Team Lead, Ravi Krishnamurthy. SoCalGas and those parties under SoCalGas' direction are responsible for directing the contractors who will perform the permanent abandonment of SS-25. Should clarification be required or disagreements arise between Blade and SoCalGas; the CPUC, DOGGR, Blade, and SoCalGas (the entities) shall meet and approve forward going steps. If the entities are unable to agree on any activities described for Phase 3, Blade will document such differences and the designated regulatory agency will act as the arbiter, and make the final decision.
>
> The Phase 3 plan is subject to change as additional information from the well and other data may become available. Throughout the process at least daily, the entities shall informally review the Phase 3 plan. In addition, the Phase 3 Extraction Protocol and Phase 3 plan will be formally reviewed at the end of each sub-phase. If a situation occurs when site dynamics change and a real-time human decision is required; the PIC or SoCalGas (for safety related) may take immediate mitigating or abating action. In addition, Blade reserves the right to deviate from these procedures and protocols as unique situations arise in the field. Furthermore, the Blade team shall document any significant deviation from these procedures and protocols

> that may affect the ability to safely P&A the well or collect data and evidence for RCA purposes, and notify the CPUC, DOGGR and SoCalGas. Blade shall obtain approvals from the CPUC, DOGGR and SoCalGas in advance of the affected activity. If the entities are unable to agree on any activities described for Phase 3, Blade shall document such differences, and the designated regulatory agency will act as the arbiter and make the final decision.
>
> Blade, the CPUC, DOGGR and SoCalGas personnel (including advisors, consultants and contractors) will be present during all activities of Phase 3.

The document draft Version 0 was issued on September 09, 2016, to SoCalGas and the regulators for review and comments. Based on meetings, feedback, and discussions, subsequent versions were issued. Version 1 was issued on September 15, 2016, following a meeting held on September 13, 2016. Version 2 was issued following a meeting held on September 23, 2016. The meetings included SoCalGas, DOGGR, DOGGR-IT, CPUC, and Blade. Version 3 was issued November 29, 2016, based on comments from SoCalGas. Version 4 was updated based on comments from CPUC and issued February 19, 2017. Version 5 included an updated logging program and was issued on July 09, 2017. Version 6, the final version, was updated based on the ETOP meeting and issued on July 14, 2017.

3.2 Hazard Identification Meetings Discussion

The detailed Phase 3 operational work plan involved moving a rig onto the well; extracting the tubing, casing, and wellhead components; gathering downhole wireline logging information; and the subsequent permanent abandonment of the SS-25 well. In preparation for these planned operations, Blade conducted two task-based HAZid risk assessment meetings. The objective of these meetings was to conduct formal risk assessment evaluating the operational plans for Phase 3 and to determine whether the risks (consequence and probability of occurrence) were suitably managed with safeguards. Tasks that were not suitably managed were identified, and action plans were developed to reduce the risks to As Low As Reasonably Practicable (ALARP).

The first HAZid meeting was held on August 11, 2016, and was attended by representatives from SoCalGas, Weatherford, AECOM, Boots and Coots, DOGGR-IT, CPUC, and the Pipelines and Hazardous Materials Safety Administration. A follow-up meeting was held on September 23, 2016, to present the results of the first HAZid to DOGGR personnel and then to conduct a risk assessment of the revised operational tasks to determine whether additional risks needed to be addressed. The meeting was attended by representatives from DOGGR, SoCalGas, Weatherford, Boots and Coots, DOGGR-IT, and CPUC. The August 11, 2016, meeting resulted in 43 action items, and the September 23, 2016, meeting resulted in 11 action items.

In February and March 2017, two events occurred that impacted the reconciliation of the HAZid action items. In February, DOGGR issued a letter describing the requirements for the first stage NOI covering the tubing removal and 7 in. casing logging operations for SS-25. The letter stipulated that a cement plug be set in the tubing from 8,175 to 7,590 ft instead of the abandonment mud that had been discussed at the September 23, 2016, HAZid. Then, in late March 2017, SoCalGas was directed by DOGGR to P&A the SS-25A well. The pulling of the tubing string, logging of the production casing, and cementing operations were all successfully done with the Ensign 334 workover rig. Based on the SS-25A operations, Blade and SoCalGas decided to use the workover rig to conduct these same activities on the SS-25 well. These two events generated 13 additional action items.

The report *SS-25 Phase 3A Task-Based HAZid Risk Assessment* [6] documents the August 11, 2016, meeting and includes the HAZid concept and methodology, Phase 3A task list, attendee list, action items, and HAZid worksheets. A total of 63 hazards were identified and analyzed.

Work was done to close out the action items and the report *Phase 3 HAZid Action Item Reconciliation and Close Out Status* [7] was prepared to document the results of the HAZid work. All action items that could be closed out prior to the rig work starting were closed out. The remaining items were closed out just after the operations commenced.

3.3 Phase 3 Tubulars Handling Protocol Document Discussion

Considerable planning and preparation efforts were conducted to properly handle and manage the joints of tubing and casing and the wellhead components extracted from SS-25 and SS-25A. A key driver was the requirement that all well and wellbore equipment was considered to be evidence, and therefore every effort needed to be taken to improve the chance for recovery of casing, tubing, and downhole equipment and to avoid inadvertent damage to equipment. The planning and preparations therefore focused on preserving the tubulars in their as-recovered condition, preventing post-recovery damage, and ensuring that all items were tracked and identified to maintain traceability to determine and maintain a record of their original position in the well. Highlights of these preparations include the following:

- A Tubulars Handling Protocol [3] was developed to define how the tubulars and tree would be extracted from the well and to ensure the preservation of the evidence by describing the various steps, procedures, and requirements from the point of removal from the well, through on-site examination and cleaning, to preparation for transport and storage. This document went through several iterations following reviews and comments from the DOGGR-IT, National Labs (Sandia, Lawrence Berkeley, Lawrence Livermore), SoCalGas, and CPUC.
- Extensive testing of corrosion inhibitors was conducted at the Blade laboratory in Houston between December 2016 and January 2017. Nine different products from three different manufacturers were tested and evaluated. The results showed that Tectyl 846 was the optimum choice based on the following test criteria:
  - It is transparent after drying to maintain individual joint traceability.
  - It is firm enough to resist handling damage to the coating during bolstering and transportation.
  - It provides adequate protection against corrosion.
  - It satisfies California's Volatile Organic Compound (VOC) limits for coatings (≤3.5 ppg).
  - It is easy to removal prior to inspection and analysis, and it causes no damage to underlying surface after cleaning.

  Other corrosion inhibitors were effective from a corrosion mitigation perspective, but had issues with transparency or VOC compliance or were affected significantly by basic handling. This corrosion inhibitor testing work is discussed in the report *Screening of Corrosion Inhibitors for use on SS-25 Tubulars – Phase I and II* [8].
- A full-scale field test was conducted on February 09, 2017, using a mock cleaning and coating station set up at the SS-24 well site. The objectives were to:
  - Confirm that Sentinel 747, proposed by Argus Contracting, was effective for cleaning the OD under field conditions.
  - Confirm that Tectyl 846 could be efficiently applied under field conditions.
  - Estimate the cleaning and coating time and chemical volume requirements.

SoCalGas provided several joints of 2 7/8 in. tubing that had been recently extracted from another Aliso Canyon well for use during the field test. Argus Contracting provided the cleaning equipment, chemicals, and crew. The test methodology is described in the document *SS-25 Phase 3 Pipe Cleaner and Corrosion Inhibitor Test Protocol* [9]. The OD and ID of five joints of tubing were successfully cleaned, and then the OD was coated with the corrosion inhibitor. The test results are detailed in the report *SS-25 Phase 3 Pipe Cleaner and Corrosion Inhibitor Test Protocol Test Results* [10]. The lessons learned from this exercise were incorporated into the Tubulars Handling Protocol.

- Blade conducted a 2-day dry run exercise of the tubulars handling procedures and plans for the Blade personnel who would be involved, which began on March 04, 2017. The intent was to ensure that there was a clear and common internal understanding of the Tubulars Handling Protocol requirements, the definition of a *flaw*, and the techniques that would be used to preserve and protect a flaw. This exercise included a detailed review and discussion of the handling protocol and practicing the visual inspection and flaw protection procedures on the SS-24 pipe mentioned in the previous bullet. The Tubulars Handling Protocol was subsequently revised based on the lessons learned from this exercise.
- Frames and accessories for DRILLTEC's Resist-All Packaging (RAP) bolstering system were purchased from Energy Alloys for 2 7/8 in. tubing and 7 in. casing. Bolstering was the primary method used for preventing handling damage during transportation and storage.
- The PS-20 well site was selected as the location where the pipe cleaning, coating, and storage would be done because of insufficient room on the SS-25 well site. Doby Hagar Trucking set up a waste containment system, installed a series of pipe racks, and provided a crane. Argus set up two containers to store their equipment and chemicals. SoCalGas set up a camera surveillance system and arranged for 24-hour security. Blade set up a climate-controlled Conex trailer to be used for evidence storage.
- The South Coast Air Quality Management District (SCAQMD) required a permit for the volume of Tectyl 846 that would be sprayed in the pipe ID because of the amount of VOC that would be generated. A permit was not required for the Tectyl 846 that would be rolled onto the OD. Argus sent the permit application on March 22, 2017, to cover the requirements for SS-25A and SS-25, and it was approved on May 2. The permit noted that Sentinel 747 could not be used as a cleaner because SCAQMD did not accept the method the supplier used to calculate VOC content. Argus proposed VOC-compliant Sentinel 909 as an alternative, which was subsequently field tested at PS-20 and found to be suitable.
- Blade decided that the extracted tubulars would be transported to Houston to be inspected at the NOV Tuboscope Sheldon Road facility because the proprietary full-length electromagnetic and ultrasonic inspection technologies used for the inspection were unavailable in California. Blade rented a 15,000 ft^2, climate-controlled warehouse in Houston to serve as the RCA storage facility. AECOM installed a security system, which included internal and external video surveillance cameras. Veterans Security provided physical security during nonbusiness hours and weekends. Blade developed the warehouse protocol, which addressed restricted site access control and shipping and receiving procedures [11].

A draft version of the Tubulars Handling Protocol document was issued on October 24, 2016, for comments. Version 1 was updated based on comments from SoCalGas, DOGGR-IT, the National Labs, further planning work, and corrosion inhibitor testing and was issued on March 09, 2017. Version 2 included corrected typos and was issued April 04, 2017. Version 3 was updated per the lessons learned from the SS-25A extraction experience and issued July 12, 2017. Version 4, the final version, was updated based on SoCalGas comments and issued on July 31, 2017.

An internal supplemental procedure *Phase 3 Tubulars Handling Supplemental Procedures* [12] was developed to address topics that did not need to be in the Tubulars Handling Protocol but needed to be agreed upon and followed internally. This document discussed such topics as document processing and control, traceability of sectioned joints, and PS-20 site management.

3.3.1 Tubulars Handling Process Overview

As outlined in the flowchart in Figure 3 and detailed in the Tubulars Handling Protocol, the basic tubulars handling process is described in this section. Note that all of the Phase 3 tubulars handling operations were witnessed by representatives from CPUC and DOGGR-IT and witnesses from interested parties.

1. The rig crew pulled several joints from the well and laid the joints down on the pipe rack at SS-25. The tubing connections were broken out using Weatherford's tubing tongs, and the breakout was monitored and recorded using Weatherford's torque-turn equipment. The casing connections were not backed out. Instead, the casing was cut on the rig floor just below the connection so that connection could be preserved intact for later testing. Blade conducted an Ultrasonic (UT) and a Magnetic Particle Inspection (MPI) of the area prior to making the cut to ensure that there were no internal pipe body flaws at the cut location. Blade visually inspected and photographed the connections on the rig floor, and assigned each joint a unique Joint Sequence Number (JSN) for traceability.
2. Rig operations were paused while Blade visually inspected the joints on the pipe rack, which consisted of:
    a. Documenting the inspection results for each individual joint on an Evidence Data Sheet (EDS) and with photographs.
    b. Taking scale and solids samples as necessary. Each sample was given a unique number that tied the sample back to the joint it was taken from, and each sample had its own EDS. Samples were subsequently stored in the refrigerator in the Blade evidence trailer at PS-20.
    c. Permanently stenciling the JSN on both ends of the joint.
3. The joints were then loaded on a trailer while Blade filled out Change of Custody (COC) forms for each joint and sample by which Blade released the joints and samples to be moved from SS-25.
4. Blade escorted the joints as they were moved to PS-20, while rig operations recommenced and several more joints were pulled.
5. At PS-20, Blade filled out the COC forms whereby Blade received the joints and samples at the new location. The joints were then unloaded onto the pipe racks. The trailer returned to SS-25 to pick up the next joints.
6. Argus cleaned the joints using brushes, rags, and Sentinel 909, and the joints were allowed to dry.
7. Blade conducted a second visual inspection of the cleaned joints using the same procedures as before. The results were documented in a second EDS. The final inspection disposition was that either the joint had a flaw(s) or that it did not. An evaluation of the severity or relevance of the flaw was not part of these visual inspections. The flaw evaluation was done at a laboratory after the pipe had been transported to Houston. Normal handling damage (e.g., slip marks) was not considered to be a flaw.

8. Argus applied the corrosion inhibitor Tectyl 846 to the joints using rollers on the OD and sprayed it onto the ID. The joints were then allowed to dry and cure overnight.
9. At the end of each day, Blade photocopied and scanned all the various documents that had been generated and then uploaded them to Blade's ftp site along with all the pictures taken that day.
10. The next morning, Blade inserted Volatile Corrosion Inhibitor (VCI) foam strips into the ID on both sides of each joint and installed thread protectors on the pin and box of the tubing and rubber end caps on the ends of each joint of casing. The joints were then loaded onto bolsters for storage and transport.

After inspection, the casing joints were cut again at PS-20 to provide a 5 ft section with the connection in the middle. These connection sections were wrapped in VCI, and a moisture barrier bag containing desiccant was built around the section. Air was purged from the bag, and the section was crated. In some cases, select joints were not cleaned, but were instead wrapped in VCI, set in a moisture barrier bag, and crated. This allowed the section to be transported to Houston and then examined in its as-recovered condition under laboratory conditions.

The tree was handled in a similar manner. It was transferred whole to PS-20 where the various components were disassembled and cleaned. Blade visually inspected and photographed the components and assigned each a unique number, which was permanently stenciled onto the component. Argus coated the ID surfaces with Tectyl 846. The individual components were then placed on a wooden base of what would become a crate. VCI foam was inserted into the ID; a moisture barrier bag containing desiccant was built around the component, and the air was purged from the bag. The sides and top of the crate were then assembled. The crating services were provided by Orange Country Crating.

The solids, liquid, and gas samples collected were shipped following the COC procedures and analyzed at one or more of these independent laboratories in Texas—Texas OilTech Laboratories in Houston (compositional analysis), Premier Oilfield Group in Houston (X-ray diffraction and Raman spectroscopy), Schlumberger in Houston (CHDT compositional analysis), and Ecolyse in College Station (microbial analysis).

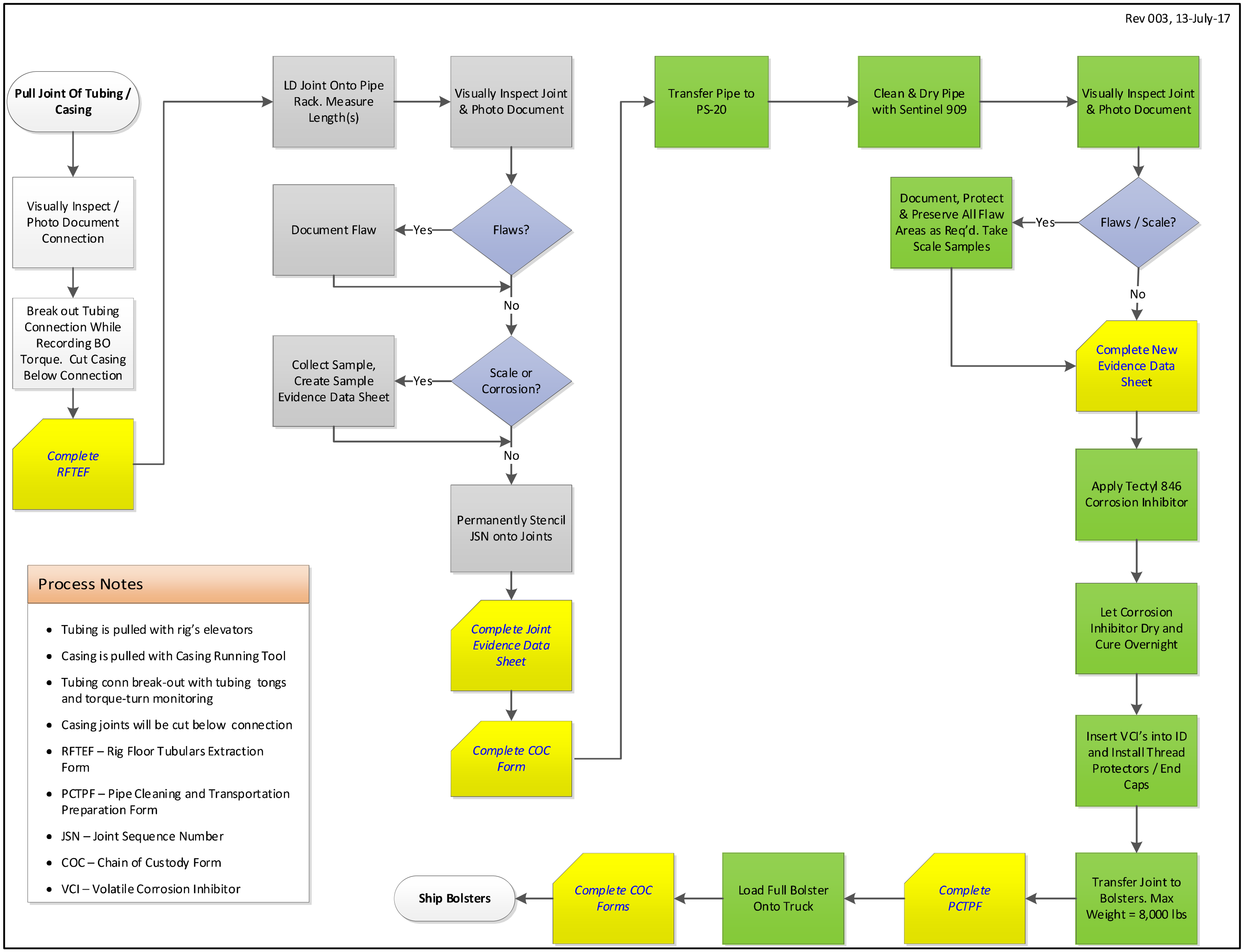

Figure 3: Tubulars Handling Protocol Overview Flowchart

4 Phase 3 Operations Review

Because of uncertainties around the condition of the SS-25 wellbore, the Phase 3 operations were conducted in stages. Data were collected and then analyzed at the end of each stage before moving on to the next. Figure 4 shows the status of the well at the start of operations. The fluid levels were at 124 ft in the tubing, at 282 ft in the 7 in. x 2 7/8 in. annulus, and at 344 ft in the 11 3/4 in. x 7 in. annulus. The Versa-Line MID logs run in April 2016 indicated that there was metal loss at approximately 895 ft and 4,456 ft in the 7 in. casing and at approximately 151 ft and 192 ft in the 11 3/4 in. casing.

Based on the experience from SS-25A, Blade and SoCalGas decided to conduct the tubing extraction with the Ensign 334 service rig to take advantage of the rig crew's previous experience with the tubulars handling requirements. The Ensign rig 540, a larger, more capable drilling rig, would be used for the 7 in. casing work. The Phase 3 operations lasted from July 31, 2017, to September 12, 2018, and were conducted during daylight hours (nominally 6 AM to 6 PM) 7 days a week. Representatives from SoCalGas, CPUC, and DOGGR-IT were on-site for all of the operations. Appendix A shows a summary of the daily operations reports for SS-25.

4.1 Phase 3A Operations: Tubing Extraction and 7 in. Casing Logging

Blade expanded the summary steps from the Phase 3 protocol document into a detailed work plan for the Phase 3 field work. The first work plan issued on July 31, 2017, was *Work Plan SS-25 Phase 3A Tubing Extraction and 7" Casing Logging* [13]; it covered extracting the tubing and logging the 7 in. casing and then pausing the operations to determine the next steps. SoCalGas sent DOGGR the NOI for this work on February 24, 2016, and DOGGR issued the permit on June 06, 2016. The overall plan was to:

1. Recover tubing fluid samples using a slickline fluid sampler.
2. Set a cement plug in the tubing from 8,175 ft to 7,590 ft.
3. Set a bridge plug in the tubing at 7,590 ft and pressure test the plug to 500 psi.
4. Move in and rig up the Ensign 334 rig.
5. Attempt to fill the tubing and 7 in. x 2 7/8 in. annulus with 9.0 ppg mud.
6. Nipple down the tree and tubing head adaptor.
7. Nipple up the Blowout Preventer Equipment (BOPE) with a 6 in. diverter. Test the BOPE and function test the diverter.
8. Run a free point tool to determine the free point of the tubing.
9. Cut the tubing at approximately 7,590 ft if the tubing is free (there were contingency plans if the tubing was not free).
10. Pull and lay down the tubing to 1,050 ft. Circulate the well with clear fluid in preparation to running the downhole video camera.
11. Pull up to 850 ft. Run the camera to inspect the 7 in. casing in the area of 895 ft.
12. Stop operations, evaluate next steps, and obtain approval for next steps.

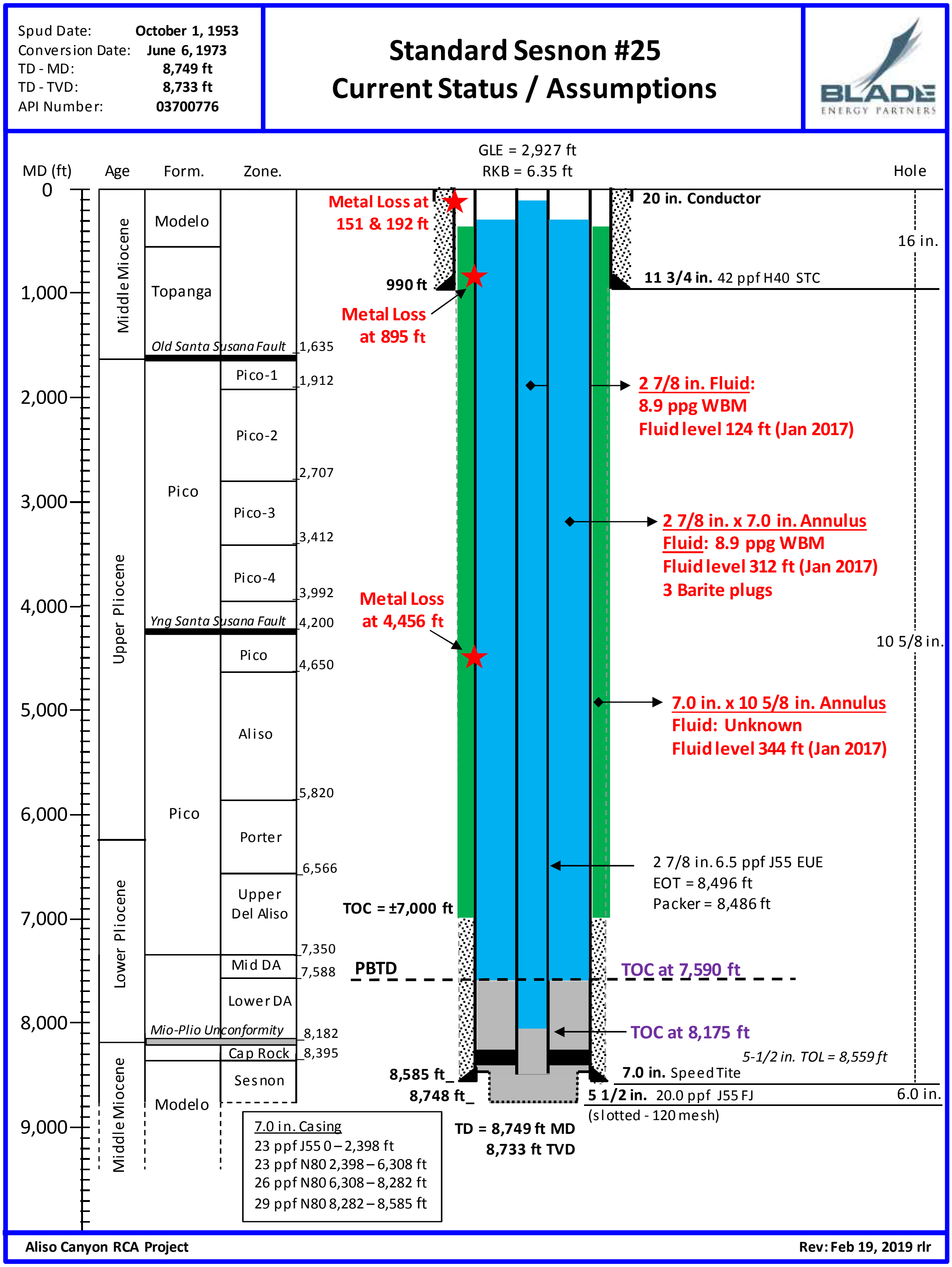

Figure 4: Well Status at the Start of Phase 3 Operations

The Phase 3 operations at SS-25 began on July 31, 2017. Fluid samples were taken from the 2 7/8 in. tubing in accordance with Blade's Tubing Fluid Sampling and Analysis [14], and Tubing Fluid Sample Extraction Procedure documents [15]. Samples were taken at 210, 310, 1,500, 1,600, 3,000, 3,100, 4,500, 4,600, 6,000, 6,100, 7,500, and 7,600 ft using Western Wireline's Flow Through Sampler tool. Texas OilTech Laboratories and Ecolyse processed the samples and sent them to their laboratories in Houston for analysis under their respective COC procedures.

A Halliburton coiled tubing unit was mobilized to the location on August 02, 2017. The coiled tubing was run inside the 2 7/8 in. tubing, and a cement plug was set from 8,175 to 7,580 ft. A Cast Iron Bridge Plug (CIBP) was run on the coiled tubing; it was set at 7,572 ft and pressure tested to 500 psi.

On August 10, 2017, the Ensign 344 service rig was moved in, and was rigged up over the next several days. Attempts were made to fill the A and B annuli with 9 ppg Flowzan mud between August 15 and August 17, 2017. This proved unsuccessful, indicating that there was communication between the two annuli and the surrounding formation.

On August 19, 2017, the tree was nippled down, and the BOPE and diverter were nippled up and tested. The tree was transferred in one piece to PS-20, where it was dissembled into its individual components and then cleaned, inspected, and crated in accordance with the Tubulars Handling Protocol procedures described in Section 3.3.1.

On August 21, 2017, Tiger Wireline ran a 2 1/4 in. gauge ring, which tagged the CIBP in the tubing at 7,575 ft. This was followed by their free point tool, which showed that the tubing string was free down to the CIBP. Baker Hughes then ran their mechanical pipe cutter and cut the tubing at 7, 555 ft with 10,000 lbf of overpull. 20 bbl of 9.0 ppg Flowzan was pumped down the tubing in an effort to establish circulation without success.

The next 7 days were spent pulling 210 joints of tubing. The joints were inspected and then transferred to PS-20 per the tubulars handling procedures. The number of joints that could be pulled in a day was limited by the amount of time it took to process the pipe at PS-20. Every joint pulled on a particular day needed to be cleaned and coated with corrosion inhibitor that same day to minimize the chances of surface corrosion. As such, laying down 30 joints of tubing per day ended up being the operational maximum.

Blade observed an occasional low-magnitude but sharp increase in tension (i.e., overpull) on the string weight indicator during the extraction of the 2 7/8 in. tubing. The overpull was spaced roughly in 31 ft increments. Some of the tubing connections were observed to have a 1/2 to 1 in. area of shallow deformation at the bevel on the upper side of the connection. Blade interpreted this as a probable full circumferential parting of the 7 in. casing and that the tubing connections were momentarily hung up as they passed through the parted area. This needed to be confirmed because it had major implications in further operations, so the tubing extraction was stopped when the base of the tubing reached 953 ft. Baker Hughes wireline was rigged up and used to run the EV downhole video camera through the tubing and out into the 7 in. casing. Figure 5 shows a schematic of the well configuration for the video camera work. With the video camera positioned at the end of the tubing the tubing was slowly raised concurrent with pumping clear 8.5 ppg KCl fluid while the ID of the 7 in. casing was observed with the camera.

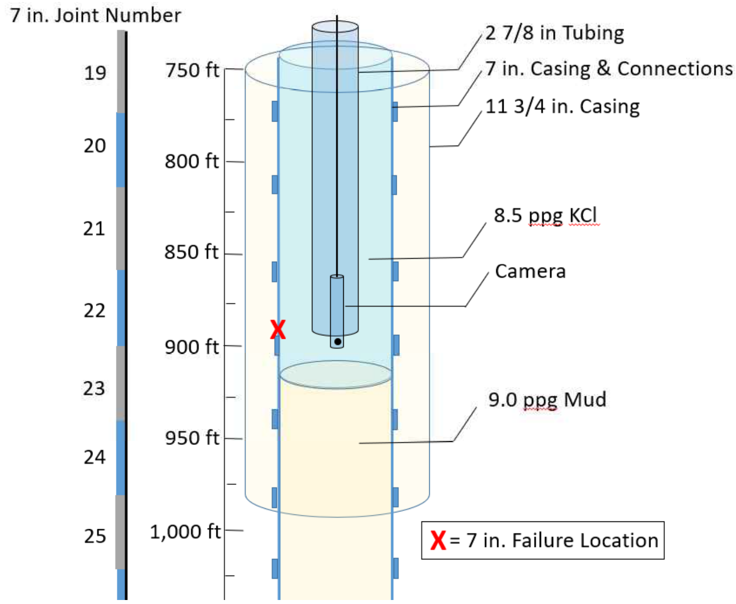

Figure 5: Well Configuration for Through-Tubing Camera Run to View 7 in. Casing Failure Area

On August 31, 2017, the 7 in. casing was found to have completely parted at 892 ft near the base of joint number 22. The distance between the upper and lower parted sections was approximately 5 in. The final joints of tubing were pulled and processed at PS-20. A total of 244 tubing joints were extracted from the well. Operations were suspended on September 02, 2017, to evaluate the new well data and decide the next steps.

4.2 Phase 3A Contingency Operations: 7 in. Casing Extraction and Logging

A meeting was held on September 07, 2017, to review the well status and propose the next steps with DOGGR District. DOGGR-IT, CPUC, and SoCalGas also attended. Based on the results of the meeting, SoCalGas sent DOGGR a Supplemental NOI on September 08, 2017, for the recovery of the parted 7 in. casing, logging the 11 3/4 in. casing, tying the 7 in. casing back to surface, and running a set of 7 in. casing and formation evaluation logs. DOGGR issued a permit for the work on October 07, 2017. The overall plan was to:

1. Run a video camera to inspect the 7 in. casing above the fluid level around 300 ft.
2. Run a casing caliper in the 7 in. casing to around 875 ft.
3. Set a Retrievable Bridge Plug (RBP) in the casing at a depth based on camera and caliper results.
4. Nipple down the BOP, diverter, tubing head, and double-studded adaptor.
5. Pick up on the casing and remove the casing slips.
6. Cut the casing and lay down approximately 20 ft of the casing to allow for a gap between the upper and lower sections of parted casing.
7. Hang off the casing in the wellhead. Install a full-opening safety valve.
8. Shut the wellhead valves and secure the well.
9. Rig down and move off Rig 334.
10. Move in and rig up Rig 540.

11. Install spacer spools and well control equipment.
12. Pull and lay down the upper 7 in. casing.
13. Run logs in the 11 3/4 in. casing.
14. Recover a section of the casing below the parted casing depth while leaving the stub above the 11 3/4 in. shoe depth.
15. Run additional logs in the 11 3/4 in. casing.
16. Run in with the tieback casing to the casing stub. Latch on the stub and tie back the 7 in. casing to surface.
17. Collect fluid samples from the 7 in. casing.
18. Run casing and formation evaluation logs in the 7 in. casing.
19. Displace the well to clear brine. Filter the fluid.
20. Run a video camera to view features in the 7 in. casing identified based on the casing inspection logs.
21. Displace the clear brine with 9 ppg mud. Secure the well.
22. Stop operations, evaluate the next steps, and obtain approval for the next steps.

Operations recommenced on October 10, 2017. The EV camera was run to inspect the 7 in. casing down to the top of the fluid level at 322 ft, followed by a Baker Hughes caliper log run in the 7 in. casing from 866 ft. A RBP was set in the 7 in. casing at 200 ft, and the tubing head was removed. A new casing head was installed, and the upper 12 ft of the 7 in. casing was cut and removed. The remaining 7 in. casing was hung off in the tubing hanger using a spear. The 12 ft section was inspected and processed at PS-20.

On October 13, 2017, the Ensign 334 service rig was demobilized, and the Ensign 540 drilling rig was mobilized and rigged up between October 15 and October 29, 2017. On October 18, 2017, Blade issued the revised detailed work plan *Work Plan SS-25 Phase 3-A Contingency, Extract Parted 7" Casing, 11 3/4" Logging, 7" Casing Tieback and 7" Casing Logging* [16]. Extraction of the 7 in. casing began on October 30, 2017. Over the next eight days, 22 joints of 7 in. casing were extracted, inspected, and processed at PS-20 per the Tubulars Handling Protocol. The EV camera was run to inspect the 11 3/4 in. casing down to the top of the fluid level at 275 ft, followed by a Baker Hughes caliper log run in the 11 3/4 in. casing from 875 ft to surface.

From November 08 to 13, 2017, an NOV Ratchet Pawl Casing Extraction tool was run on a new 7 in. workstring to latch onto the original 7 in. casing just below the connection between joint numbers 22 and 23. Figure 6 and Figure 7 show a layout drawing of the NOV Rachet Pawl Casing Extraction tool and photographs of its use in SS-25, respectively. The ratchet pawls are spring loaded fingers that fold inward as the tool descends over the 7 in. Speedtite connection and then spring back to perpendicular below the 7 in. Speedtite connection. Conventional fishing overshots and spears would have imparted substantial damage to the upward facing 7 in. casing failure. This NOV Rachet Pawl Casing Extraction tool was specifically designed and manufactured for this application to prevent damage to the OD of the 7 in. casing, especially in the area where the casing parted. The EV camera was deployed through the NOV Ratchet Pawl Casing Extraction tool and assisted in locating and avoiding damage to the top of the 7 in. parted casing. The 7 in. casing was successfully swallowed by the NOV Rachet Pawl Casing Extraction tool. After three unsuccessful cut attempts using the Baker Hughes Mechanical Pipe Cutter, a chemical cutter was used to cut the casing at 930 ft. The 38 ft of 7 in. casing that was recovered included the lower portion of the parted casing.

ITEM NO.	PART NUMBER	DESCRIPTION	QTY.
1		10-3/4" OD TOP SUB	1
2		10-7/8" OD GUIDE	1
3		RATCHET PAWL BODY	1
4		RATCHET PAWL	6
5		PAWL SPRING	6
6		PAWL PIN	6

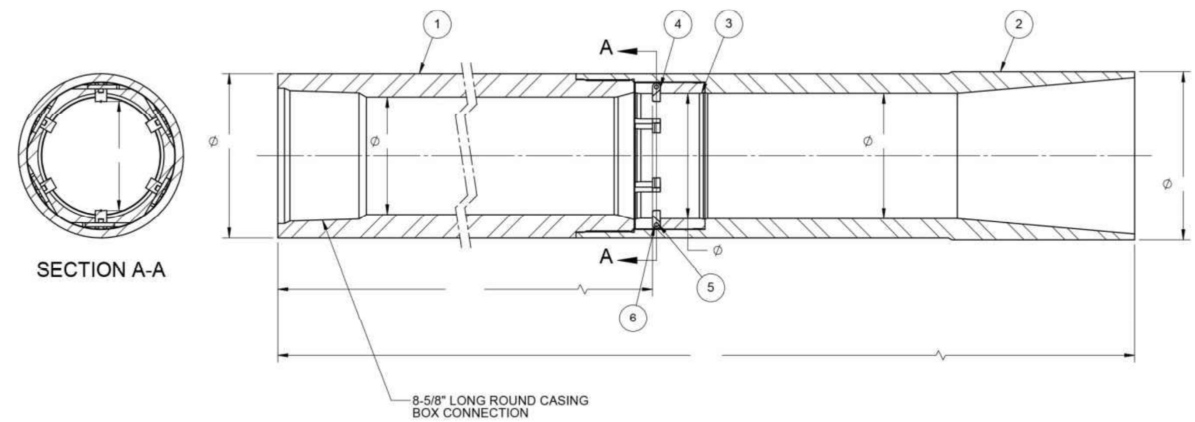

Figure 6: Layout Drawing of NOV Ratchet Pawl Casing Extraction Tool

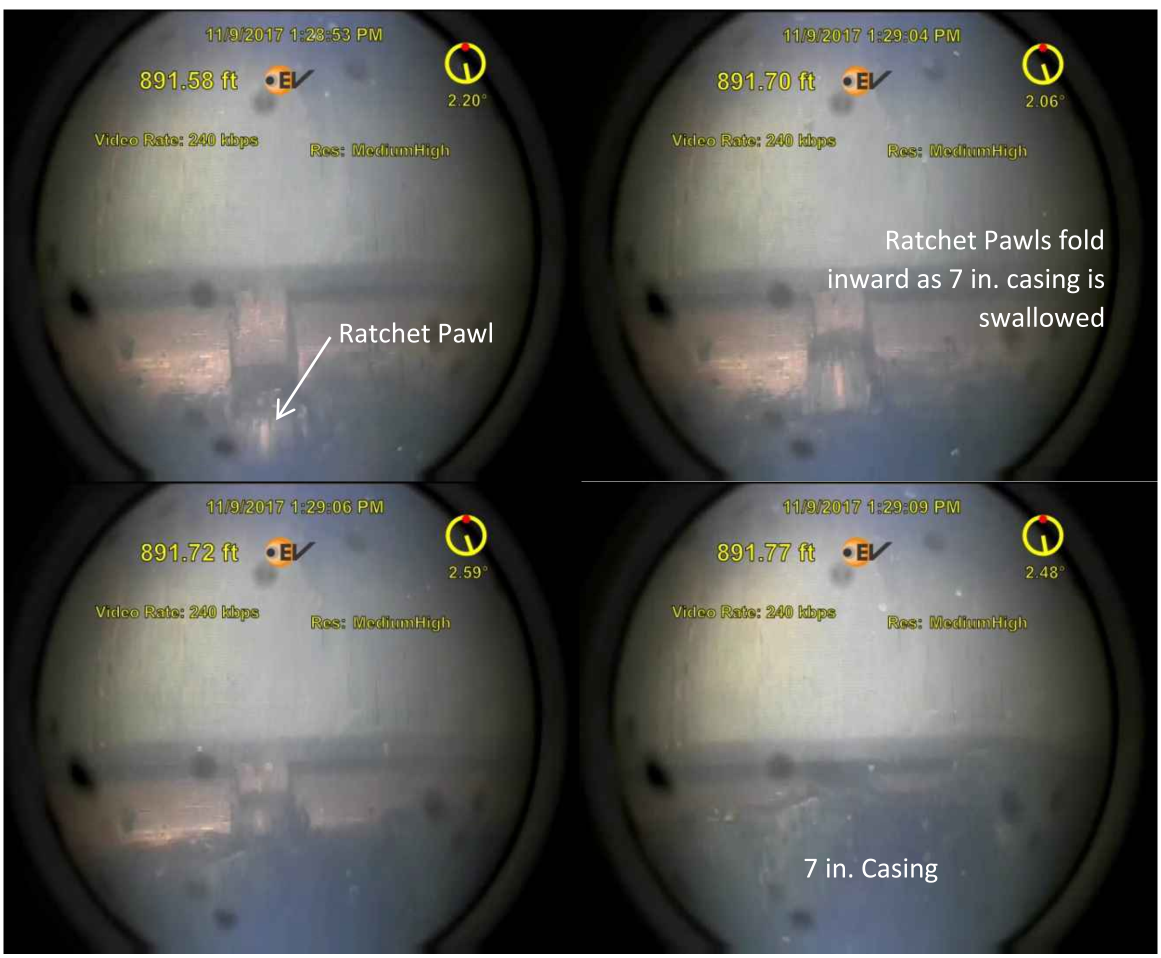

Figure 7: Camera-Assisted Fishing of 7 in. Casing Using the NOV Ratchet Pawl Casing Extraction Tool

A Weatherford casing patch overshot tool was next run to latch onto the 7 in. casing at 930 ft. The 7 in. casing was cut at 939 ft, and a further 9 ft of 7 in. casing was extracted. A total 23 joints (926 ft) of 7 in. casing were recovered, leaving the top of the 7 in. stub 51 ft above the 11 3/4 in. shoe at 990 ft.

On November 16, 2017, Versa-Line's MID-2 log was run in the 11 3/4 in. casing from 939 ft to surface, followed by Schlumberger's Litho Scanner and PNX logs over the same interval. On November 17, 2017, the Weatherford casing patch overshot tool was run on a new 7 in. 29 ppf tieback string and latched onto 7 in. stub at 939 ft. The 7 in. casing slips were set after pulling 25,000 lbf of overpull.

Fluid samples were taken from the 7 in. casing in accordance with Blade's Annulus Fluid Sampling and Analysis [17], and 7 in. Annulus Fluid Sampling procedure [18] documents. Samples were taken at 500, 600, 1,000, 1,100, 2,500, 2,600, 4,000, 4,100, 5,500, 5,600, 7,000, and 7,100 ft using Western Wireline's Flow Through Sampler tool. Texas OilTech Laboratories and Ecolyse representatives processed the samples and sent them to their labs in Houston for analysis.

Cleanout runs were made with a junk basket and scraper to prepare the well for logging. The top of the 2 7/8 in. tubing stub was tagged at 7,555 ft, and new 9.0 ppg Flowzan was displaced into the casing. The period from December 01 to December 15, 2017, was spent running logs in the 7 in. casing. These activities are summarized as follows:

- December 1, 2017: Ran Baker Hughes' 56-arm caliper from 7,549 ft to surface. Ran Versa-Line's MID-2 log from 7,549 ft to surface. Ran Versa-Line's MID-3 log from 1,090 to 949 ft.
- December 2, 2017: Completed running the MID-3 log from 949 ft to surface. Ran Baker Hughes' HRVRT log from 7,531 ft to surface. Ran Schlumberger's Pulsar log from 7,549 ft to surface.
- December 3, 2017: Ran Schlumberger's UCI-NEXT log from 7,549 to 3,100 ft.
- December 4, 2017: Completed running the UCI-NEXT log from 3,100 ft to surface. Ran Schlumberger's IBC-SSCAN log from 7,540 to 4,000 ft.
- December 5, 2017: Completed the IBC-SSCAN log from 4,000 ft to surface. Suspended operations because of high winds and fire danger.
- December 7, 2017: Ran Schlumberger's CPET log from 7,549 ft to surface. Ran the 3 1/2 in. workstring to 7,555 ft. Displaced the casing with 12% KCl brine. Circulated and filtered the fluid through a Baker Hughes Diatomaceous Earth (DE) filter system until the Nephelometric Turbidity Units (NTUs) were less than 10 in preparation for EV camera run.
- December 10–December 13, 2017: Ran the EV camera and inspected the 7 in. casing and the connection areas from 939 to 7,544 ft.
- December 14–December 15, 2017: Well Analysis Corporation ran their conventional noise and temperature logs from 7,549 ft to surface. Scientific Drilling ran a gyro survey from 7,549 ft to surface.

A 3 1/2 in. kill string was run to 7,513 ft, and the well was shut in. Operations were suspended on December 16, 2017, to process and review the new log data and determine the next steps. Figure 8 shows the status of the wellbore at this point.

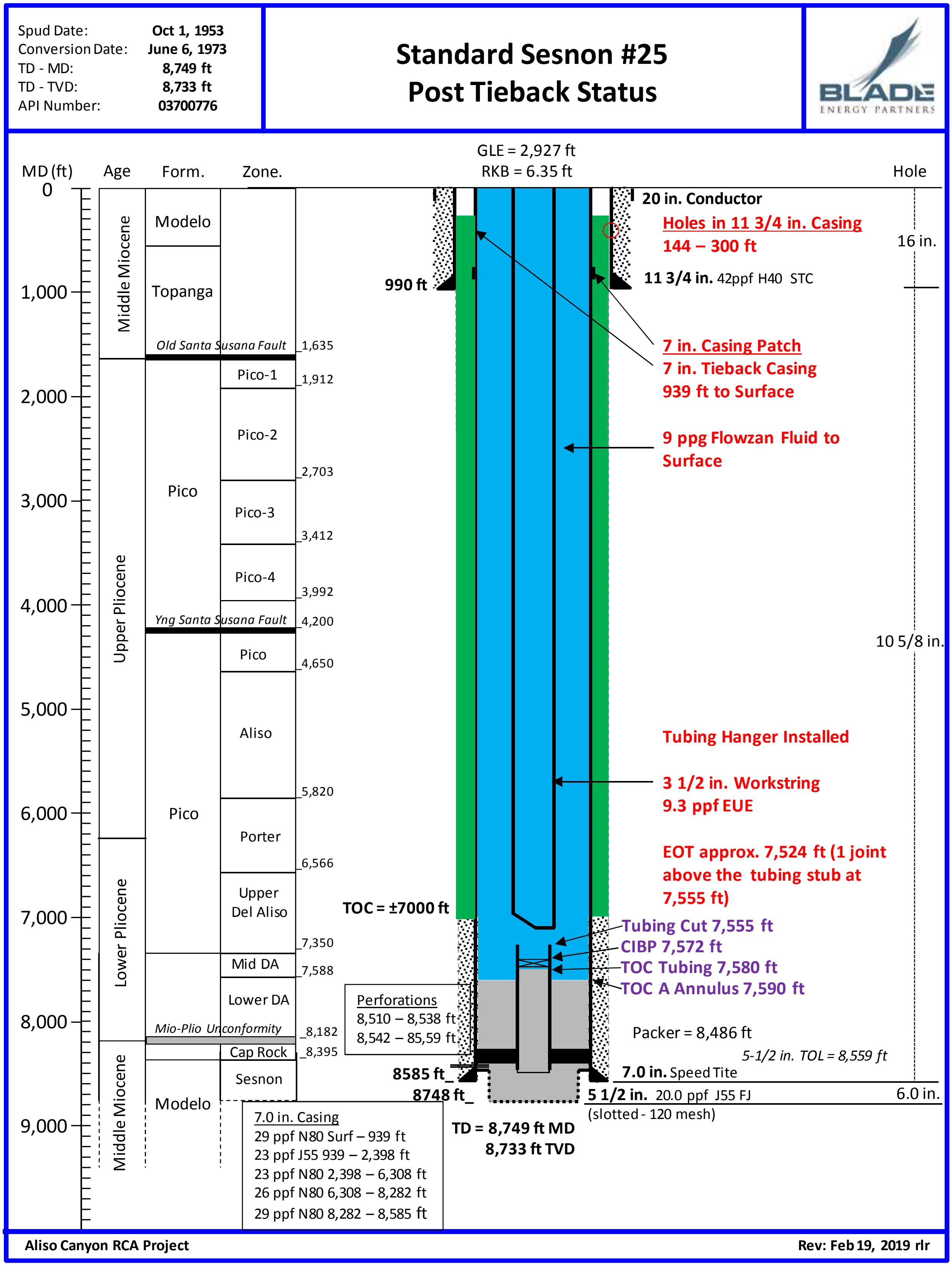

Figure 8: Well Status After 7 in. Casing Extraction and Tieback

4.3 Phase 3A Contingency Part 2 Operations: 7 in. Casing Extraction and Plug and Abandonment

Blade held several meetings in late January 2018 to discuss the logging results and the plan forward with CPUC, DOGGR-IT, and SoCalGas. The logs had shown that there was 7 in. OD corrosion down to 1,015 ft, and that no casing anomalies relevant to the RCA existed below that depth. Blade concluded that, going forward, collecting corrosion data on two more joints of casing and characterizing the area near the 11 3/4 in. shoe were important for the RCA. Operationally, this would involve cutting the 7 in. casing at 1,024 ft (34 ft below the 11 3/4 in. shoe), extracting the two additional casing joints, running wireline logs in the openhole area, and then tying the 7 in. casing back inside the 11 3/4 in. shoe. It was recognized by all the parties that working in the open hole posed a risk to the P&A. However, the logs also showed that the 7 in. casing was free at 1,024 ft, so that the risk of getting stuck while recovering the two additional joints was low. The logs also showed that the degree of lateral support to the casing provided by the formation and solids in the annulus progressively increased below 1,024 ft so that the risk of not being able to tie back the casing was also low.

A meeting was held on February 08, 2018, to review the logging data, well status, and proposed next steps with DOGGR. DOGGR-IT, CPUC, and SoCalGas were also present at the meeting. SoCalGas subsequently began preparing a Supplemental NOI with input from Blade and had several more follow-up meetings with DOGGR to discuss the P&A plans and requirements. SoCalGas sent DOGGR a Supplemental NOI on March 30, 2018, to P&A the lower part of the well to 1,040 ft, recover two additional joints of 7 in. casing from 1,024 ft, log the open hole and 11 3/4 in. casing, and complete the final P&A of the well. DOGGR issued a permit for the work on April 27, 2018. The overall plan was to:

1. Run a noise and temperature survey above and below the 11 3/4 in. shoe to evaluate potential flow paths for the 11-3/4 in. x 7 in. annulus fluid.
2. Run a gyro survey in the 7 in. casing from surface to 1,500 ft at 10 ft stations.
3. Run 5 in. wash pipe to clean out around the 2 7/8 in. tubing stub at 7,555 ft to the Top of Cement (TOC) in the 7 in. x 2 7/8 in. annulus at 7,590 ft.
4. Run a joint of 5 in. wash pipe and set cement plug #1 from 7,590 to 7,390 ft.
5. Run Schlumberger's CHDT and take 26 fluid samples from the 7 in. annulus between 6,716 and 975 ft.
6. RIH and take 7 in. casing core samples using the Schlumberger's MSCT at 7,337 and 7,126 ft.
7. Set cement plug #2 from 7,390 to 6,890 ft.
8. Take a MSCT sample at 6,721 ft.
9. Set cement plug #3 from 6,890 to 6,616 ft.
10. Pressure test the 7 in. casing to 500 psi for 30 minutes.
11. Perforate and squeeze the Upper Del Aliso-1 formation, leaving cement from 6,616 to 6,360 ft inside the casing.
12. Take an MSCT sample at 6,260 ft.
13. Perforate and squeeze the Lower Porter formation leaving cement from 6,360 to 6,095 ft inside the casing.
14. Take an MSCT sample at 6,020 ft.

15. Set cement plug #4 from 6,095 to 5,870 ft.
16. Perforate and squeeze the Upper Porter formation leaving cement from 5,870 to 5,600 ft inside the casing.
17. Perforate and squeeze the A-36 Sand leaving cement from 5,600 to 5,377 ft inside the casing.
18. Set cement plug #5 from 5,377 to 5,077 ft.
19. Take an MSCT sample at 4,791 ft.
20. Set cement plug #6 from 5,077 to 4,704 ft.
21. Perforate and squeeze the A-1 Sand leaving cement from 4,704 to 4,500 ft inside the casing.
22. Pressure test the casing to 500 psi for 30 minutes.
23. RIH with a casing scraper to the TOC. Run and set a CIBP at 4,500 ft.
24. Take MSCT samples at 4,110 and 3,666 ft.
25. Set cement plug #7 from 4,500 to 4,000 ft.
26. Set cement plug #8 from 4,000 to 3,500 ft.
27. Perforate and squeeze the annulus, leaving cement from 3,500 to 3,300 ft inside the casing.
28. Set cement plug #9 from 3,300 to 2,800 ft.
29. Take an MSCT sample at 2,713 ft.
30. Perforate and squeeze the PGS formation, leaving cement from 2,800 to 2,690 ft inside the casing. Run a CBL from 2,690 to 2,000 ft while holding 500 psi to confirm cement integrity behind the casing.
31. Take MSCT samples at 2,553, 2,372, 2,289, 2,037, and 1,925 ft.
32. Set cement plug #10 from 2,690 to 2,190 ft.
33. Set cement plug #11 from 2,190 to 1,690 ft.
34. Take MSCT samples at 1,625, 1,564, 1,140, 1,092, and 1,035 ft.
35. Set cement plug #12 from 1,690 to 1,270 ft.
36. Set cement plug #13 from 1,270 to 1,040 ft.

Recover Two Additional 7 in. Casing Joints

1. Run a hydraulic casing cutter and cut the 7 in. casing at 1,024 ft (34 ft below the 11 3/4 in. shoe).
2. Nipple down the BOPE, diverter, and tubing head.
3. Run a 7 in. casing spear, engage casing, pick up, and remove the casing slips.
4. Nipple up and test the BOPE and diverter.
5. Run the spear and engage the casing.
6. Pull and lay down the tieback casing, and release the tieback overshot.
7. Lay down the two original joints of 7 in. casing according to the Blade Tubulars Handling Protocol.

Run Openhole Logs

1. Run an openhole caliper from the 11 3/4 in. casing shoe to the top of the 7 in. casing stub at 1,024 ft.

2. Run Schlumberger's FMI log from the 11 3/4 in. casing shoe to the top of the 7 in. casing stub.

Log the 11 3/4 in. Casing

1. Run a casing scraper to the 11 3/4 in. casing shoe.
2. Run the CHDT and take fluid samples outside the 11 3/4 in. casing at locations to be determined based on the log results.
3. Take 11 3/4 in. casing samples at locations to be determined based on the log results.
4. Run a gyro survey in the 11 3/4 in. casing from the shoe to surface at 10 ft stations.
5. RIH open ended and displace to clear fluid, and attempt to fill the casing.
6. Filter the fluid to <10 NTU or until the fluid is deemed suitable for running the video camera.
7. RIH and record downhole video from surface to the 11 3/4 in. casing shoe.

Perform Final P&A Operations

1. Run a 10 5/8 in. bit and clean out to the top of the 7 in. casing stub. Displace the clear fluid with 9 ppg polymer mud.
2. Run the 7 in. tieback casing with the casing patch overshot and latch on to the casing stub.
3. Run a hydraulic cutter and cut the 7 in. casing above the shoe at 980 ft. Lay down the tieback casing.
4. Isolate the 11 3/4 in. shoe setting a cement plug from 1,040 to 860 ft.
5. Set an 11 3/4 in. cement retainer at 860 ft.
6. Set cement plug #14 from 860 to 810 ft.
7. Perforate and squeeze the base of fresh water leaving cement from 810 to 780 ft inside the casing.
8. Set cement plug #15 from 780 to 580 ft.
9. Set an 11 3/4 in. cement retainer at 580 ft.
10. Set cement plug #16 from 580 to 380 ft.
11. Set cement plug #17 from 380 to 180 ft.
12. Set cement plug #18 from 180 to 15 ft.
13. Nipple down the BOPE.
14. Cut off the casing head and release it to Blade for RCA evaluation.
15. Cut the 11 3/4 in. casing 5 to 10 ft below ground level.
16. Perform a bubble test. Weld on the well identification plate.
17. Rig down and move off the Ensign 540 rig.

On May 15, 2018, Blade issued the final work plan version *Work Plan SS-25 Phase 3-A Contingency Part 2* [19], which covered this remaining work. Operations recommenced on May 16, 2018.

The 3 1/2 in. kill string was pulled and laid down. Scientific Drilling ran a gyro survey from 1,500 ft to surface with 10 ft survey stations. Well Analysis Corporation ran a noise and temperature log survey, which involved pumping small volumes of fluid into the 11 3/4 in. x 7 in. annulus and then listening for indications of flow at the 11 3/4 in. shoe. On May 21, 2018, a 5 in. wash-pipe bottomhole assembly was run to clean out the area around the 2 7/8 in. tubing stub at 7,555 ft to the TOC in the 7 in. x 2 7/8 in. annulus at 7,590 ft. The first abandonment cement plug was set from 7,590 to 7,376 ft and tagged with 10,000 lbs on May 25, 2018. DOGGR personnel were on-site to witness the pumping and tagging all of the cement plugs.

Schlumberger ran their CHDT tool and conducted an annular fluid sampling program from May 29 to June 10, 2018. Fluid samples were taken from the 7 in. annulus at 6,716, 6,240, 4,810, 4,285, 4,121, 3,659, 2,706, 3,000 2,295, 2,000, 1,000, 1,680, 1,664, 1,104, 1,088, 1,072, 1,054, 1,006, 994, and 975 ft. Schlumberger ran their MSCT tool and cut a core sample of the 7 in. casing at 7,337 ft, and attempted to cut a core at 7,126 without success. The second abandonment cement plug was set from 7,376 to 6,877 ft and tagged with 10,000 lb on June 18, 2018.

The next 47 days from June 19 to August 05, 2018, were spent setting a series of consecutive cement plugs in the 7 in. casing from 6,877 to 1,066 ft in accordance with the DOGGR permit requirements. After 17 further attempts, only four MSCT samples of the 7 in. casing were successfully recovered from 2,553, 2,289, 1,925, 1,625, and 1,564 ft. In some cases, the MSCT core bit could not drill through the casing wall, but in most cases the core sample was not recovered at surface and apparently fell out of the tool as it was pulled to surface.

On August 06, 2018, the 7 in. casing was cut at 1,025 ft. A spear was run to engage the casing and the 7 in. tieback string, casing patch, and two joints of the original casing pulled from the well. The two joints were inspected and processed at PS-20 per the Tubulars Handling Protocol. On August 09, 2018, Schlumberger ran a caliper log and an FMI log in the open hole from 1,016 ft to the 11 3/4 in. shoe at 990 ft.

The period from August 11 to August 27, 2018, was spent running logs in the 11 3/4 in. casing. These activities are summarized as follows:

- August 11, 2018: Well Analysis Corporation ran a noise and temperature log survey from 990 ft. Baker Hughes ran a GR/JB/CCL log from 990 ft to surface, and attempted to run their 56-Arm Caliper log but there were ID restrictions from debris inside the casing. A casing scraper was run to 484 ft to clear the debris.
- August 12, 2018: The casing scraper run was completed to 990 ft. Baker Hughes successfully reran the 56-Arm Caliper log from 990 ft to the surface. Baker Hughes next ran their IntEx log from 990 ft to surface and attempted to run their HRVRT log but the tool failed.
- August 13, 2018: Scientific Drilling ran a gyro survey in the 11 3/4 in. casing from 990 ft to the surface at 10 ft survey stations. Baker Hughes attempted to run their HRVRT log again without success.
- August 14, 2018: After making tool repairs, Baker Hughes ran their HRVRT log from 990 ft to surface. Schlumberger ran their IBC log from 990 ft to the top of the fluid at 188 ft.
- August 15, 2018: Schlumberger ran their UCI and SSCAN logs from 990 ft to the top of the fluid at 190 ft.
- August 16, 2018: Schlumberger ran their Pulsar log from 1,005 ft to 600 ft.
- August 17, 2018: Schlumberger ran their NEXT-Litho Scanner log from 1,005 to 600 ft and their CPET log from 990 to 400 ft where the tool failed.
- August 18, 2018: After making tool repairs, Schlumberger ran the CPET log from 400 ft to the surface. Baker Hughes ran the EV downhole camera to inspect the 11 3/4 in. casing above the fluid level at 213 ft.

- August 19, 2018: Continued inspecting the 11 3/4 in. casing with the EV downhole camera from 990 to 972 ft, at 892 ft, and from 743 to 701 ft.
- August 20–August 25, 2018: Schlumberger ran their CHDT tool and took fluid samples from the 11 3/4 in. annulus at 872, 860, 556, 434, 372, and 355 ft.
- August 26–August 27, 2018: Schlumberger ran their MSCT tool and took core samples of the 11 3/4 in. casing at 970, 896, 816, 720, 706, 638, 550, 510, 416, 350, 315, 308, 285, 270, and 242 ft.

A 10 5/8 in. bit was run to clean out the area around the top of the 7 in. stub at 1,025 ft followed by a mill to dress off the top of the stub in preparation for running the tieback. On August 29, 2018, a Weatherford casing patch overshot tool and 7 in. tieback was run and engaged the stub with 30,000 lb of overpull. A 6 in. bit was run in the 7 in. casing, and it tagged the cement plug at 1,066 ft. The 7 in. casing was then cut at 978 ft and the tieback string was laid down. Two cement plugs were set to isolate the 11 3/4 in. shoe area bringing cement from 1,066 to 822 ft. The cement top was tagged on September 01, 2018, and an 11 3/4 in. cement retainer was set at 822 ft.

From September 02 to September 09, 2018, a series of consecutive cement plugs was set, bringing the cement in the 11 3/4 in. casing to 52 ft. Another 11 3/4 in. cement retainer was set at 94 ft, and the casing above it was tested to 250 psi. The BOPE was nippled down, and the 20 in. conductor casing was cut 10 ft below ground level. The 11 3/4 in. casing was then cut just above the 20 in. cut, and the attached casing head and section of 11 3/4 in. casing were inspected and processed at PS-20 per the Tubulars Handling Protocol.

On September 10, 2018, an 11 3/4 in. riser was welded onto the 11 3/4 in. stub to bring the top of the casing to 5 1/2 ft below ground level. The final cement plug was set from 52 ft to the top of the 11 3/4 in. casing. A successful bubble test was conducted and witnessed by a DOGGR representative, and a plate was welded onto the top of the 11 3/4 in. casing. On September 13, 2018, the Ensign 540 rig was released, and the Phase 3 operations concluded. Figure 9 shows the final P&A status of the SS-25 well.

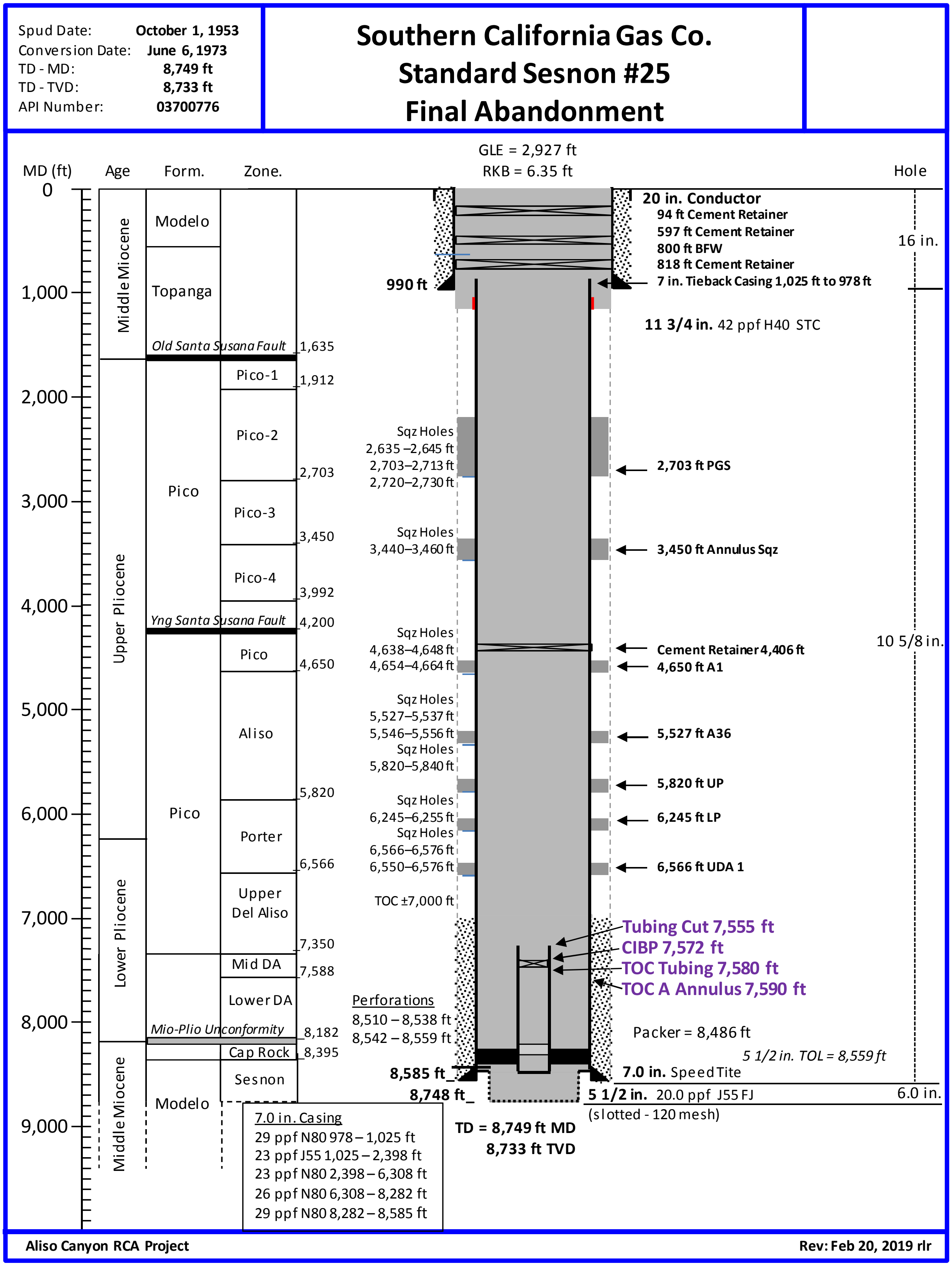

Figure 9: SS-25 Final Well Status

Table 2 shows a summary of some key dates of the Phase 3 activity. Numerous meetings were held between June 15, 2016, and February 24, 2017, to work out details of the Phase 3 work, resulting in several revisions of the document *Phase 3 Tubing, Casing, Wellhead Extraction Protocol* [2]. In all, 207 days were spent with a rig on SS-25 conducting Phase 3 operations. The rest of the Phase 3 time was dedicated to preparation and getting approval for the work.

Table 2: Summary of the Phase 3 Field Activity

Date	Phase 3 Field Activity	Cum. Days
October 23, 2015	SS-25 started leaking gas.	
January 29, 2016	Blade arrived at Aliso Canyon to start the RCA.	
June 15, 2016	Blade met with DOGGR in Ventura to review Phase 3.	0
February 24, 2017	SoCalGas submitted the SS-25 NOI.	254
April 17, 2017	DOGGR issued the SS-25A permit.	306
May 08, 2017	Rig work (Ensign 334) started on SS-25A to extract tubing, log casing, and P&A the lower wellbore.	327
June 06, 2017	The SS-25 permit was issued to extract the tubing and run logs.	356
July 29, 2017	The temporary P&A was completed on SS-25A, and the rig was released. (83 rig days)	409
July 31, 2017	The SS-25 pre-rig work started. (10 rig days)	411
August 10, 2017	The SS-25 rig work (Ensign 334) started Phase 3A to recover the tubing.	421
September 01, 2017	Finished extracting 244 joints of tubing, a camera run was run to identify parted casing depth, and paused for permits to be issued for next steps (23 rig days)	443
October 02, 2017	The SS-25 permit was issued for Phase 3A Contingency to cut and pull parted casing and run logs.	474
October 12, 2017	Pulled 12 ft piece of 7 in. casing, and released Rig 334 (5 rig days)	484
October 30, 2017	Started operations with Ensign Rig 540 to extract 7 in. casing	502
November 07, 2017	Ran camera and caliper to inspect the 11 3/4 in. casing	510
December 16, 2017	Finished extracting 22 joints of 7 in. casing, ran tieback casing, and evaluated 7 in. casing with logs and camera runs (48 rig days)	549
March 30, 2018	SoCalGas submitted the SS-25 Supplemental NOI.	653
April 25, 2018	The SS-25 permit was issued by DOGGR.	679
May 16, 2018	Started operations to extract two joints of 7 in. casing, evaluate the 11 3/4 in. casing with logs and camera runs, and P&A the well	700
September 13, 2018	Finished SS-25 P&A, and released the rig (121 rig days)	820

4.4 Tubulars Extraction Summary

The following is a summary of the extraction results. Details of the extracted equipment can be found in the *SS-25 Master Pipe Tracker* document [20].

- **2 7/8 in. tubing:** A total of 244 joints (7,551.1 ft) of tubing were extracted. This consisted of 6 joints (186.8 ft) of 2 7/8 in. 6.5 ppf N80 EUE tubing, and 238 joints (7,364.3 ft) of 2 7/8 in. 6.5 ppf J55 EUE tubing. Fifty-six samples of solids or liquids found on the OD and ID of the joints during the inspection were taken for laboratory analysis. The tubing was transported to Blade's RCA storage facility in Houston on October 24, 2017, in accordance with the transportation protocol *Aliso Canyon RCA: SS-25 Tubing and Wellhead Logistics* [21].

- **7 in. casing:** In October 2017, 23 joints of 7 in. 23 pf J55 Speedtite casing were extracted. Forty-one solids and liquids samples found on the OD and ID during the inspection were taken for laboratory analysis. These joints were transported to Blade's RCA storage facility in Houston on December 05, 2017, in accordance with the transportation protocol *Aliso Canyon RCA: SS-25 Casing Logistics* [22].

  Two additional joints of 7 in. 23 pf J-55 Speedtite casing were extracted in August 2018. Forty-one solids and liquids samples found on the OD and ID during the inspection were taken for laboratory analysis. These joints were transported to Blade's RCA storage facility in Houston on September 21, 2018, in accordance with the transportation protocol *Aliso Canyon RCA: SS-25, P-45 and P-35 Casing Logistics* [23].

  A total of 25 joints (1,024.8 ft) of 7 in. casing were extracted. Figure 10 shows how the casing joints and connections were situated in the well.

- **Wellhead and tree assembly:** In August 2017, the tree assembly was broken down into its various components—tubing hanger, tubing head, double-studded adapter assembly, casing slips, and valves. Four solids samples found on the OD and ID during the inspection were taken for laboratory analysis. These components were transported to Houston with the tubing on December 05, 2017. The casing head was extracted in September 2018 and transported to Houston with the last joints of casing in December 2018. Figure 11 shows the wellhead stack-up configuration.

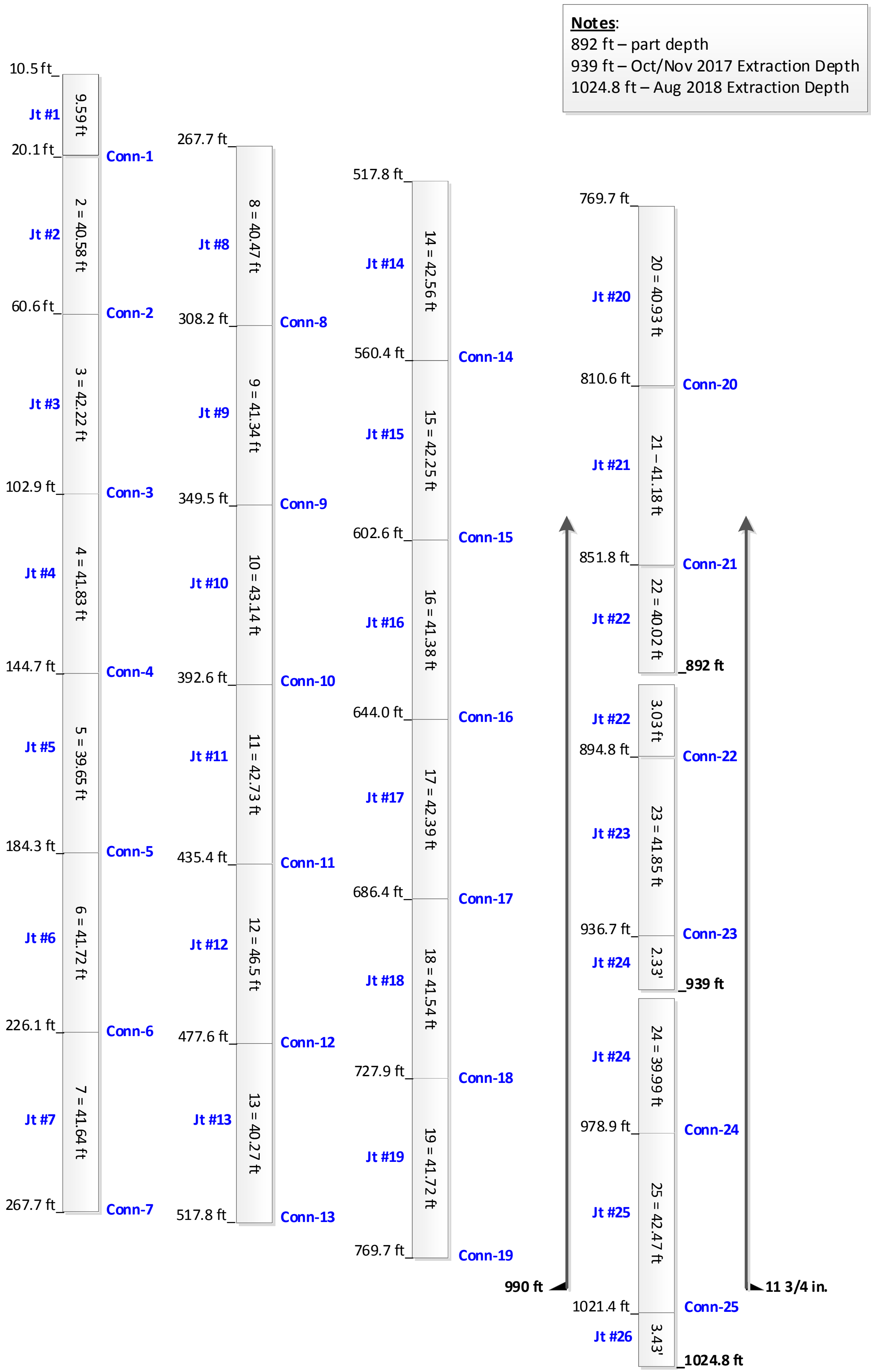

Figure 10: 7 in. Casing and Connection Locations

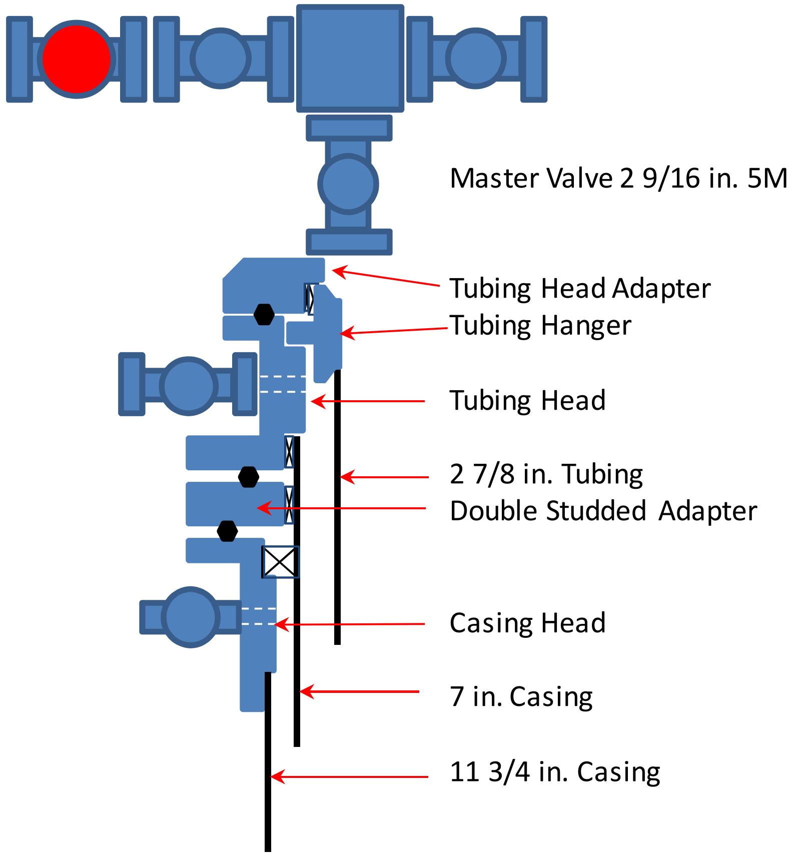

Figure 11: Wellhead Stack-up

5 Other RCA-Related Work During Phase 3

Other RCA well evaluation work, which overlapped the various phases, was conducted on several wells. Casing was extracted by SoCalGas on several P&A'd wells. The Blade RCA team visually examined casing recovered from the wells and took samples as noted (Table 3).

Table 3: Summary of Other Wells Casing Extraction and Sampling

Well	Date	Comments
Porter 34	March 2018	• Blade visually inspected eight joints of 7 in. 23 ppf J55 Speedtite casing while it was recovered during the well P&A and collected 19 surface-scale samples, which were processed by Ecolyse and sent to their lab in Texas for analysis. • Seven joints were transferred to PS-20 for cleaning and supplemental inspection per the SS-25 Tubulars Handling Protocol. • The joints were cut to section out the connections, which were then crated. • The casing and connections were transported to Houston on April 25, 2018, for further evaluation per the transportation protocol *Aliso Canyon RCA:P-34 and SS-44A Casing Logistics* [24].
SS-9 Borehole (TH-1)	March 2018	• The Los Angeles Regional Water Quality Board required SoCalGas to evaluate the presence and quality of groundwater in the vicinity of SS-25. Geosyntec was contracted to drill a borehole to 1,100 ft at the nearby SS-9 location using a Yellow Jacket Drilling drill rig. Geosyntec called the well TH-1. Drilling began on March 13, 2018. • Blade witnessed the operations, acquired four ground water samples, and ran several logs to further characterize the shallow geology near SS-25: – April 04–April 05, 2018: Advisian ran the following logs: Fluid Temperature and Conductivity log from 548 to 334 ft, their Acoustic Televiewer from 548 to 324 ft, their Formation Conductivity and Natural Gamma from 548 to 80 ft, their Nuclear Magnetic Resonance log from 548 to 80 ft, and their Optical Televiewer from 501 to 80 ft. – April 19–April 24, 2018: Advisian ran the following logs: Fluid Temperature and Conductivity log from 1,100 to 300 ft, their Nuclear Magnetic Resonance log from 1,100 to 80 ft, Formation Conductivity and Natural Gamma from 1,100 ft to surface. Schlumberger ran the following logs: AIT-PEX from 1,100 ft to surface, ADT-HNGS from 1,100 ft to surface, ADT-HNGS from 1,100 ft to surface, FMI and Modular Sonic Imaging Platform (MSIP) logs from 1,100 ft to surface, CMR and NEXT from 1,100 ft to surface. Schlumberger attempted to take formation fluid samples with their MDT tools but were unsuccessful due to deteriorating hole conditions.
SS-44A	April 2018	• Blade visually inspected the 8 5/8 in. 36 ppf K55 casing in Tuboscope's Bakersfield yard where it was being stored after the well P&A and moved eight joints to PS-20 for further evaluation. Three surface-scale samples were collected for analysis. • One joint was crated and transported to Houston with the Porter 34 casing.

Well	Date	Comments
SS-12	June 2018	• Blade visually inspected 92 joints of 7 in. 23 ppf N80 LTC casing while they were recovered during the well P&A. Seven joints were transferred to PS-20 for further evaluation. Blade concluded that these joints were not of interest to the RCA. • Blade visually inspected 14 joints of 9 5/8 in. 40 ppf J55 Speedtite casing while they were recovered during the P&A. It was concluded that these joints were not of interest to the RCA.
Porter 45	August 2018	• Blade visually inspected seven joints of 7 in. 23 ppf J55 casing after they had been extracted during the well P&A. • Two joints were transferred to PS-20 and then transported to Houston on September 21, 2018, for further evaluation in accordance with the transportation protocol *Aliso Canyon RCA: SS-25, P-45 and P-35 Casing Logistics* [23].
Porter 35	August 2018	• Schlumberger took 22 CHDT fluid samples from the 7 in. annulus between 3,450 and 450 ft from August 03 to August 05, 2018. • Blade visually inspected 22 joints of 7 in. 23 ppf J55 Speedtite casing while it was recovered during the well P&A, collected 56 surface-scale samples, which were processed by Ecolyse and sent to their laboratory in Texas for analysis. • One joint was transferred to PS-20 and then transported to Houston on September 21, 2018, with the Porter 45 casing.
SS-25B	December 2018	• Blade developed a logging program to evaluate the upper section of the 8 5/8 in. production casing to coincide with the P&A of the well, which is located on the same site as SS-25: • December 10, 2018: Baker Hughes ran their caliper and HRVRT logs from 2,000 ft to surface, and Versa-Line ran their MID-2 and MID-3 logs from 1,000 ft to surface. • December 11, 2018: Schlumberger ran their IBC log from 2,000 ft to surface. • December 15–December 16, 2018: Schlumberger ran their CHDT tool and attempted to get six annular fluid samples without success.

6 References

[1] Blade, "Aliso Canyon Master Sample Tracker (AC-RCA Master Fluid Sample Tracker, Rev Oct 17, 2018.xlsx)".

[2] Blade, "SS-25 Phase 3 Tubing, Casing, Wellhead Extraction Protocol (AC-RCA SS25 Phase 3 Tubing Casing Wellhead Extraction Protocol Ver 6 2017-07-14.pdf)".

[3] Blade, "SS-25A Wellsite Tubulars Handling Protocol (AC-RCA SS25A Tubulars Handling Protocol Rev 003, 09-May-17.pdf)".

[4] DOGGR, "State Oil and Gas Supervisor Order 1109, March 4, 2016 (State Oil and Gas Supervisor Order 1109.pdf)".

[5] Blade, "SS-25A TP&A and RCA Operations Report".

[6] Blade, "SS-25 Phase 3A Task Based HAZid Risk Assessment, 12 August 2016, Rev 1, (SS-25 3A HAZid Report August 14th 2016.pdf)".

[7] Blade, "Phase 3 HAZid Action Item Reconciliation and Close Out Status, 12 September 2017, Rev 003, (AC-RCA PH3 Final HAZid Reconciliation Report, Rev 003, 12Sept17.docx)".

[8] Blade, "Screening of Corrosion Inhibitors for use on SS-25 Tubulars – Phase I and II (2017-02-13 AC-RCA_Corrosion_Inhibitor_Screening_Report_Ver003-reduced size.pdf)".

[9] Blade, "SS-25 Phase 3 Pipe Cleaner and Corrosion Inhibitor Test Protocol (Pipe Cleaner Test Phase 3 SS 25 Rev 0.pdf)".

[10] Blade, "SS-25 Phase 3 Pipe Cleaning and Corrosion Inhibitor Field Application Test Protocol Test Results (Pipe Cleaning Test Results Phase 3 SS 25 Rev 1.pdf)".

[11] Blade, "AC-RCA Phase 3 Warehouse Handling Protocol Rev 001, (AC-RCA Phase 3 Warehouse Handling Protocol Rev 001, 2017-10-18.pdf)".

[12] Blade, "Phase 3 Tubulars Handling Supplemental Procedures (AC-RCA PH3 Tubulars Handling Supplemental Procedures, Rev 001, 07May17.docx)".

[13] Blade, "Work Plan SS-25 Phase 3-A Tubing Extraction and 7” Casing Logging, 31 July 2017, Rev 03, (AC-RCA SS25 Phase 3A Work Plan Rev 03 2017-07-31.pdf)".

[14] Blade, "Phase 3 Tubing Fluid Sampling and Analysis Approach (AC-RCA SS25 Phase 3 Tubing Fluid Sampling and Analysis Approach Ver 02.pdf)".

[15] Blade, "Tubing Fluid Sample Extraction from Western Wireline Kuster Flow Through Sampler (FTS) (2017-07-27 AC-RCA SS25 Phase 3 Tubing Fluid Sample Extraction Procedure from Slickline Tool Final Ver 02.pdf)".

[16] Blade, "Work Plan SS-25 Phase 3-A Contingency, Extract Parted 7” Casing, 11-3/4” Logging, 7” Casing Tieback and 7” Casing Logging (AC-RCA SS25 Phase 3A Contingency Work Plan Rev 03.docx)".

[17] Blade, "Phase 3 Annulus Fluid Sampling and Analysis Approach (AC-RCA SS25 Phase 3 Annulus Fluid Sampling and Analysis Approach Ver 3.pdf)".

[18] Blade, "SS-25 Fluid Sampling 7" Annulus (AC-RCA SS-25 Fluid Sampling of the 7” Casing Post Tubing Extraction V002.docx)".

[19] Blade, "Work Plan SS-25 Phase 3-A Contingency Part 2, 15 May 2018, Rev 1, (AC-RCA SS25 Phase 3A Contingency Part 2 Work Plan Rev 1 2018-05-04.pdf)".

[20] Blade, "SS-25 Master Pipe Tracker (SS-25 Master Pipe Tracker, 2018-02-26.xlsx, or latest version)".

[21] Blade, "AC-RCA SS25 Tubing Logistics Rev 5 (AC-RCA SS25 Tubing Logistics Rev 5 2017-10-18.pdf)".

[22] Blade, "AC-RCA SS25 Casing Logistics Rev 002 (AC-RCA SS25 Casing Logistics Rev 002 2017-11-28.pdf)".

[23] Blade, "AC-RCA SS25 P45 P35 Casing Logistics Rev 001 (AC-RCA SS25 P45 P35 Casing Logistics Rev 001, 2018-09-18.pdf)".

[24] Blade, " AC-RCA P34 SS44A Casing Logistics Rev 000 (AC-RCA P34 SS44A Casing Logistics Rev 000, 2018-04-20.pdf)".

[25] Blade, "SS-25A Master Pipe Tracker (SS25A - Master Pipe Tracker, 15-June-17.xlsx, or latest version)".

[26] Blade, "SS-25 Phase 3 Wellsite Tubulars Handling Protocol (AC-RCA Phase 3 Tubulars Handling Protocol Rev 004, 31-July-2017.pdf)".

[27] Blade, "SS-25A Fluid Sampling and Analyses Protocol (SS 25A Fluid Sampling and Analysis Protocol v2 05-09-2017 Final.pdf)".

[28] Blade, "Work Plan SS-25 Phase 3-A Contingency, Extract Parted 7" Casing, 11-3/4" Logging, 7" Casing Tieback and 7" Casing Logging, 18 October 2017, Rev 04, (AC-RCA SS25 Phase 3A Contingency Work Plan Rev 04.pdf)".

[29] Blade, "SS-25A Work Plan, 9 May 2017, (SS25A Well Work Plan 05.09.17 Final.pdf)".

Appendix A RCA Project Timelines

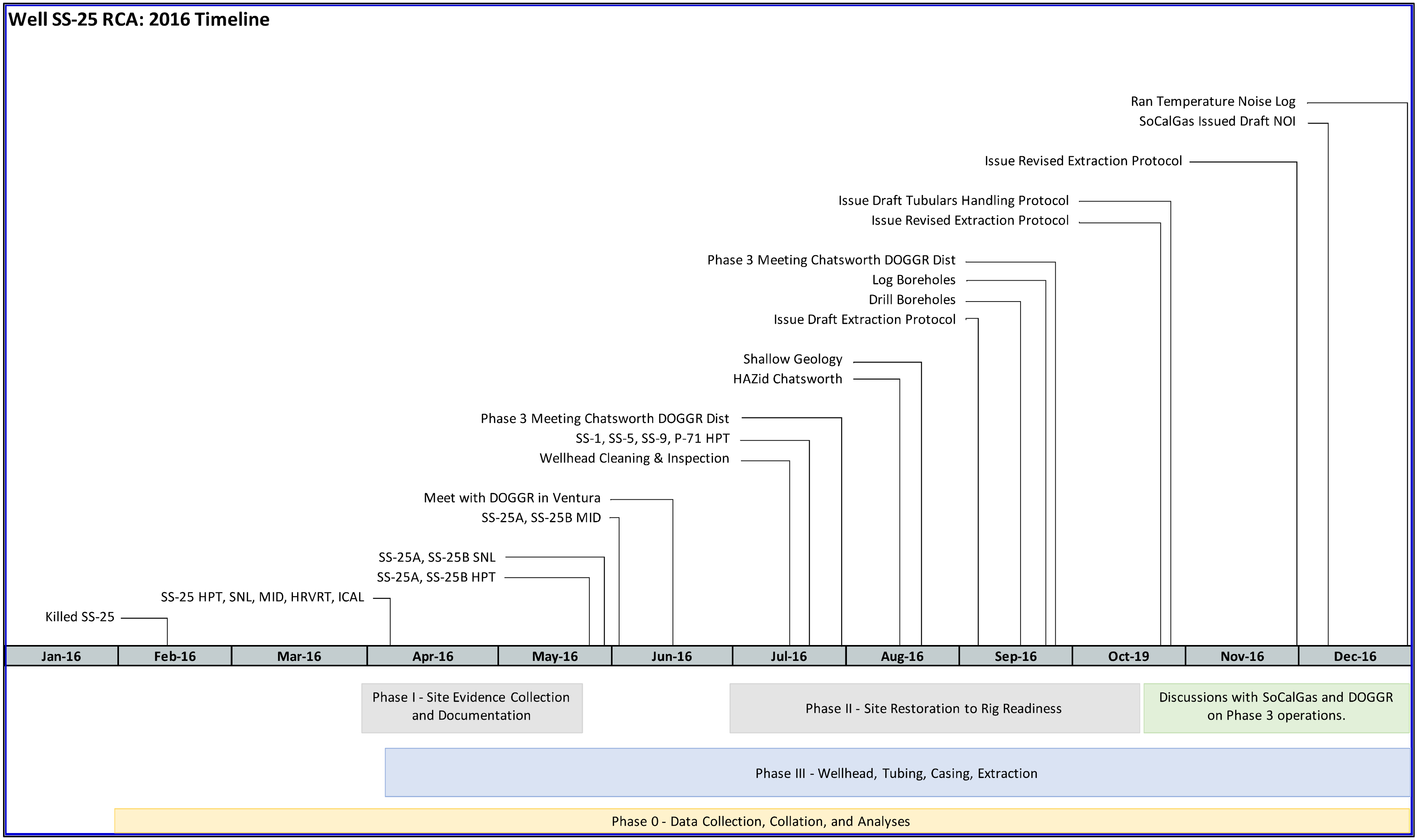

Figure 12: RCA Activities Timeline for 2016

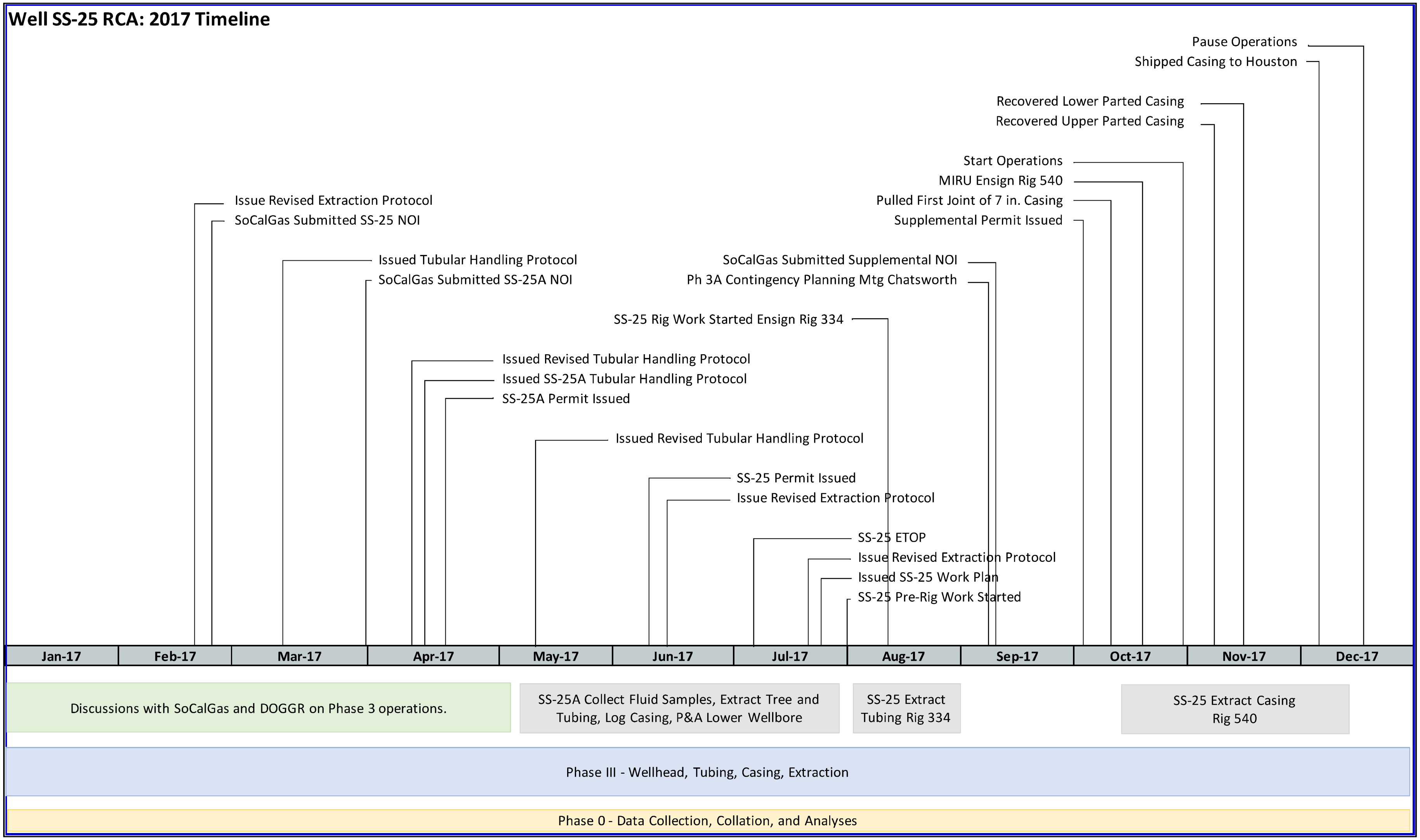

Figure 13: RCA Activities Timeline for 2017

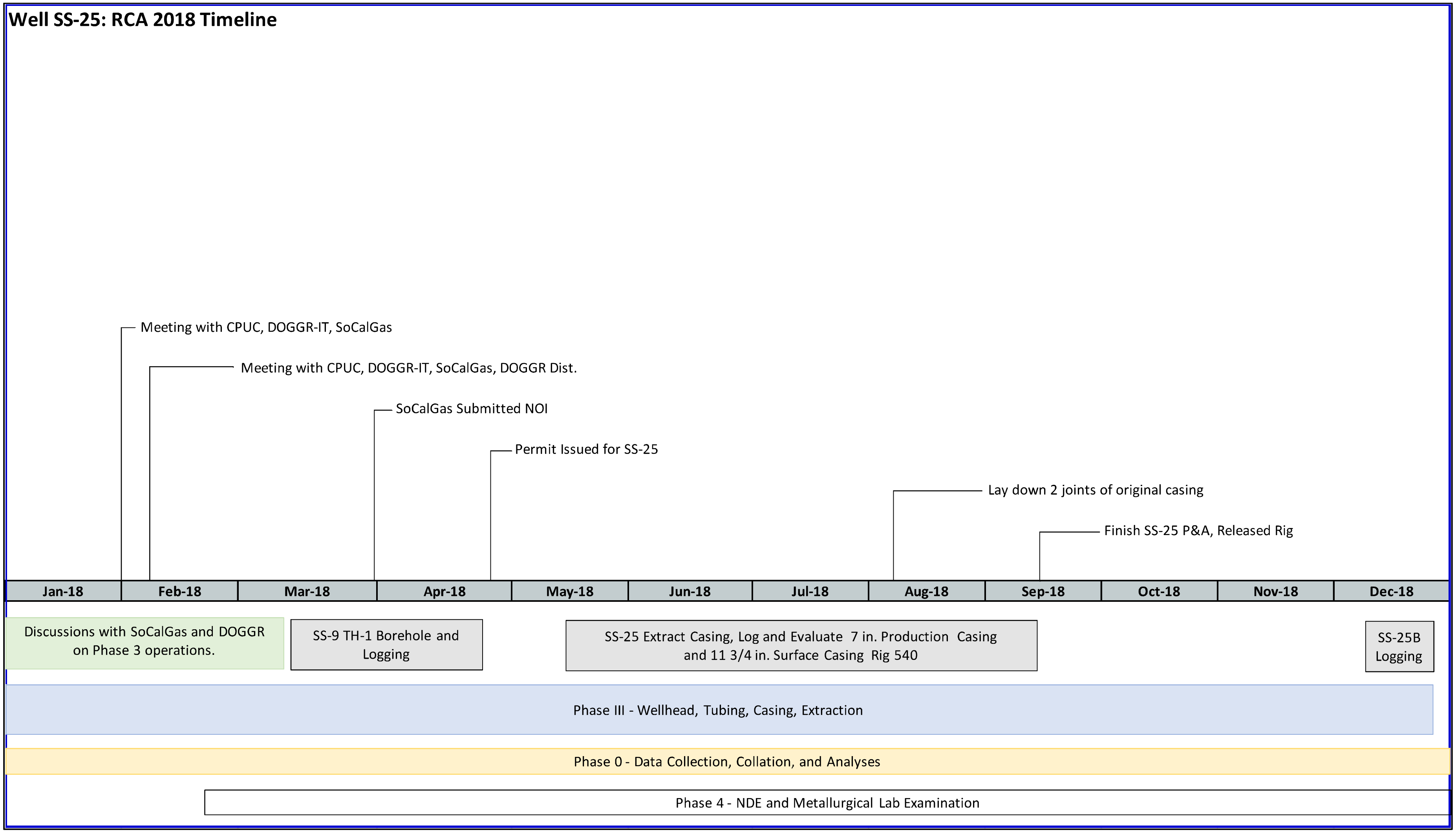

Figure 14: RCA Activities Timeline for 2018

Appendix B Phase 3 Evaluation Work Summary

Table 4 is a summary of evaluation work done from April 2016 through December 2018. Significant log evaluation work was done on wells in addition to SS-25. The SS-25 site was evaluated by a shallow geophysical study and by drilling and logging four boreholes.

Table 4: Summary of Well Evaluation Work

Well	Date	Comments
SS-25	Apr 2016	HPT (High-Precision Temperature) SNL (Spectral Noise Log) MID (Magnetic Imaging Defectoscope) HCAL (Hotwell Caliper) MVRT (Micro Vertilog Tool)
SS-25A	May 2016 Jun 2016	HPT SNL MID
SS-25B	May 2016 Jun 2016	HPT SHL MID
SS-1 SS-5 SS-9 P-71	Jul 2016	HPT
SS-25A SS-25B	Aug 2016 Start Sep 2018 End	DTS (Distributed Temperature Sensing)
Site SS-25	Aug 2016 Sep 2016	Shallow Geophysical Study
Site SS-25	Sep 2016	Drilling and Logging of Four Boreholes
SS-25	Oct 2016 Start Jul 2017 End	DTS
SS-25	Dec 2017	Noise and Temperature
SS-25A	May 2017 Jun 2017	PNX (Pulsed Neutron Extreme) IBC-SSCAN (Isolation Scanner, Sonic Scanner) UCI-NEXT (Ultrasonic Corrosion Imager, Litho Scanner) CPET (Corrosion and Protection Evaluation Tool) MID ICAL (Imaging Caliper) HRVRT (High-Resolution Vertilog) Video Camera
SS-25	Aug 2017	Video Camera 7 in.
SS-25	Oct 2017	Video Camera 7 in. ICAL 7 in.

Well	Date	Comments
SS-25	Nov 2017	Video Camera 11 3/4 in. GR-JB ICAL 11 3/4 in. MID NEXT PNX
SS-25	Dec 2017	ICAL 7 in. HRVRT Pulsar (Multifunction Spectroscopy) UCI-NEXT IBC-SSCAN CPET Video Camera Noise and Temperature Gyro
SS-9 Borehole	Mar 2018 Apr 2018	Borehole Drilling, Sampling, and Logging
SS-25	May 2018	Gyro Noise and Temperature
SS-25	Jun 2018	CHDT 7 in. MSCT 7 in.
SS-25	Jul 2018	MSCT 7 in. CBL
SS-25	Aug 2018	MSCT 7 in. Openhole Caliper FMI (Formation Microimager) Noise and Temperature ICAL 11 3/4 in. IntEx (Integrity Explorer CBL) HRVRT 11 3/4 in. Gyro HRVRT 11 3/4 in. IBC 11 3/4 in. UCI 11 3/4 in. SSCAN 11 3/4 in. Pulsar 11 3/4 in. CPET 11 3/4 in. NEXT 11 3/4 in. Video Camera CHDT 11 3/4 in. MSCT 11 3/4 in.
SS-25A	Sep 2018	DTS Conclusion

Well	Date	Comments
SS-25B	Dec 2018	MID 2 and MID 3 8 5/8 in. ICAL 8 5/8 in. HRVRT 8 5/8 in. IBC 8 5/8 in. CHDT 8 5/8 in.

Appendix C SS-25 Daily Report Summary

The following summary includes abbreviations and terminology commonly used in rig daily reports as a reference to the day to day on-site operations. No attempt was made to edit or clean up the verbiage.

Table 5: SS-25 Daily Report Summary

Date	Daily Report Summary for Well SS-25
Pre-Rig Work	
7/31/2017	Held 'Pre-Spud' Meeting. Remove DTS from SS-25 and install DTS in SS-25A. RU and function test tubing fluid sampling equipment (TOL, Ecolyse, Western WL). Waiting on regulatory approval of sampling protocol No rig on location
8/1/2017	WO approval of sampling protocol. RU Western and TOL equipment. Recover samples from tubing at 210, 310, 1500, 1600, 3000, and 3100 ft.
8/2/2017	RU Western and TOL equipment. Recover samples from tubing at 4500, 4600, 6000, 6100, 7500, and 7600 ft. Start RU CT unit
8/3/2017	RU CTU and cementing equipment. Fill coil to confirm volume with dye test. RIH - tag TOC at 8194' CTM with 3000 lbs. PU to 8192'. M&P 7 bbls spacer, 5 bbls 14.8 ppg cmt, 3 bbls spacer and displace while PU to 7580'. Halco realized error in displacement - cmt was underdisplaced. POOH.
8/4/2017	MU CT motor and mill BHA. RIH and tag TOC at 7625'. Drill/wash cmt to 8194' (569') with water at 5-8 fpm. Displace to mud. POOH
8/5/2017	RIH w/cmt nozzle, TOC at 8194'. M&P 7 bbls spacer, 5 bbls 14.8 ppg cmt, 3 bbls spacer and displace while PU to 7580'. Circ out 1.5 ann volumes. POOH.
8/6/2017	RIH and tag cement at 7580'. POOH. WO DOGGR
8/7/2017	RIH w/ 2.470" scraper and 2.3” gauge bar on CT at 66 fpm. Tag TOC at 7580'. POOH
8/8/2017	RIH w/ 2.12" CIBP at 44 fpm. Tag at 7572' (8' high). Got permission from DOGGR to set BP. Drop 9/16" ball, pressure up to 2638 psi and set CIBP at 7572'. PU and test plug to 500 psi for 15 min. Re-tag at 7572'. POOH
8/9/2017	DOGGR & SCG Meeting. No ops at SS-25 site
Rig Work	
8/10/2017	MIRU Ensign 344. Move in 3 vertical mud tanks and transfer fluids. Spot rig, accumulator and doghouse
8/11/2017	Cont. MIRU. Spot trip tank, raise mast, lay out guidewires. No well work.
8/12/2017	No well work. Assorted protocols and procedures being finalized
8/13/2017	No well work. Assorted protocols and procedures being finalized
8/14/2017	Received final SCG-DOGGR District protocol and Ok to proceed. RU confined entry team and extend piping from A and B annulus to ground level. Install cellar pump. Test new lines to 250/1000 psi. RU trip tank piping. Install rig floor. Attempt to install DTS into SS-25 - could not pass 91 ft.
8/15/2017	RU Wireline and RIH with 75# sinker bars and 1.645" gauge ring to 1500' with no issues. Repeat with 30 lbs of sinker bars - no issues. RD WL. Install DTS to 1456 ft with no issues. Begin hole filling procedures. Starting fluid level: A = 282 ft, B = 334 ft. Pump 31.3 bbls 9# Flowzan brine down A annulus, 10 bbls 9# Flowzan down B annulus. Fluid levels at end of day: A = 214 ft, B = 304 ft.

Date	Daily Report Summary for Well SS-25
8/16/2017	Cont. hole filling procedures: Starting fluid level: A = 288 ft, B = 301 ft. Pumped 105 bbls 9 ppg Flowzan high vis pill (FV=268) down B annulus, and 8 bbls 9 ppg Flowzan down A annulus. Fluid levels at end of day: A = 114 ft, B = 152 ft.
8/17/2017	Cont. hole filling procedures: Starting fluid level: A = 136 ft, B = 152 ft. Pumped 113.6 bbls 9 ppg Flowzan high vis pill (FV=368) down B annulus, and 4.6 bbls 9 ppg Flowzan down A annulus. Fluid levels at end of day: A = 95 ft, B = 70 ft. Pulled DTS.
8/18/2017	Shoot fluid levels (A=118', B=84'). WOO. RU for confined entry. Remove and replace lockdown screws in WH
8/19/2017	Shoot fluid levels (A=155', B=133'). ND tree - had to cut off bolts with a torch. Transfer tree to PS-20 for inspection, cleaning and coating. NU BOP's and diverter.
8/20/2017	Shoot fluid levels (A=164', B=155'). Cont. NU and testing BOP's and diverter
8/21/2017	Shoot fluid levels (A=173', B=164'). Fin BOPE testing. RU Tiger WL. Ran 2.25" GR/CCL. Tagged CIBP at 7575 ft. POOH. RIH with free point tool. Tubing was free at 1st joint above CIBP. RD Tiger
8/22/2017	Shoot fluid levels (A=173', B=170'). Discuss tubing cutting depth with, and get approval from DOGGR-D. RU Baker WL. Pull 10K tension. RIH with MPC to 7555', and cut tubing. RU Onyx separator. PU tubing 1 ft and attempt to estab circulation - pump 20 bbls of 9 ppg Flowzan down tubing - No returns. Pull and LD 2 jts of tubing. Tubing tongs fail - cease operations. Transfer jts to PS-20.
8/23/2017	Pull and LD 30 jts of 2 7/8" tubing, and transfer to PS-20
8/24/2017	Pull and LD 30 jts of 2 7/8" tubing, and transfer to PS-20
8/25/2017	Pull and LD 30 jts of 2 7/8" tubing, and transfer to PS-20
8/26/2017	Pull and LD 30 jts of 2 7/8" tubing, and transfer to PS-20
8/27/2017	Pull and LD 30 jts of 2 7/8" tubing, and transfer to PS-20
8/28/2017	Pull and LD 30 jts of 2 7/8" tubing, and transfer to PS-20.
8/29/2017	Pull and LD 27 jts of 2 7/8" tubing, and transfer to PS-20. Pump 30 bbls 3% KCl brine down A ann and 15 bbls down tubing in preparation for camera run.
8/30/2017	Pull and LD 3 jts of 2 7/8" tubing, and transfer to PS-20. RU Baker WL and EV Camera. Ran camera and caliper to EOT at 953'. Investigate area from 953-1040' while slowly pumping brine. Pull and LD 1 jt of 2 7/8" tubing and transfer to PS-20. Investigate area around EOT at 922' to 884' while slowly pumping brine.
8/31/2017	Pull and LD 1 jt 2 7/8" tubing and transfer to PS-20. RU Baker WL, Ran camera to EOT and investigate area from 892-888' while slowly pumping brine down tubing. Found 7" casing parted at ~887.5 ft
9/1/2017	WO DOGGR approval to continue. Pull and LD last 28 jts of 2 7/8" tubing, and transfer to PS-20. Total of 244 jts extracted.
9/2/2017	Pause Operations
9/3/2017	Pause Operations
9/4/2017	Pause Operations
9/5/2017	Pause Operations
9/6/2017	Pause Operations
9/7/2017	Chatsworth DOGGR Meeting
9/8/2017	NOI for PH3 Contingency operations sent. Operations suspended pending DOGGR approval of NOI

Date	Daily Report Summary for Well SS-25
9/9/2017	Operations suspended pending DOGGR approval of NOI
10/2/2017	DOGGR issued permit for Phase 3A Contingency
10/3/2017	Prepare to start operations Oct 9, 2017
10/4/2017	Prepare to start operations Oct 9, 2017
10/5/2017	Prepare to start operations Oct 9, 2017
10/6/2017	Prepare to start operations Oct 9, 2017
10/7/2017	Prepare to start operations Oct 9, 2017. Notified DOGGR to commence operations Oct 9.
10/8/2017	Prepare to start operations Oct 9, 2017
10/9/2017	Stand by due to high wind
10/10/2017	RIH with video camera in 7" casing to top of fluid at 322'. RIH with Baker Caliper tool in 7" casing to 866'. Set RBP at 200' in 7" casing.
10/11/2017	ND BOP. Removed Tubing Head. Cut bolts with welder. Pulled 90K with the rig to remove the tubing head.
10/12/2017	Removed casing slips. Installed new casing head. Cut and removed 12' of 7" casing. MU spear and landed spear and casing in tubing hanger.
10/13/2017	RDMO Ensign Rig 334.
10/14/2017	Cleared location.
10/15/2017	Prepare to MI Rig 540
10/16/2017	MIRU Ensign 540. MI and spot back of the rig equipment.
10/17/2017	MI equipment and RU. Pinned sub base to rig.
10/18/2017	MI equipment and RU. Spotted fuel tank and took on fuel. Spotted shaker pit.
10/19/2017	Start generators and confirm operations. Crew confined entry training.
10/20/2017	Assemble and RU pieces.
10/21/2017	Assemble and RU pieces. Install pump liners. Install spacer spool and diverter.
10/22/2017	NU BOP. Raise mast. Install pump liners.
10/23/2017	NU BOP. Install pump liners.
10/24/2017	NU annular BOP and control lines. Calibrate tanks.
10/25/2017	NU BOP. Inspect pipe arm. Work on shakers.
10/26/2017	Test BOP. Rebuilt standpipe valve. Inspect mast and pipe arm. Install bell nipple.
10/27/2017	Test BOP. Repair leaks. Take on 400 bbl of mud. Notified DOGGR of planned start of operations on Oct 30. BOP inspection- Good.
10/28/2017	Finish testing BOP. Repair leak on standpipe.
10/29/2017	Finish RU. Clean rig. Safety walk around- Good.
10/30/2017	Pull hanger. Pull 7" casing to rig floor. Cut casing below connection and LD 1 joint of 7" casing. Send casing to PS-20.
10/31/2017	Extracted 7" casing. Cut casing below connection and LD 3 joints of 7" casing. Send casing to PS-20.
11/1/2017	Released RBP and laid down. Extracted 7" casing. Cut casing below connection and LD 3 joints of 7" casing. Send casing to PS-20.

Date	Daily Report Summary for Well SS-25
11/2/2017	Extracted 7" casing. Cut casing below connection and LD 3 joints of 7" casing. Send casing to PS-20.
11/3/2017	Extracted 7" casing. Cut casing below connection and LD 3 joints of 7" casing. Send casing to PS-20.
11/4/2017	Extracted 7" casing. Cut casing below connection and LD 3 joints of 7" casing. Send casing to PS-20.
11/5/2017	Extracted 7" casing. Cut casing below connection and LD 3 joints of 7" casing. Send casing to PS-20.
11/6/2017	Extracted 7" casing. Cut casing below connection and LD 1 joints of 7" casing. Send casing to PS-20.
11/7/2017	Extracted 7" casing. Recovered bottom of upper section of parted casing and LD 1 joints of 7" casing. Send casing to PS-20. RIH with video camera in 11 3/4" casing to top of fluid at 275'. Identified holes in 11 3/4" casing. RIH with caliper log to 875'. RIH with 10.48" gauge ring and junk basket. Confirmed holes in 11 3/4" casing from 144 - 300'.
11/8/2017	RIH with NOV extraction tool on 7" casing to 890'. MU side entry sub for camera. RIH with video camera. Fluid cloudy. Pump 170 bbl of KCl fluid. Pull up camera and Shut Down for Night.
11/9/2017	Attempt to view fish using camera, no good. POH with camera. Install a 10' pup joint. RIH with camera and pump fluid to clear up area. Monitor fish entering extraction tool. POH camera. LD side entry sub. Swallow fish and latch on to fish. Pull 5K tension. RIH with Baker MPC cutter. Attempt to cut at 915'. Anchors slipped. Started new cut. Unable to cut 7" casing. POH with cutter. Blade worn.
11/10/2017	Pull tension on casing to 7.5K over. Set in slips with 5K over. RIH with MPC cutter. Attempt to cut at 920'. Not able to cut 7" casing. POH.
11/11/2017	RU Western Wireline and RIH with chemical cutter. Cut 7" casing at 930'. Indication of cut with weight drop off. RD WWL. POH with 7" casing workstring. No fish. Checked pawl dimensions and found pawls were deformed outward.
11/12/2017	Attempted to MU NOV extraction tool with new pawl assembly. Sent tool to town for thread redressing and assembly. RIH with NOV extraction tool and latch on to fish.
11/13/2017	RU side entry sub for camera. RIH with video camera. Engaged fish with extraction tool. Viewed chemical cut at 930' not fully cut. POH with camera. Worked pipe up to 12K over. Not able to free fish.
11/14/2017	PU on casing workstring to reposition casing in the slips. Worked string up and down and were unable to confirm the fish was on the extraction tool. POH and found the upper part of the lower section of parted casing in the extraction tool. Cut the fish using the Cameron cold cutter tool. LD the fish in 2 pieces. Send casing to PS-20.
11/15/2017	RIH with WFT casing patch overshot tool. Worked over top of fish at 931' and latched overshot. RU Western Wireline and RIH with chemical cutter. Cut 7" casing at 939'. POH with cutter. Worked casing to pull fish loose with 20K over. POH with casing fish. LD 7" casing fish. Send casing to PS-20.
11/16/2017	RU Baker eline. RIH with Versa Line MID-2 log and log from 939' to surface. RD Baker. RU SLB. RIH with Lithoscanner and log from 939' to surface.
11/17/2017	RIH with SLB PNX log and log from 939' to surface. RD SLB. MU WFT overshot type casing patch and RIH with 7" 29 ppf tieback casing. Got over stub at 939.5' with overshot. Pull 25K over. Drop and set surface casing slips.
11/18/2017	RU Western Wireline and RIH with fluid sampler. Take 8 of 12 fluid samples for chemical analysis.
11/19/2017	Took remain 4 fluid samples with WWL. RD WWL. Filled casing and pressure tested casing to 500 psi- Good. Lifted BOPs. Cut 7" casing. ND BOP. Changed rams to 3 1/2".
11/20/2017	ND BOP. Removed spacer spool. Install DSA and Tubing Head. NU spacer spool and BOP.
11/21/2017	NU BOP. Test BOP. DOGGR inspection of BOP- Good.

Date	Daily Report Summary for Well SS-25
11/22/2017	Clean location and prep for logging on Monday.
11/23/2017	Monitor well.
11/24/2017	Monitor well.
11/25/2017	Monitor well.
11/26/2017	Monitor well.
11/27/2017	RIH with 6" gauge ring, stopped at 7397'. POH. Recovered golf balls and seals. RIH with caliper, stopped at 7397'. POH. RIH with caliper and log up from 7200'.
11/28/2017	Remove carbide dressing from WFT junk basket. RIH with JB and 3 1/2" tubing to 7454', 1 ft above TOF. Circulate and displace to 9 ppg Flowzan.
11/29/2017	Reverse circulate above fish while rotating. POH. LD JB. Recovered small amount of rocks, rubbers, metal shavings. RIH with scraper BHA, bumper sub, Magnet, Brush and scraper. RIH with scraper BHA.
11/30/2017	RIH and tag top of tubing stub at 7555'. Circulate and condition fluid to reduce solids content. POH.
12/1/2017	POH and LD BHA. RIH with Baker 56 arm caliper and log from 7549' to surface. RIH with Versa Line MID-2 log and log from 7549' to surface. RIH with MID-3 log and log from 1090' to 949'.
12/2/2017	Run MID-3 log from 949' to surface. RIH with Vertilog HRVRT. Log from 7531' to surface. RDMO Baker Eline. RU SLB Eline. RIH with Pulsar Multi-function Spectroscopy log. Logged from 7549' to surface.
12/3/2017	LD PMS tool. Cut off 3500' of eline. Re-headed line. MU UCI-NEXT (Ultrasonic Corrosion Imager - Lithoscanner. RIH. At 800' line stranded. POH and cut off 1000' of line. Re-headed. Log from 7549' to 3100'.
12/4/2017	Run UCI-NEXT log from 3100' to surface. LD tool. MU IBC-SSCAN tool. RIH and log from 7540' to 4000'.
12/5/2017	IBC-SSCAN log from 4000' to surface. Shut well in and evacuate at 13:00 hours due to high wind and fire danger.
12/6/2017	Suspend operations due to fire and high wind danger.
12/7/2017	Startup operations at 0600 hrs. Shut down for 41 hours. LD IBC-SSCAN tools. MU CPET (Corrosion and Protection Evaluation Tool). RIH and log up.
12/8/2017	Logging with CPET. Finished log. RD SLB. RIH with beveled collar on 3 1/2" tubing workstring.
12/9/2017	RIH to 7552'. Displace hole to 9 ppg KCl brine. Filter fluid.
12/10/2017	Filtered fluid to <10 NTU. POH with tubing to 3983'. RU Baker and EV camera. RIH to first casing collar at 4007'. Problems with camera. POH with camera.
12/11/2017	RIH with camera. Log connections and joints from 4008 - 4304'. Problems with camera. POH and change camera motor. RIH and log connections and joints from 4304 - 5027'. RIH with camera logging downview from 5027 - 7544'. POH with camera logging sideview from 7544 - 4008'. POH with camera. RD camera.
12/12/2017	Reverse circulate and filter fluid at 4011'. 2 NTU out. POH to 1739'. RU Baker eline. RIH with camera and view casing and connections from 1730' to 4008'. POH. RD camera.
12/13/2017	RIH 1 joint to 1770'. Reverse circulate and filter fluid at 33 spm. NTU out 1. POH tubing. RIH with camera and log down to 939'. Log connections and pipe to 1731'. RIH and check indications to 1898'. POH. RD eline and camera.

Date	Daily Report Summary for Well SS-25
12/14/2017	RU and ran temperature - noise log from 7549 - surface. Ran gyro survey from 7549 - 2700'. Shut down due to high wind.
12/15/2017	Finish running gyro survey from 2700' to surface. PU and RIH 3.5" EUE tubing to 7548'. 243 joints.
12/16/2017	RIH and tagged at 7555'. Pull up 2 joints and prep to reverse circulate at 7513'. Reverse circulate and displace 9 ppg KCl with 9 ppg Flowzan fluid. MU tubing hanger with BPV. Land hanger and run in lock screws. Rig on standby.
12/17/2017	Rig on standby waiting for next steps and approval.
12/18/2017	Rig on standby waiting for next steps and approval. Removed KCl fluid and moved to PS-20. Removed vertical KCl tank and transfer pump. Pumped fresh water through lines.
12/19/2017	Rig on standby waiting for next steps and approval.
4/25/2018	**DOGGR Permit Issued**
5/15/2018	Pre-Operations meeting at PS-20. SCG, DOGGR Distr, DOGGR-IT, CPUC, Blade
5/16/2018	RU Weatherford to test BOP. Attempted to back out landing pups. Connection above the hanger broke. Lifted annular BOP. Attempted to lock connection using Baker Lock. Not successful. Rig repair, electrical and Pason. DOGGR inspected the BOPE.
5/17/2018	Attempted to break connection, not successful. Lifted the BOP stack and broke connection at the tubing hanger. MU BOP flange. Testing BOP. Rig repair concurrent with testing; blower motor in HPU. Leak in HCR valve.
5/18/2018	Change out HCR valve. Ensign 3 1/2" drill pipe was delivered to PS-20. Fishing tools were delivered to PS-20. Test BOPE.
5/19/2018	Pull tubing hanger. POH and LD 243 joints of 3 1/2" tubing kill string. Moved tubing to PS-20.
5/20/2018	RU Scientific Surveys. Ran gyro survey to 1500'. RD Scientific. RU WAC. Run Noise and Temperature base line survey to 1500'. Noise readings every 100'. Shot FL at 297'. Parked tool at 990'. Pumped 5 bbl fluid in B annulus. Shot FL at 288' (+9'). Took noise readings, quiet near the shoe. Small noise at 890'. More noise higher. Parked tool at 490'. Pumped 5 bbl fluid. FL 279' (+9'). Took noise levels around 300'. RD WAC.
5/21/2018	MU 5" BHA to clean out around the tubing stub at 7555'. PU 3 1/2" R3 G-105 15.5 ppf drill pipe and RIH 94 R-3 joints to 4320'.
5/22/2018	RIH 3 1/2" DP from 4320' to 7547'. Circulate and condition mud. RIH and tag at 7550' with no pump or RPM with 7K. Washed and rotated to 7585' cement stringers. CO to 7588'. CO hard cement to 7590'. Tag at 7590' with DOGG witness, John Abeid. POH to around 5874'.
5/23/2018	Finish POH. LD one joint of WP, finger basket and jars. RIH to set Cement Plug #1, 200' (planned 7590 - 7390').
5/24/2018	RIH and tag at 7590'. Mix and pump Plug #1, 7.7 bbl 14.8 ppg Deep Blend. POH 9 joints. Reverse circulate. Pull 4 more joints. WOC.
5/25/2018	RIH and tagged cement at 7376' with 10K. Witnessed by John Abeid. POH and LD BHA. RIH kill string.
5/26/2018	Shut down for Holiday Weekend.
5/27/2018	Shut down for Holiday Weekend.
5/28/2018	Shut down for Holiday Weekend.
5/29/2018	POH kill string. ND bell nipple. NU shooting flange. RIH with SLB CHDT tool to 6716'. Pressure vs. time plotter failed. Trouble shoot equipment.

Date	Daily Report Summary for Well SS-25
5/30/2018	SLB attempted to get pressure vs. time plotter working. Trouble shoot equipment.
5/31/2018	Trouble shoot and change out equipment. System seems to be working.
6/1/2018	RIH with CHDT tool. Took samples at 6716', 6240', 5980'.
6/2/2018	RIH with CHDT tool. Took samples at 4810', 4285', 4186'.
6/3/2018	RIH with CHDT tool. Took samples at 4121', 3659', 2706'.
6/4/2018	RIH with CHDT tool. Took samples at 2560', 2295', 2031'. Took wellbore fluid samples at 3000' and 2000'. POH and found tool plugged with cuttings and fine solids.
6/5/2018	Pressure tested casing to 500 psi for hour, good test, witnessed by DOGGR. RIH with CHDT tool. Took sample at 1918'. Took wellbore fluid samples at 2000' and 1000'.
6/6/2018	RIH with CHDT tool. Took samples at 1680', 1664', 1552'.
6/7/2018	RIH with CHDT tool. Took samples at 1218', 1168'. Attempted to sample at 1116', failed packer seal test. POH to check tools.
6/8/2018	RIH with CHDT tool. Took samples at 1104', 1088', 1072'. Discovered the tool offset was incorrect by 12'. The depths shown are corrected depths.
6/9/2018	RIH with CHDT tool. Took samples at 1054', 1046'. Suspected the tool was plugged. POH and found a fitting below the drill block was plugged with drill bit casing cuttings.
6/10/2018	RIH with CHDT tool. Took samples at 1006', 994'. Bit failed. POH changed bit. RIH. Took sample at 975'. POH. RD SLB CHDT.
6/11/2018	Pressure tested casing to 500 psi. Test failed. RIH with a packer to 1130', 2000', 2760'. Back side tested good to 500 psi. DP side bled off pressure.
6/12/2018	Located casing leak between 4760' and 4835'. CHDT at 4810'. POH with packer.
6/13/2018	Finish POH with packer. RU SLB. RIH and cut MSCT core coupon at 7337'. Recovered coupon. RIH with kill string, 34 joints.
6/14/2018	POH kill string. RU SLB. Attempt to cut a casing coupon at 7126'. No progress for 90 minutes. POH. No recovery. RD SLB. RIH kill string.
6/15/2018	POH kill string. ND annular BOP. NU new annular BOP. Test blind and pipe rams and annular with WFT. RIH with 620' of 2 7/8" tail pipe to ~1500'.
6/16/2018	RIH with DP to 7376'. Broke circulation. Mix and pump Plug #2, 19.1 bbl of 14.8 ppg Deep Blend slurry. POH to 6776' and reversed out. No cement returns. WOC.
6/17/2018	No well work. WOC.
6/18/2018	Fill well with 5.8 bbl. RIH and tag Plug #2 at 6877'. POH to 1500'.
6/19/2018	Finish POH. RU SLB. RIH and cut MSCT coupon at 6721'. Milled for 5 hours. POH. No recovery.
6/20/2018	RIH to 6877'. Mix and pump Plug #3. PU to 6600' and reverse out. Cement returns as planned. WOC.
6/21/2018	Tag cement at 6611'. Good tag, witnessed by DOGGR. POH. RU Halliburton to check injection rate through leak at 4810'. Not able to inject. RU Western Wireline and perforate for UDA-1 squeeze 6566 - 6576'. Establish injection with Halliburton. Not able to inject. Pressured up to 560 psi and SD pump. Pressure bled to 430 psi in 10 minutes. RIH with packer BHA while SoCal discusses the next steps with DOGGR.
6/22/2018	TIH while waiting on DOGGR to approve the plan. POH to add perforations as required by DOGGR. RU Western and perforate 6550 - 6560'. Check injection rate with Halliburton. No injection. RIH with tail pipe and packer.

Date	Daily Report Summary for Well SS-25
6/23/2018	TIH to 6611'. Mix and pump 10.6 bbl of cement for UDA Squeeze #1. Reverse out. WOC.
6/24/2018	RIH and tag cement at 6365'. Good tag, witnessed by DOGGR. Displace the well from 8.9 ppg Flowzan to 9 ppg KCl fluid. POH to 1500', kill string depth.
6/25/2018	Finished POH. Left the packer and tail pipe in the hole. 2 7/8" EUE connection backed off between the unloader and the packer. RIH with a short catch overshot.
6/26/2018	Finished TIH to top of the fish. Engaged the overshot and POH with the fish.
6/27/2018	POH kill string. RU SLB. Cut MSCT core at 6260' in 60 minutes. POH. No recovery. RD SLB. RU Halliburton to check casing leak injection rate. RU WWL and perforate the LP 6245 - 6255'. Halliburton checked injection rate post-perforating. Pressure up to 560 psi and bled to 200 psi in 5 minutes. Perforated to squeeze the Lower Porter 6245 - 6255'. Checked injection. Pressure up to 550 psi. Bled to 133 psi in 5 minutes. RD WWL. RIH with kill string.
6/28/2018	POH with kill string. RIH with 16 joints of tubing and WFT PR-3 packer. Tagged at 5530', packer at 5023'. Checked packer for circulation and setting. No success. POH to check packer.
6/29/2018	POH. LD Packer. RIH with tubing, packer and drill pipe to 6360'. Mix and pump 13 bbl of cement. Balance plug. Pull up and reverse out at 6030'. WOC.
6/30/2018	RIH and tagged cement at 6090'. Lower Porter squeeze plug. RU SLB. Attempted to cut a MSCT SWC at 6020'. Not able to cut through the casing. RD SLB. RIH kill string.
7/1/2018	RU Halliburton. Mix and pump Plug #4, reversed out. WOC.
7/2/2018	RIH. Tag cement at 5911'. Witnessed by DOGGR. RU WWL and perforate 5820 - 5830'. Attempted to establish injection rate. Not successful. Perforate 5830 - 5840'. Attempted to establish injection rate. Not successful. RD WWL. RIH with tubing and packer for cement squeeze.
7/3/2018	Finished RIH. Mix and pumped Upper Porter squeeze #3. Pull up and reversed out at 5450'. WOC.
7/4/2018	Shut down for Holiday July 4.
7/5/2018	Tag cement at 5627'. Witnessed by DOGGR. Attempted to establish injection rate. RU WWL and perforate A-36 sand 5527 - 5537'. Attempted to establish injection rate. Pressure to 486 psi and bled to 275 psi in 5 min. Perforated 5546 - 5556'. Attempted to establish injection rate. Pressure to 487 psi and bled to 82 psi in 5 min. RIH with kill string.
7/6/2018	Mix and pump A-36 Sand squeeze #4. Pick up to 5187' and reverse out. WOC.
7/7/2018	Rig repair. Tagged TOC at 5343'. Witnessed by DOGGR. Mix and pump Plug # 5. Pull up to 4893' and reverse out. WOC.
7/8/2018	RIH and tag TOC at 5132'. Witnessed by DOGGR. RU SLB. Attempted to cut MSCT at 4791'. Cut through casing. No recovery. RD SLB. RIH kill string.
7/9/2018	RIH to 5132'. Mix and pump Plug #6. Pull up to 4680' and reverse out. WOC.
7/10/2018	RIH and tag TOC at 4724' (33' below required TOC). Circulated hole clean. POH. RU Halliburton and pressure test the casing for 60 minutes per DOGGR requirements. Start pressure 620 psi, final pressure 585 psi. Perforate A-1 sand 4654 - 4664'. Attempt to inject with Halliburton. Initial pressure 406 psi, final pressure 32 psi in 5 minutes. Consult with DOGGR on next steps. Perforate 4638 - 4648'. Attempt to inject. Initial pressure 414 psi, final pressure 91 psi in 5 minutes. RD WWL. RIH kill string.
7/11/2018	RIH to 4724'. RU Halliburton and pump 15 bbl of 14.8 ppg slurry for A-1 Sand Squeeze #5. Pull up to 4298' and reverse out. Circulate the long way. WOC.

Date	Daily Report Summary for Well SS-25
7/12/2018	RIH and tagged the TOC at 4409'. Tag witnessed by DOGGR. POH. Sniffed for gas by SoCalGas. Pressure tested the casing. Initial pressure 572 psi, final pressure 765 psi, +193 psi in 60 minutes. DOGGR would not accept the test. Re test the casing. Initial pressure 550 psi, final pressure 565 psi, +15 psi in 60 minutes. DOGGR witnessed and accepted the test. MU and RIH with Weatherford cement retainer on drill pipe. Slow progress RIH due to repairing 2 hydraulic leaks.
7/13/2018	Fill hole with 0 bbl. Finish RIH with cement retainer. Set cement retainer at TOC, 4409 - 4406'. Circulate the hole clean. POH. RU SLB for MSCT cores. RIH to 4110'. Cut core. Core cutting time of 47 minutes. POH. No recovery. MU and RIH with 5" OD magnet. Worked magnet on bottom. POH. No recovery. RIH kill string.
7/14/2018	Fill hole with 10.5 bbl. POH kill string. RU SLB. RIH to 3666'. Cut core. Core cutting time of 56 minutes. POH. No recovery. MU and RIH with 5" OD magnet. Worked magnet on bottom. POH. No recovery. RIH with tubing stinger and DP for cement plugs.
7/15/2018	Fill hole with 14.4 bbl. RU Halliburton. Mix and pump Plug #7, 4406 - 3951', 17.9 bbl. POH to 3945'. Mix and pump Plug #8, 3945 - 3470', 18.9 bbl. Reversed out. WOC. Rig maintenance and repair.
7/16/2018	Fill hole with 10.5 bbl. Safety stand-down meeting involving SoCalGas and Ensign until 12:30 hours. Safety incident on Sunday regarding a man in the mast and moving the top drive. RIH and tag TOC at 3803’, 237’ low. RU Halliburton and pump Plug 8A, 15 bbl of 14.8 ppg slurry from 3803 – 3422’. POH to 3422’. Problems with top drive while POH. Reverse out at 3422’. WOC.
7/17/2018	Fill hole with 1.2 bbl. RIH and tagged TOC at 3665', 99' low. Circ clean. Repair top drive. RU Halliburton and pump Plug 8B, 10 bbl of 14.8 ppg slurry with 1% CaCl2 from 3665 - 3411'. POH to 3400'. Reverse out. WOC. Check top drive and change hydraulic hose on mast.
7/18/2018	Fill hole with 1.0 bbl. RIH and tagged TOC at 3494’, good tag, witnessed by DOGGR. Circulate and condition fluid. POH for perforations. RU Western Wireline. RIH and perforate 3450 – 3460’. RU Halliburton to establish injection. Pressure to 304 psi. Bled to 0 psi in 5 minutes. RIH and perforate 3440 – 3450’. Check injection with Halliburton. Injection rate 3.2 bpm at 42 psi. RIH with kill string and prepare for squeeze cement.
7/19/2018	Fill hole with 7.8 bbl. RIH to 3494’. RU Halliburton. Mix and pump 25 bbl of 14.8 ppg cement. Pull to 2720’. Pump 7.2 bbl to fill the hole. Closed BOP. Pumped 1 bbl. Pressured up to 300 psi. RD Halliburton. Circulated with rig pump. WOC.
7/20/2018	Fill hole with 0.9 bbl. RIH and tag TOC at 2886'. Good tag witnessed by DOGGR. Mix and pump Plug #9, 5.3 bbl 14.8 ppg cement with 1% CaCl2 from 2886 - 2750'. Pull up to 2750' and reverse out. Circulate clean. POH for MSCT. Rig maintenance and repair.
7/21/2018	Fill hole with 0 bbl. RU SLB. RIH and soft tag at 2772'. RIH and cut MSCT core at 2713'. POH. No recovery on internal magnet. RIH with Weatherford magnet. POH. No recovery. RD SLB. RU Halliburton. Attempted to establish injection base line. Bad test because the hole was not full. RU WWL and perforate 2703 - 2713'. Fill hole with 13.5 bbl. Attempt to establish injection. No injection. RIH and perforated 2720 - 2730'. Fill hole with 11.6 bbl. Attempt to establish injection. No injection. RIH and perforated 2635 - 2645'. Fill hole with 16 bbl. Attempt to establish injection. No injection. RD WWL and Halliburton. RIH with tubing and kill string.
7/22/2018	Fill hole with 28 bbl. RIH and tagged at 2779'. RU Halliburton. M&P Squeeze #7 21.3 bbl of 14.8 ppg cement. Pull to 2131' and reverse out. Circulate and condition fluid. POH to 1500'. WOC.
7/23/2018	POH with kill string. Replaced a hydraulic hose on the iron rough neck. Changed bolts in IRN. MU 6" bit and 4 - 4-3/4" DC and RIH. Tag TOC at 2464'. SoCal worked with DOGGR for approval to clean out cement to 2563'. Drilled out cement from 2464 - 2563' (99') for 10' of rathole for the MSCT at 2553'. Circulated clean.

Date	Daily Report Summary for Well SS-25
7/24/2018	Fill hole with 0.2 bbl (hole full). POH with bit. RD bell nipple and RU SLB lubricator adapter. RU SLB. Cut and recovered MSCT at 2553' with the internal magnet. RIH. Cut MSCT at 2372'. Bit stuck, had to work the bit in and out to retract the bit. POH. No recovery. RD SLB. RIH kill string.
7/25/2018	Fill hole with 3.2 bbl. POH with kill string. RU SLB. RIH with fishing magnet. No recovery of MSCT 2372'. Cut MSCT at 2289'. POH. Recovered coupon. Coupon was jammed in the bit. RD SLB. RU Halliburton. Attempt to establish injection. Pressured up to 200 psi and shut down. Pressure bled to 95 psi in 5 minutes. Mix and pump 18.6 bbl of 14.8 ppg slurry from 2563 - 2090', Squeeze #8. Pull to 1990' and reverse out. Circulate around. POH, WOC.
7/26/2018	Fill hole with 2.6 bbl. POH. LD tubing. MU 6" re-run bit and 4 4-3/4" DC and RIH. Pressure tested the casing to 500 psi with the rig pump. Pressure bled off. LD bit and DC. MU test packer. RIH and pressure test to locate leak. Isolated leak to CHDT at 1006'. RIH kill string.
7/27/2018	Fill hole with 0 bbl. POH. LD packer. MU 6" re-run bit and 4-3/4" DC and RIH. Tag TOC at 2163'. Drill cement to 2695'. Circulate well clean. POH for CBL.
7/28/2018	Fill hole with 0.5 bbl. POH. LD BHA and bit. ND bell nipple. NU lubricator adapter flanges. RU C&J Tiger and run CBL from 2695 - 2000'. Attempt to hold pressure. Repair leaks in lubricator flanges. Ran CBL log with 500 psi pressure. RD Tiger. RIH kill string.
7/29/2018	Fill hole with 0 bbl. POH with kill string. RU SLB. Cut MSCT core at 2037'. POH. No recovery. Ran fishing magnet, no recovery. Cut MSCT core at 1925'. POH, recovered core. RD SLB. RIH with tubing for cement plug.
7/30/2018	Fill hole with 3.5 bbl. RU Halliburton. Mix and pump Plug #10, 20 bbl of 14.8 ppg from 2695 - 2187'. Reversed out at 2187'. Mix and pump Plug #11, 20 bbl of 14.8 ppg from 2187 - 1690'. Reversed out at 1690'. WOC.
7/31/2018	Fill hole with 0.5 bbl. RIH and tag Plug #11 at 1739'. Good tag witnessed by DOGGR. POH. RU SLB. RIH. Cut MSCT core at 1625'. Recovered core. Cut MSCT core at 1564'. Recovered core. Cut core at 1140'. No recovery. RIH with fishing magnet. No recovery. RD SLB.
8/1/2018	Fill hole with 3.8 bbl. RU SLB. RIH and cut MSCT core at 1092'. POH. No recovery. RIH with fishing magnet, no recovery. RIH and cut MSCT core at 1035'. POH. No recovery. RIH with fishing magnet, no recovery. RIH with tubing stinger. Mix and pumped Plug #12, 20 bbl of 14.8 ppg cement from 1739 - 1270'. Lost returns while cementing. POH to 1200'. Pumped 30 bbl to fill hole. Circulate 45 bbl to clean drill string and to fill the hole, no returns.
8/2/2018	Fill hole with 17.5 bbl. RIH and tag TOC at 1300'. Good tag witnessed by DOGGR. Mix and pump 12 bbl, Plug #13 from 1300 - 1030'. No returns during job. POH to 1030' and attempted to reverse out. No returns. Circulated to clear pipe, no returns. WOC 4 hours. RIH and tagged TOC at 1066'. Good tag witnessed by DOGGR. Filled the hole with 39.5 bbl. Fluid level dropping. MSCT hole at 1035' exposed. RU Halliburton. Filled hole with 58 bbl and established injection rate of 2.2 bbl at 90 psi. SDFN.
8/3/2018	Rig maintenance. Change valves in mud pits. Inspections, etc.
8/4/2018	Cleaned and inspected mud pits – replaced valves and gaskets. Transfer 420 bbls of 9 ppg Flowzan to pits. Cleaning out cellar, shaker pit, Inspecting pipe racking arm, traction motors, accumulators, and so on.
8/5/2018	Rig shut down for the day.
8/6/2018	Fill hole with 13.7 bbl 9 ppg Flowzan fluid. POH. NU bell nipple. MU hydraulic cutter. RIH and tag TOC. Pull up to 1025' and cut 7" casing. Pumped 61 bbl with no returns. POH with cutter. Cutter blades indicated cutting through the casing. Prepare to ND BOP.

Date	Daily Report Summary for Well SS-25
8/7/2018	ND BOP. RU for confined space entry. ND tubing head and DSA. Spear casing and pull casing slips. Remove slips. Set casing down and release spear. NU 48" spacer spool. NU diverter spool. NU BOP.
8/8/2018	Speared the casing and pulled casing to the rig floor. Removed the spear. RU CRT. POH with 22 joints of tieback casing and casing patch. Removed casing patch. Pulled and visually inspected 2 joints of 7" casing. Collected samples for Ecolyse. Laid down casing. Preserved casing and connections for shipment at PS-20.
8/9/2018	RU SLB. RIH with openhole caliper. Sat down at 950'. Worked the tool and made no progress. POH. RD SLB. RIH with casing scraper to 350'. POH and found scraper coated with heavy oil / tar. RIH with 10-5/8" bit to 950' and tagged. Worked bit through tight spot 950 - 960'. RIH to 1005' and tagged. Washed and rotated through tight spot. Pumped 130 bbl. Shut off pump and rotary and dry tagged the 7" casing at 1025'. POH. Spot SLB.
8/10/2018	RIH with SLB sinker bar and GR. Tagged at 1016', 9' above the 7" top. POH. MU caliper tool. RIH. Log showed washout below the shoe. POH. MU FMI tool and RIH. Logged open hole. POH. RD SLB. RIH with casing scraper. Did not pump. POH. LD scraper. RIH open ended for Noise and Temperature run.
8/11/2018	RU WAC (Well Analysis Corp) and run a noise temperature log to 990'. Pump 15 bbl down the drill pipe. Log temperature up. RIH to 300'. Take noise readings at 300', 250', 200' water noise, 150' water noise, 100' drip noise. Fluid level at 170'. RD WAC. RU Baker and run gauge ring, junk basket, gamma ray and CCL. RIH with 56 arm caliper and log up. Make repeat caliper run. Dirty casing noted near the shoe and around 250'. RD Baker. RIH with casing scraper to 484'.
8/12/2018	Finish RIH with casing scraper to 990'. POH. LD scraper and send to WFT for redress. RU Baker and RIH with caliper log. Fabricate 11 3/4" shooting nipple with 11" 3M flange. Collected soil samples and SS-25B tote water samples. Made several passed with the caliper from 250 - 270' due to restriction. The ID restriction cleared up. RD caliper. MU IntEx (CBL) tools and RIH. Log up IntEx tool. RU gyro and HRVRT log. RIH to 914' and tagged. Attempted to log up. Log started working around 700'. Logged to surface. RD Baker for the night.
8/13/2018	RU Scientific Surveys. Ran gyro survey to 990'. RD Scientific. RIH with casing scraper with fixed blades and bumper sub to 990'. POH to 990', RIH to 990'. POH. No pumping. RU Baker and run HRVRT without gyro tool. Tool stopped at 505'. POH logging. Added tool for additional weight. RIH and stopped at 950'. Worked tool, no success. Logged from 950 - 37'. RD Baker for the night.
8/14/2018	RU Baker. RIH with HRVRT and Gyro to 967'. Log up. RD Baker. RU SLB. RIH with IBC Isolation Scanner and log. Log from 990' to top of fluid at 188'. RD SLB for the night.
8/15/2018	RU SLB. RIH with UCI Ultrasonic Casing Imager and log. Log from 990' to top of fluid at 195'. RU Sonic Scanner (SSCAN) and RIH. Log from 990' to top of fluid at approximately 190'. RD SLB for the night.
8/16/2018	RU SLB. RIH with Pulsar tools to 1005'. Tool not working. Got tool working. Log up to 600' at 200 ft/hr. Ran repeat log. POH. Attempt to MU CPET tools. Missing a module. Waiting on module and Lithoscanner logging tools. RD SLB for the night.
8/17/2018	RU SLB. RIH with NEXT Lithoscanner tools to 1005'. Log up to 600' at 300 ft/hr. Ran repeat log. POH. MU CPET tools. RIH. Problems getting tool to function. Tool started working. Log up from 990' to 400' taking readings every 6'. RD SLB for the night.
8/18/2018	RU SLB. RIH with CPET tools. Log up from 400' to surface taking readings every 6'. Ran repeat section. RD SLB. RU Baker and EV Camera on the 11" 3M flange and shooting nipple. RIH with the camera. Observe and record casing holes from 190 to 133'. Tagged fluid at 213'. Logged out in side view mode. RD camera and Baker for the night.

Date	Daily Report Summary for Well SS-25
8/19/2018	RU bell nipple. RIH to 990'. Pump 120 bbl 3% KCl to displace the Flowzan mud. RU Baker, EV Camera and Tiger side entry sub on the 3 1/2" DP. RIH camera to 990'. Pump clear fluid and observe surface casing from the shoe at 990' to 972'. POH camera. RD side entry sub. POH to 886'. RU Baker pump in sub. Observe casing around 892'. POH. RD pump in sub. POH DP to 740'. RU side entry sub. RIH with camera. Observe casing from 743' to 701'. RD Baker and EV camera. Shut well in for the night.
8/20/2018	No well work. Waiting on SLB CHDT tools, personnel and bottles. Rig maintenance.
8/21/2018	No well work. Waiting on SLB CHDT tools, personnel and bottles. Rig maintenance.
8/22/2018	No well work. Waiting on SLB CHDT tools, personnel and bottles. POH with DP. NU lubricator adapter in preparation for CHDT. Rig maintenance.
8/23/2018	RD lubricator adapter. Tools too big to fit in the lubricator. RU SLB on the shooting nipple. RIH with CHDT tools. Attempt to take a fluid sample at 920'. No flow. Plugged hole. Pull up to 872'. Attempted to take a fluid sample at 872'. Annulus pressure 139 psi. Bled to bottles and pressure declined. Plugged hole. Pull up to 790'. Attempted to take a fluid sample. No flow. Plugged hole. Took wellbore fluid samples at 900' and 350'. POH and RD SLB for the night.
8/24/2018	RU SLB on the shooting nipple. RIH with CHDT tools. Attempt to take a fluid sample at 566'. Annulus pressure 85 psi. Plugged hole. Pull up to 434'. No flow. Annulus pressure 15 psi. Plugged hole. Pull up to 372'. Annulus pressure 15.5 psi. Attempted to take a fluid sample. Tight, no flow. Plugged hole. Pulled up to 355'. Annulus pressure 27 psi. Flowed to bottles. Plugged hole. Pulled up to 330'. Attempted to take a fluid sample. Tight, no flow. Plugged hole. POH and RD SLB for the night.
8/25/2018	RU SLB on the shooting nipple. RIH with CHDT tools. Attempt to take a fluid sample at 965'. No flow. Plugged hole. Pull up to 860'. Flowed to bottles. Annulus pressure 132 psi. Plugged hole. Pull up to 650'. Tight, no flow. Plugged hole. Pulled up to 490'. Annulus pressure 33.5 psi. No flow. Plugged hole. POH and RD SLB .
8/26/2018	RU SLB and RIH with MSCT tools. Cut and recovered casing samples at 242', 270', 285' (external pitting), 308', 315', 350', 416', 510'. Pumped 110 bbl 3% KCl prior to first sample to raise the fluid level above 242’ to cool the tools. Pumped 62 bbl 3% KCl after the sample at 285’ to raise the fluid level above the sample at 308’. RD SLB for the night.
8/27/2018	RU SLB and RIH with MSCT tools. Cut and recovered casing samples at 550', 638', 706', 720', 816', 896', 970'. RD SLB. Installed bell nipple. RIH with 10-5/8" bit and drill pipe to 910'. SDFN.
8/28/2018	RIH with bit and tagged up at 995'. Wash and ream to 1012'. Bit running rough. POH and found loose cones on the bit. RIH with different bit. RIH and tagged at 1012'. Running rough. Rechecked tally and found an error. The corrected depth is 1025', the correct depth of the casing stub. POH. MU sizing shoe to dress top of stub. RIH to 1025'. Wash and ream over the stub to 1027.7'. Pull up and shut in for the night.
8/29/2018	Washed and reamed over top of stub to 1028.4'. Dressed stub and circulated. POH with mill. MU casing patch and RIH with tieback casing. Engaged the casing patch over the casing stub. Pulled 30K tension over the string weight. Landed the tieback casing in the floor slips. Cut the casing at surface in preparation for tripping in with a bit to cleanout to the TOC at 1066'. Landed the Casing Running Tool in the casing for well control and SDFN.

Date	Daily Report Summary for Well SS-25
8/30/2018	RD CRT. RIH with 6" bit to 1027' and tagged. Rotated and worked through casing patch. RIH to 1030' taking weight. Started pump and pressured up indicating the drill string was plugged. POH to check for plugged bit. Bit was plugged. Cleaned out bit and bit sub and TIH. Ran through the casing patch. Rotated and washed cement stringers to 1066', original TOC. Circulated bottoms up. POH and MU hydraulic casing cutter. RIH and cut the casing at 978' in 4 minutes. POH with cutter. POH and lay down 7" tieback.
8/31/2018	RIH with cement stinger centralized and DP to 1066' for 11 3/4" Shoe Squeeze. Mix and pump 25 bbl of 14.8 ppg cement. Pull up to 700'. Pump 6 bbl to clear pipe. WOC. RIH and tagged TOC at 894' (15' lower that required). Contacted DOGGR for approval for the next steps. Decision made to pump a second plug to meet the TOC requirement. Mix and pump 7 bbl of 14.8 ppg cement (890 - 835'). Pull up to 700'. Pump 6 bbl to clear pipe. WOC. SDFN.
9/1/2018	RIH and tagged TOC at 822'. POH. RIH and set cement retainer at the TOC.
9/2/2018	Shut down for Holiday.
9/3/2018	Shut down for Holiday.
9/4/2018	RIH and tagged cement retainer at 818'. Mix and pump 29 bbl of 14.8 ppg cement, Plug #14/15 from 818' to 580'. WOC. RIH and tagged TOC at 638' (58' low). Mix and pump 7 bbl of 14.8 ppg cement, Plug #14/15A from 638' to 580'. RIH and tagged TOC at 597'.
9/5/2018	RIH with cement retainer and tagged at 591' (6' high). POH retainer. TIH with 10-5/8" bit. Washed and reamed from 584' to 593'. Drilled to 597'. POH. RIH with casing scraper to 596'. POH. RIH with cement retainer. Set retainer at 597'. POH.
9/6/2018	RIH with cement stinger. Tagged retainer at 595'. Mix and pump 24 bbl of 14.8 ppg cement, Squeeze #10, from 595' to 395'. Pull to 350' and WOC.
9/7/2018	RIH and tag cement at 423' (28' low). Mix and pump 24 bbl of 14.8 ppg cement, Squeeze 11, from 423' to 223'. WOC. RIH and tag cement at 243' (20' low). Mix and pump 17 bbl of 14.8 ppg cement, Squeeze 12, from 243' to 100'. WOC. RIH and tagged cement at 163' (63' low). Circulated with full returns. Mix and pumped 8 bbl of 14.8 ppg cement, Squeeze #13, from 163' to 96'. Reversed out at 96'. WOC.
9/8/2018	RIH and tag cement at 96'. RIH casing scraper to 96'. POH. RIH and set a cement retainer at 94'. Pressure test casing to 250 psi, good test. Pump 10 bbl surfactant. Mix and pump 5 bbl of 14.8 ppg cement, Plug #15, 94' to 50'. Reverse out at 49'. WOC.
9/9/2018	RIH and tagged TOC at 52'. ND BOP.
9/10/2018	ND spacer spool. Cut and split conductor casing below the casing head. Cut the 11 3/4" casing below the casing head. Welded on a 11 3/4" riser so the top of the 11 3/4" casing is 5.5' below ground level. Cleaned out and washed the cellar.
9/11/2018	RIH with 1" pipe for top plug. Mix and pumped 8 bbl of 14.8 ppg cement plug. Cement to surface. POH 1" pipe. WOC for bubble test.
9/12/2018	WOC for bubble test. Clean mud pits and prepare for rig move.
9/13/2018	RU for confined entry to the cellar. Bubble test using SNOOP. Bubble test witnessed and approved by DOGGR. Welded a cap on the 11 3/4" casing. Released the rig. Final report.

Appendix D Phase 3 Operations Photos

Figure 15: Coiled Tubing Unit Rigged Up on SS-25

Figure 16: Removing the SS-25 Tree Assembly

Figure 17: Tree Disassembly, Cleaning, and Inspection at PS-20

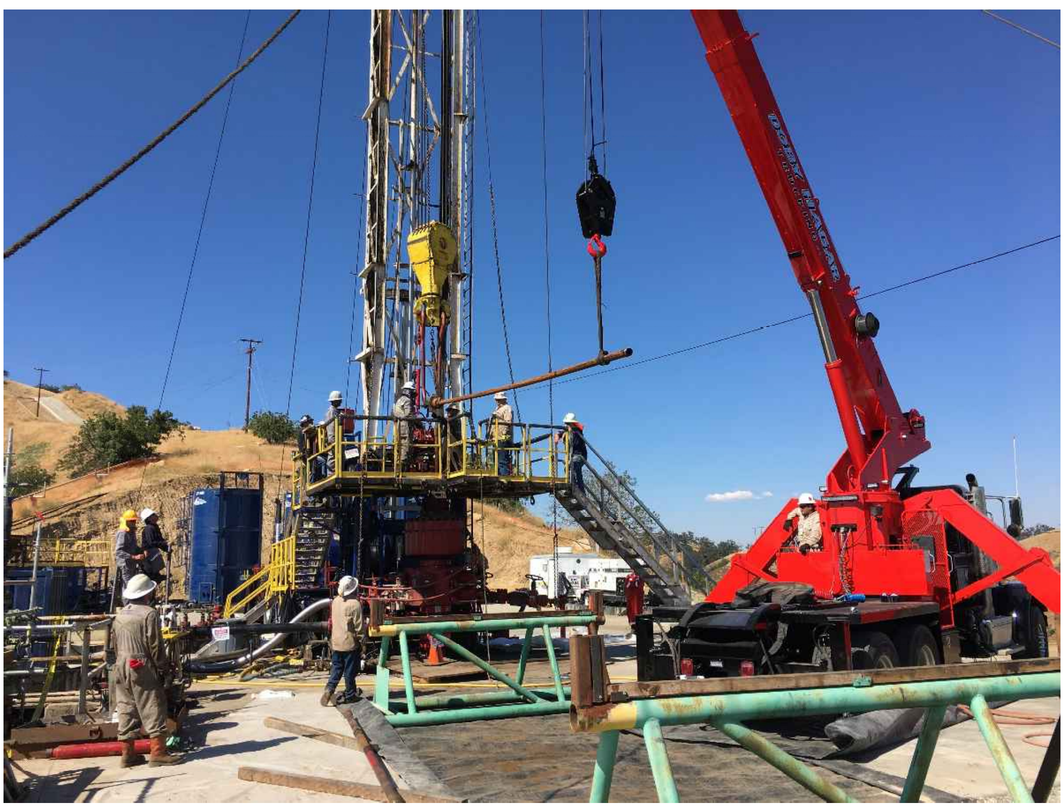

Figure 18: Laying Down Tubing with the Ensign 334 Rig

Figure 19: Tubing Unloading, Cleaning, and Coating Operations at PS-20

Figure 20: Loading Tubing onto Bolsters at PS-20

Figure 21: Ensign 540 Rig on SS-25

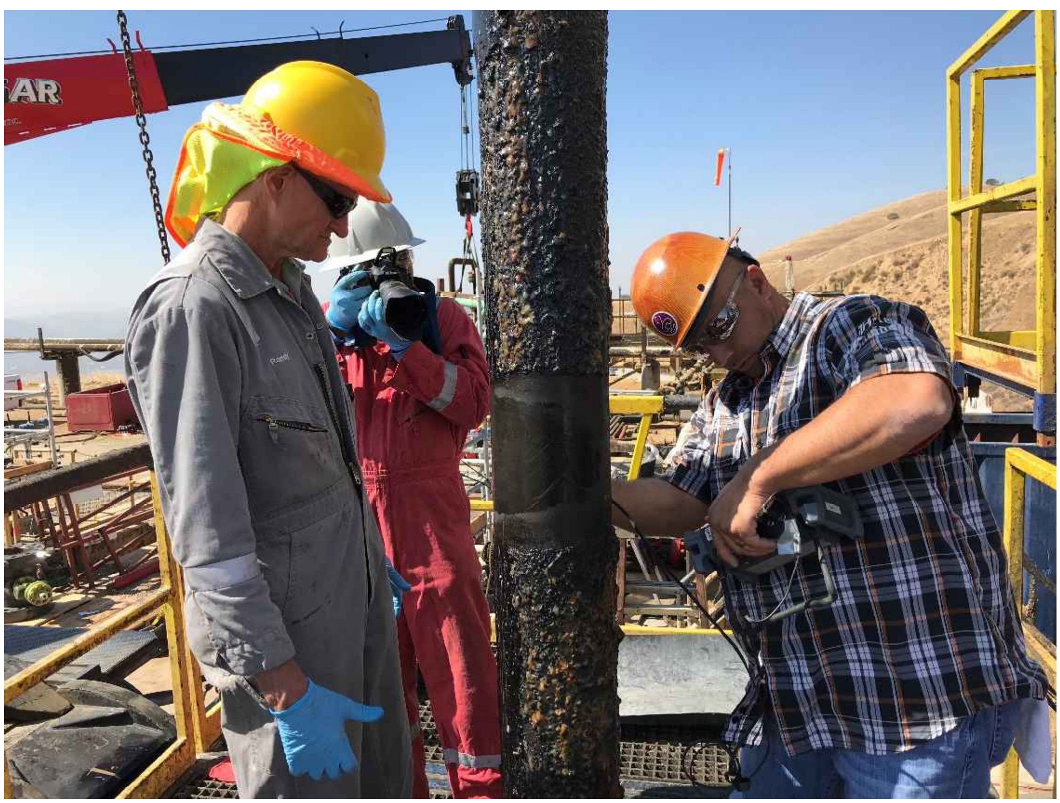

Figure 22: Inspecting the Area Below a Connection Before Cutting the 7 in. Casing

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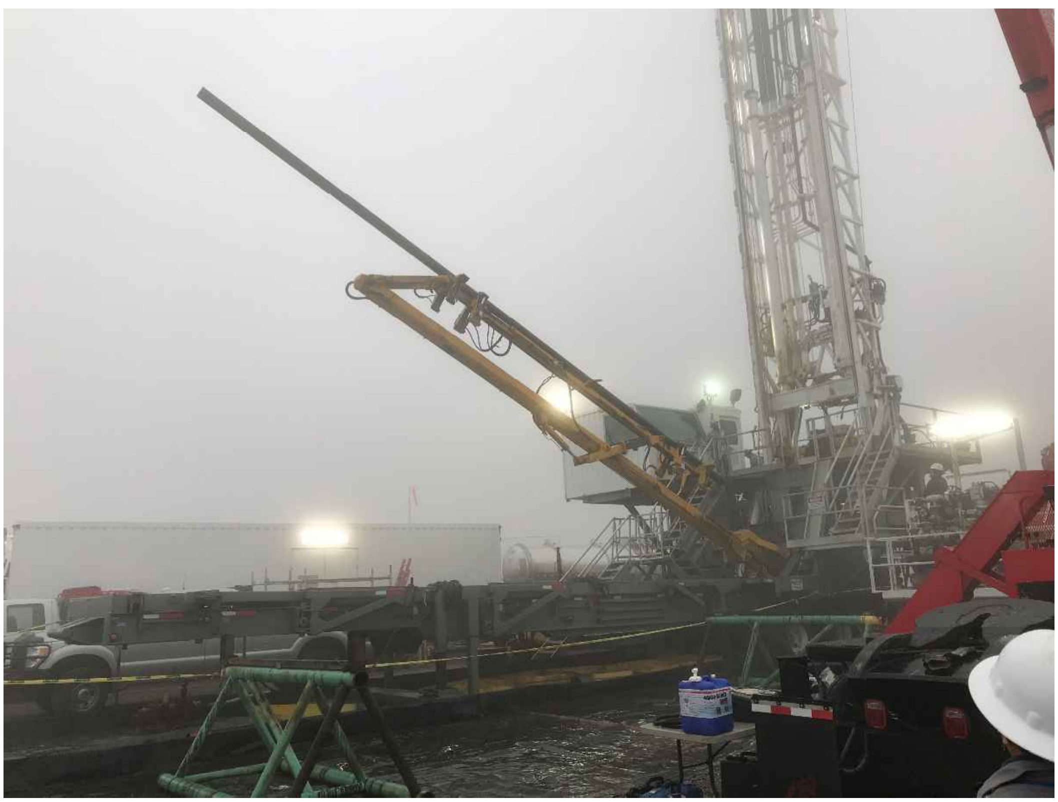

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SS-25 RCA Supplementary Report

Phase 4 Summary

Purpose:

Summarize the activities for Phase 4 of the Root Cause Analysis for SS-25

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Abstract

The gas storage well Standard Sesnon 25 (SS-25) in the Aliso Canyon Gas Storage Field located in Los Angeles County, California started leaking gas in October 2015. A relief well was drilled, and SS-25 was brought under control. The leak stopped in February 2016.

In January 2016, as part of their investigation of the leak, the California Public Utilities Commission (CPUC) and the Division of Oil, Gas, and Geothermal Resources (DOGGR) selected and gave provisional authority to Blade Energy Partners (Blade) to perform an independent Root Cause Analysis (RCA). The Blade Team and parties under Blade's direction were responsible for directing the work of subcontractors who performed the extraction of the SS-25's wellhead, tubing, and casings and the preservation and protection of associated evidence. Blade's RCA Reports, including this report, document and describe the key activities undertaken in support of the RCA effort.

Extracted evidence from the SS-25 well was shipped to the warehouse in Houston, TX. This document discusses the evidence storage, and security procedures employed during the metallurgical investigation. This document summarizes the warehouse operations which covered the reconstruction of the casing failure, nondestructive evaluation (NDE) of tubulars, and connection testing. The activities related to the metallurgical investigation including visual examination, physical measurements, micro-fractographic and metallographic examination, mechanical and chemical testing, corrosion and cracking evaluation, solid and liquid sample analyses were summarized in this document.

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1 Introduction

In October 2015, Southern California Gas (SoCalGas) experienced a blowout in their Standard Sesnon 25 Well (SS-25). SS-25 is a gas storage well located in the Standard Sesnon lease of the Aliso Canyon field. Blade Energy Partners (Blade) was contracted to conduct an RCA of the October 2015 SoCalGas blowout. The investigation began in October 2015 and was organized into six phases:

1. Phase 0 – Data collection, collation, and analysis
2. Phase 1 – Well site evidence collection and documentation
3. Phase 2 – Well site restoration to rig readiness
4. Phase 3 – Tubing, casing, and wellhead extraction
5. Phase 4 – Metallurgical examination
6. Phase 5 – Data integration and interpretation and final report

This document summarizes the activities for Phase 4 of the SS-25 RCA. NDE and laboratory metallurgical examination were used to evaluate the evidence collected. This included visual examination, physical measurements, micro-fractographic and metallographic examination, mechanical and chemical testing, and corrosion and cracking evaluation. The additional evaluation work that was done to support or supplement the conclusions drawn from the metallurgical examination is also summarized. This included corrosion sample testing, internal diameter (ID) and outside diameter (OD) laser scans, and connection testing.

Blade decided that the extracted tubulars would be transported to Houston to be inspected at the National Oilwell Varco (NOV) Tuboscope Sheldon Road facility because the proprietary full-length electromagnetic and ultrasonic inspection technologies used for the inspection were unavailable in California at the time. The laboratories that Blade identified to assist in the metallurgical examination were also located in Houston. Blade rented a 15,000 ft^2, climate-controlled warehouse in Houston to serve as the RCA storage facility. A security system, which included internal and external video surveillance cameras, was installed. Blade developed the warehouse protocol [1], which addressed restricted site access control and shipping and receiving procedures. The warehouse served as the central location for evidence storage because it provided climate control, security, space, and equipment to properly handle the evidence. These qualities also made the warehouse ideal for many of the ancillary RCA activities.

All of the tubulars and equipment extracted from SS-25 were transported from Aliso Canyon to the warehouse. The tubulars or metallurgical samples were shipped to the various labs or inspection facilities for examination and testing as required by the RCA, and then were returned to the warehouse for storage. The Phase 3 activities included the evaluation of several offset wells similar to SS-25. As discussed in the Phase 3 Summary report [2] tubulars extracted from P-34, SS-44A, P-45, and P-35 were also transported to the warehouse for examination.

1.1 Abbreviations and Acronyms

Term	Definition
API	American Petroleum Institute

Term	Definition
Blade	Blade Energy Partners
COC	Chain of Custody
CPUC	California Public Utilities Commission
CRA	Corrosion-Resistant Alloy
CVN	Charpy V-Notch
DOGGR	Division of Oil, Gas, and Geothermal Resources
EDS	Energy Dispersive Spectroscopy
EMI	Electromagnetic Inspection
FE	Finite Element
FIB	Focused Ion Beam
FLUT	Full Length Ultrasonic Inspection
GTC	General Terms and Conditions
ICP	Inductively Coupled Plasma
ID	Internal Diameter
ISO	International Organization for Standardization
JSN	Joint Sequence Number
kips	Thousand pounds
LVI	Laser Video Image
MPI	Magnetic Particle Inspection
MPN	Most Probable Number
NDE	Nondestructive Examination
NDT	Nondestructive Testing
NOV	National Oilwell Varco
NWT	Nominal Wall Thickness
OD	Outside Diameter
RCA	Root Cause Analysis
SCCM	Standard Cubic Centimeters per Minute
SCFD	Standard Cubic Feet per Day
SEM	Scanning Electron Microscope
SLM	Standard Liter Per Minute
SS	Standard Sesnon
UT	Ultrasonic Testing
VME	Von Mises Ellipse
XRD	X-Ray Diffraction

2 Evidence Storage and Security

The Blade warehouse is a 15,000 ft^2 building with 12,900 ft^2 of warehouse space. The physical address of the warehouse is 5504 Clara Road Houston, TX 77401. The trailers transporting the evidence entered the warehouse using one of two grade-level overhead doors. Figure 1 shows an (a) aerial and (b) street view of the warehouse, and Figure 2 shows a 2D layout of the warehouse and office spaces. The warehouse was equipped with air conditioning, and a dehumidifier was installed to assist with humidity control. Temperature and humidity were monitored using a remote weather station.

Figure 1: (a) Aerial and (b) Street View of the Blade Warehouse

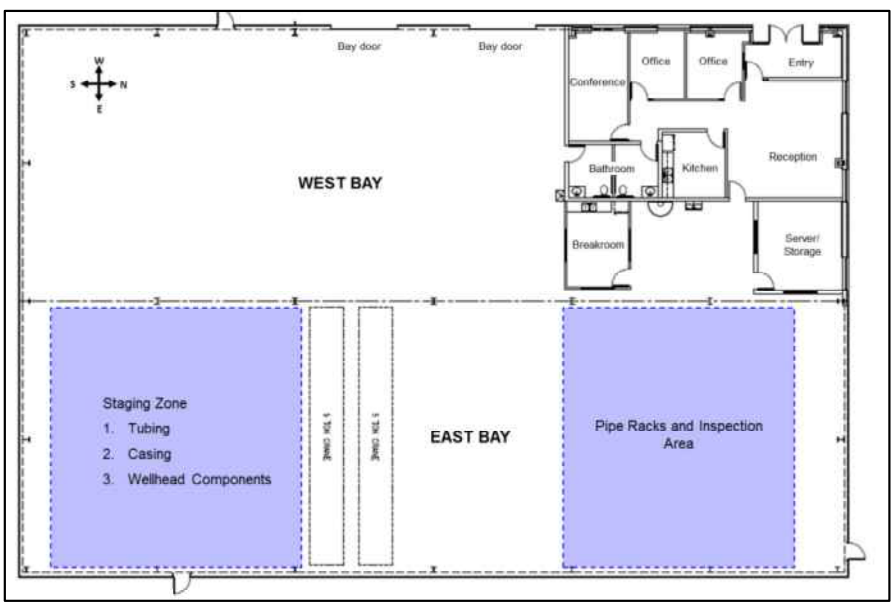


Figure 2: Blade Warehouse Layout

The east bay contained two overhead 5-ton cranes. Sections of the east bay were designated for staging and inspection. Pipe racks were installed in the inspection area to assist with cutting and inspection of the tubulars. The west bay housed the torque turn machine and the Conex trailer for connection testing. AECOM was hired to provide security for the warehouse. Cameras were installed throughout the warehouse and recorded activities 24 hours a day and 7 days a week. Entry points were equipped with a card access system. Three entry points were equipped with the system, including the front main door, the warehouse door, and the server room door. All other entry points were locked at all times. Blade personnel were assigned entry cards that logged all access to the lab. Guests were required to sign in when visiting the warehouse and were escorted by Blade personnel.

The server room housed the servers for the camera system and a refrigerator for storing evidence. Access to the server room was limited to certain Blade personnel. An alarm system and security guard company provided continuous monitoring of the warehouse outside typical business hours. Guards were permitted to enter the office spaces but were not given access to the warehouse.

Care was taken to ensure the as-recovered condition of the casing remained unchanged during transportation and storage. Blade and Doby Haggar Trucking coordinated the transportation of the well components. Figure 3 shows a trailer containing evidence inside of the warehouse. The image shows the individual crates used to protect small sections of pipe and the large crate which enclosed the larger bolstered tubulars. Cameras were installed on the trucks to monitor the load during transportation. Tandem drivers were used to allow for 24-hour movement of the evidence.

The crates were examined for transportation damage upon arrival. Tamper devices, such as Blade security tags and tamper tape, were inspected and removed as needed. No transportation damage or evidence tampering was noted for any of the shipments. Figure 4 shows examples of the tamper device used to secure the evidence. The evidence was examined as each item was removed from the crates, as needed by the RCA. Several activities were conducted at the warehouse, including the initial examination of the 7 in. casing failure, laser scanning, cutting, and connection testing. Cuts were made at the warehouse to extract features and material for testing.

Figure 3: Trailer After Arrival at Blade Warehouse in Houston, TX

The procedures and requirements for the receipt, handling, storage and retention of evidence were detailed in Blade's *Phase 4 Protocol for Metallurgical Investigation of the SS-25 Failure* [3], and *SS-25 Phase 3 Wellsite Equipment Handling Protocol for Houston, TX Warehouse* [1] documents. A chain of custody (COC) process was used to document the possession, transfer, and movement history of each item of evidence. Evidence was shipped to other labs (Premier, Ecolyse, etc.) for specific analyses. These labs received custody of the evidence and handled it according to their internal protocols and the Phase 4 protocol requirements [1]. These analyses were typically destructive in nature. All remaining evidence after the testing was returned to Blade and stored at the warehouse. Sections 2.1, 2.2, and 2.3 describe the handling and security procedures at Element, Blade Energy Laboratories, and Tuboscope, respectively.

Figure 4: Examples of Tamper Tape and Blade Security Tag

2.1 Element Security Procedures

The majority of the initial metallurgical work was conducted at Element in Houston, TX. Element is an ISO 17025 and Nadcap accredited laboratory for machining and testing of metals and non-metallics. The laboratory has restricted access, and all guests must sign in and be accompanied by an Element employee. A security cage (Figure 5) was installed at Element to secure all evidence during the investigation. The cage was constructed out of fencing materials and covered with tarps. The tarps were secured to the fencing material with Blade security tags. The tag numbers and locations were recorded at the beginning of the investigation.

The tags were periodically checked to ensure no tampering had occurred. The front of the cage had two doors secured by padlocks. One padlock was assigned to Blade, and only Blade personnel were allowed to unlock it. The other padlock was assigned to Element, and only Element personnel were allowed to unlock it. Both an Element representative and a Blade representative needed to be present when a sample was taken out of the cage or returned to the cage. At the beginning of every workday at Element, Blade and Element representatives checked the security tag to ensure that it was still intact and the cage was not compromised.

When a sample was to be taken out of the cage, an Element representative cut the security tag. Blade and Element representatives then unlocked the padlocks and obtained the sample from the cage. Blade logged the specimen name in a security log sheet whenever the sample was taken out of the cage or returned to the cage. Element verified the log sheet and countersigned the sheet for the sample that was taken out or returned to the cage. After the sample was taken out, both padlocks were locked. At the end of the work day at Element, Blade and Element personnel locked the cage with the security tag and logged the security tag number in the log sheet.

Figure 5: Security Cage at Element

2.2 Blade Energy Laboratories Security Procedures

Each specimen taken to the Blade laboratory was logged in using a security log sheet. The samples were locked inside a secured room at the end of every work day. If the sample needed to be taken out of the Blade laboratory for characterization in third-party laboratories, the sample was logged out and a proper COC form went with the sample. Blade then logged the specimen back in when it came back to the Blade laboratory.

2.3 NOV Tuboscope Security Procedures

The original COC forms, which originated in California, traveled with the joints as they were moved from the warehouse to the Tuboscope facility. Blade released custody of the tubulars to Tuboscope for the NDE work, and Tuboscope transferred custody back to Blade when the NDE work was completed and the tubulars were returned to the warehouse for storage.

The Tuboscope's Sheldon Road Facility comprises approximately 200 acres. The perimeter is completely fenced in, and the facility has only one truck entrance and exit. Entrance to the facility is allowed only between 8:00 am and 4:00 pm, after which the entrance is closed. The entrance/exit is manned 24 hours per day, 7 days per week. No truck can enter the facility without an authorized Work Order Number provided in advance by Tuboscope. Non-Tuboscope personnel can only enter the facility with signed authorization from the Division Manager.

The tubulars were stored at the Tuboscope facility for the duration of the NDE work. The movement and handling of the tubing at the Tuboscope facility was done using their internal corrosion-resistant alloy (CRA) procedures to ensure that the tubulars were not damaged during the inspection processes. The pipe movement within the facility and inspection work were tracked and documented using Tuboscope's internal inventory management system.

The tubing was stored on specified pipe racks near the cleaning and inspection work sites, and no movement of the joints or inspection work was done without an internal work order. A joint count check was done before the pipe was moved into a work site, while the work was being done, and before moving the pipe out of the work site. All of the pipe movement and inspection work was tracked and documented in Tuboscope's internal management system. Blade witnessed all tubing movement and inspection work, and conducted and documented an ‘as-found’ and ‘as-left’ inspection of the condition of the tubing at the beginning and end of each shift.

3 Metallurgical Investigation

The goal of the metallurgical analysis was to determine the cause of the SS-25 7 in. casing failure. This required an interdisciplinary approach, which included metallurgical, mechanical, chemical, and biological analyses. Several laboratories were used to accommodate the needs of the investigation. The laboratories and their primary role for the investigation were as follows:

- Blade Energy Laboratories
  - Scanning electron microscope (SEM) examination and energy dispersive spectroscopy (EDS) analysis
  - Metallography
  - Corrosion testing
- Element
  - Initial SEM examination and EDS analysis
  - Metallography
  - Material testing
- FIB-X Services (FIB-X)
  - Focused ion beam (FIB)
  - SEM examination and EDS analysis
- Premier Oilfield Group (Premier)
  - SEM examination and EDS analysis
  - Raman spectroscopy
  - X-ray powder diffraction
  - Inductively coupled plasma (ICP)
- Ecolyse
  - Biological analysis of scale and fluids
- Metcut Research (Metcut)
  - Fracture toughness testing
- Anderson and Associates
  - Fracture toughness testing
- Materials Research Company, LCC
  - Corrosion testing

Transition of specimens from one lab to another was documented on COC forms in accordance with the metallurgical investigation protocol [3].

3.1 Metallurgical Analysis

The metallurgical investigation began in February 2018 at the Blade warehouse. The upper (C022B) and lower (C023A1) segments of the failed 7 in. casing (joint 22) were removed from their protective containers and placed on a table for visual examination. C023A1 and C022B are joint sequence numbers (JSNs) which are assigned to specimens and act as identification for the specimens during the investigation. Appendix A shows the field cut locations and corresponding JSNs for the 7 in. casing.

C022B contained the upper fracture surface for the circumferential parting. C023A1 contained the lower fracture surface for the circumferential parting and the axial rupture fracture surfaces. C023A1 was in the as-recovered condition. C022B was ultrasonically cleaned in an acetone bath at the PS-20 field lab. The upper and lower segments were positioned as they were in the SS-25 well and photo documented.

The OD surface of C023A1 and C022B was scanned with a laser scanner to document the condition of the segments and to analyze additional features that were present on the surface. Figure 6 and Figure 7 show examples of an image, laser scan model, and corrosion analysis results for C023A1 and C022B, respectively. Initial measurements, such as fracture surface length, mouth opening, and wall thickness, were taken at the warehouse. Witnesses from interested parties were present for some of the initial examination at the warehouse.

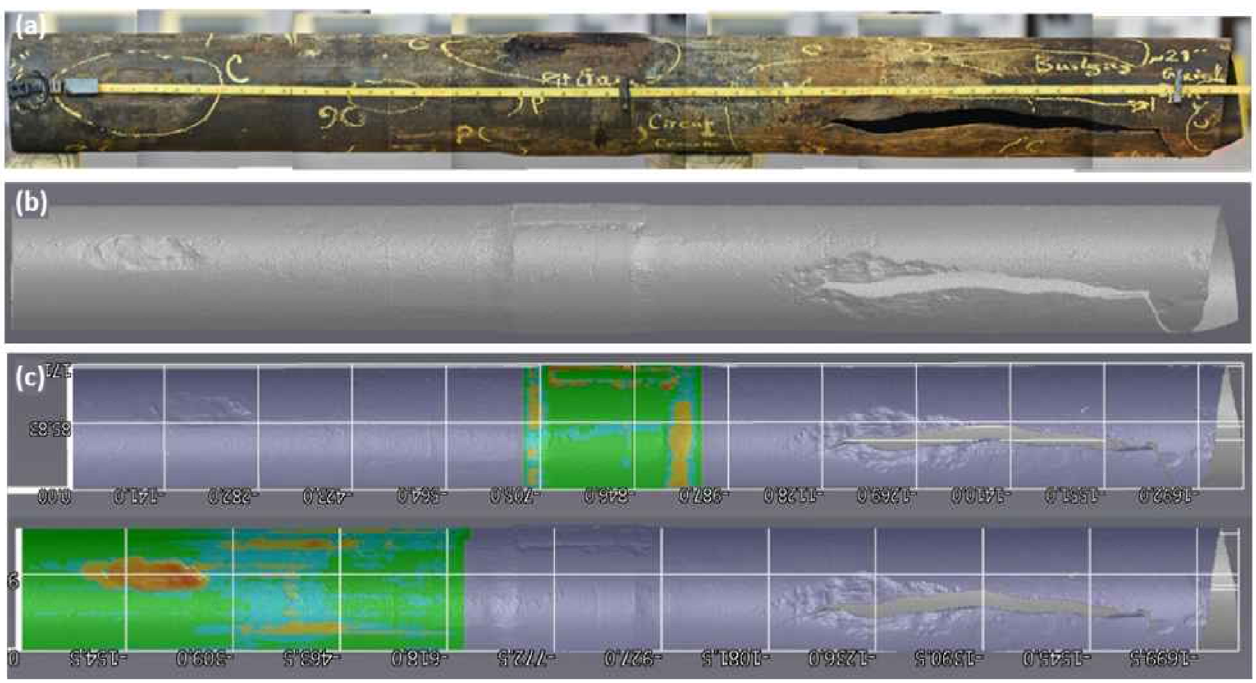


Figure 6: C023A1 (a) Photo, (b) Laser Scan Model, and (c) Corrosion Analysis Results

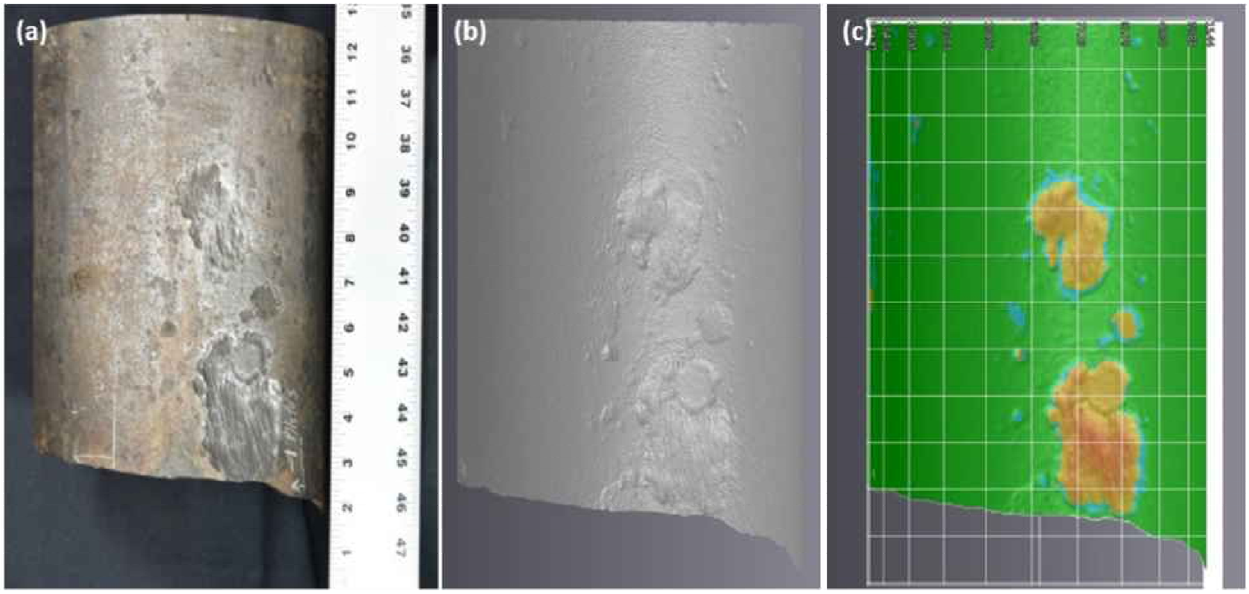


Figure 7: C022B (a) Photo, (b) Laser Scan Model, and (c) Corrosion Analysis Results

C023A1 and C022B were placed back in protective containers in preparation for shipment from the Blade warehouse to Element. Additional specimens and equipment were also prepared for transportation to Element, including 7 in. casing material for material testing, a specimen (C004C) containing a linear indication, and desiccators. The material testing specimens were 2 ft sections extracted from the ends of C001–C020 of the 7 in. casing joints. C004C was a specimen that contained a linear indication that was identified by visual examination and confirmed with magnetic particle inspection (MPI) and ultrasonic testing (UT) inspections. The desiccators were provided by Blade to protect specimens from moisture. The specimens and equipment were transported to Element on April 02, 2018, and were accompanied by Blade personnel. Figure 8 shows the specimens and equipment loaded onto a truck and in the specimen cage at Element.

Figure 8: Shipment and Storage of Evidence at Element

The following specimens were the primary focus during the investigation at Element:

- C023A1 axial rupture fracture surfaces
- C022B corrosion feature
- C004C linear indication

These specimens were examined extensively at Element. Element provided a work space for Blade personnel to work from during the investigation. Blade directed and was present for each activity during the metallurgical investigation at Element. General metallurgical activities conducted at Element (Figure 9) included the following:

- Visual examinations and photo documentation
- Specimen cutting and preparation
- Stereo microscope examinations
- SEM examinations
- EDS analyses
- Metallographic sectioning and analyses

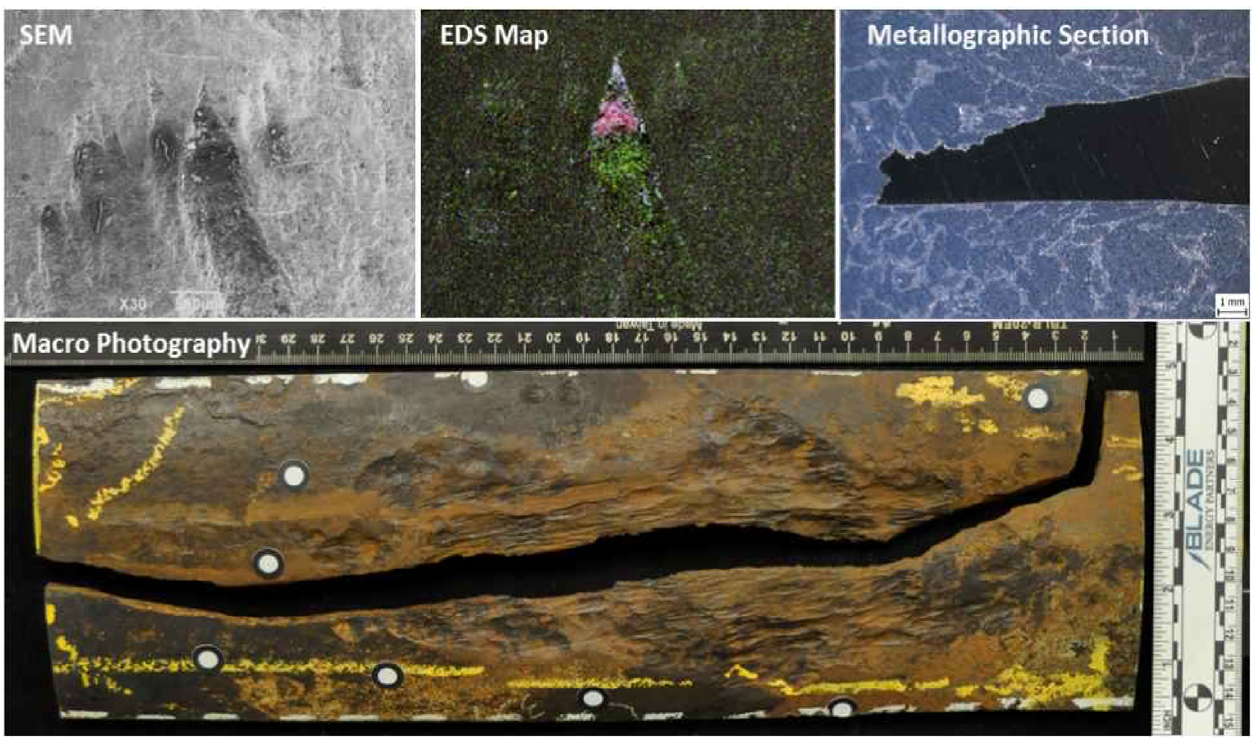


Figure 9: Examples of Activities at Element

Material testing was also conducted in parallel during the investigation and was directed by Blade. Material testing at Element included the following:

- Tensile
- Charpy-V Notch

- Hardness
- Microstructural Analysis
- Microcleanliness
- Grain Size
- Chemistry

Additional testing was conducted at Anderson and Associates, Metcut, and Blade Energy Laboratories. Anderson and Associates and Metcut performed fracture toughness testing. Blade Energy Laboratories performed critical strain testing. The goal of the material testing was to compare material properties with the standards in place at the time of the well construction. Material properties were also used for finite element (FE) and fracture mechanics analyses. Witnesses from interested parties were present during tensile, Charpy V-Notch (CVN), and fracture toughness testing. Witnesses were also provided macro photos, micrographs, and other images generated at Element on a regular basis.

The metallurgical investigation at Element was transitioned over to Blade Energy Laboratories due to construction and general scheduling conflicts at Element. Specimens were securely packaged and signed over to Blade's custody. Specimens were transported to Blade Energy Laboratories and stored in a secure room dedicated to the SS-25 RCA.

The metallurgical work continued at Blade Energy Laboratories, which included the following:

- Visual examinations and photo documentation
- Specimen cutting and preparation
- Stereo microscope examinations
- SEM examinations
- EDS analyses
- Metallographic sectioning and analyses

Additional specimens containing corrosion features were extracted from joints at the Blade warehouse and transported to Blade Energy Laboratories for the metallurgical investigation. Specimens were extracted from the following:

- C021 – Corrosion feature from pipe body
- C024B – Corrosion feature from connection
- C025 – Corrosion feature from pipe body

Figure 10 shows the corrosion features extracted from each specimen. The features were cut into smaller specimens and examined with the SEM, EDS, and Raman spectroscopy. Witnesses were provided macro photos, micrographs, and other images on a regular basis during the investigation.

Figure 10: Corrosion Features from (a) C021, (b) C024B, and (c) C025

3.2 Solids Analysis

The scales on the OD surface of the SS-25 7 in. casing were collected during Phase 3. The objectives of the scale analysis were as follows:

- To determine the composition of the scale
- To identify the corrosion products
- To determine the presence of microbes on the OD surface of the 7 in. casing
- To quantify the microbes present

Blade contracted two different laboratories to achieve these goals. The scales were sent to Premier Oilfield Group for compositional analyses using X-ray diffraction (XRD), Raman spectroscopy, SEM, EDS, and ICP. XRD was used to determine the relative amounts of the compounds identified in the scale. Raman was used to verify the compounds determined by XRD. SEM, EDS, and ICP were used to identify the individual elements that make up the compounds present in the scale samples.

The other set of scale samples was sent to Ecolyse for biological analyses. Ecolyse conducted three types of tests, namely, most probable number (MPN) analysis, quantitative polymerase chain reaction (qPCR), and amplicon metagenomics population analysis. The MPN detected the culturable bacteria and quantified them using media bottles. qPCR was used to detect the total number of microorganisms per gram of sample. qPCR detected both live and dead cells. The amplicon metagenomics was used to identify the characteristic DNA of the living or dead microbes. The amplicon metagenomics provided relative abundance of each organism.

The results of the analyses were used to understand the corrosion mechanism in the SS-25 well. The composition of the scale and the corrosion product were used to interpret corrosion evolution along the depth of the well. The biological analyses were used to determine the type and abundance of bacteria that influenced the corrosion of the 7 in. casing. The results of these analyses were incorporated in the Phase 4 report [4].

3.3 Liquids Analysis

Numerous liquid samples were obtained and analyzed during the various phases of the RCA including:

- Stormwater runoff samples
- Separator soil and water samples
- Oil samples from around the SS-25 site

- Wellbore fluid samples from the tubing and annulus
- New drilling fluid samples
- Cased Hole Dynamic Tester (CHDT) annulus fluid samples from SS-25, P-35, and SS-25B
- TH-1 groundwater samples

The objective of the analyses was to document the existing or baseline conditions for comparison with new data that would be collected as part of the RCA.

Four laboratories were used to analyze the samples – Premier Oilfield Group, Texas OilTech Laboratories, Schlumberger, and Ecolyse Inc. A compositional analysis was done which included the identification of organic compounds, trace metals, anions, cations, organic acids, pH, and alkalinity. Ecolyse conducted the same kind of biological analyses mentioned in Section 3.2.

4 Warehouse Operations

The Blade warehouse served as the central location for evidence storage because it provided climate control, security, space, and equipment to properly handle the evidence. These qualities also made the warehouse ideal for many of the RCA activities, including:

- Reconstruction of the 7 in. casing failure.
- Preparation for NDE of the tubing and casing at Tuboscope.
- ID laser scan of the 7 in. casing.
- OD laser scan of the 7 in. casing.
- Connection examination and testing.

4.1 Reconstruction of the 7 in. Casing Failure

The first task for the metallurgical investigation of the 7 in. casing failure was reconstruction of the failure. Reconstruction involved placing the fractured pieces back together to determine if any of the fracture surfaces were lost during the failure. Two joint segments, C022B and C023A1, contained the fracture surfaces for the circumferential parting and axial rupture. C022B contained the upper circumferential fracture surface, which was facing downward in the well. C022B was extracted with the upper 7 in. casing joints. C023A1 contained the lower circumferential fracture surface and the axial rupture fracture surfaces. C023A1 was facing upward in the well and was fished using a custom pawl tool.

The failure was reconstructed using both segments. The fracture surfaces were traced onto paper and plastic, cut, and positioned back to their original state. The reconstructed failure was then examined for missing pieces. Figure 11 shows the reconstruction of C023A1. The paper outlines the fracture surfaces and captures the bulging associated with the axial rupture. Figure 12 shows the completed paper reconstruction of the upper circumferential parting (C022B) and the lower circumferential parting and axial rupture (C023A1). Corrosion adjacent to the failure was also transferred to the paper for reference. The paper was removed from both casing segments and fitted together to show the original state of the 7 in. casing before the failure. The reconstruction found that all failure pieces were recovered from the well.

Figure 11: Reconstruction of C023A1

Figure 12: Completed Paper Reconstruction of C022B and C023A1

4.2 Tubing and Casing NDE at Tuboscope

Identifying flaws in the tubulars was one of the primary objectives during the metallurgical investigation. The OD surface was inspected in the field for corrosion, surface breaking cracks, damage, and other features that may have contributed to the failure. Surface breaking cracks are difficult to visually identify, especially if they are small and tight. Nondestructive testing (NDT) techniques exist for identifying both surface breaking and non-surface breaking cracks, including Electromagnetic Inspection (EMI) and Full-Length Ultrasonic Testing (FLUT) technologies. EMI is a technique that detects longitudinal flaws in ferrous steel pipe and tubes. FLUT has the ability to detect transverse, longitudinal, and oblique flaws. Both techniques were used to identify flaws in the SS-25 tubulars.

Service companies that perform full-length inspections on tubulars were limited. Tuboscope is an oilfield service company that offers many on-site inspections, including EMI and FLUT. Tuboscope was selected to inspect the SS-25 tubulars based on their inspection capabilities. Tuboscope was instructed to use their CRA handling protocol when handling the SS-25 tubulars. CRA handling procedures follow the same guidelines as those used for the SS-25 tubulars, including no metal-to-metal contact. Fork lifts were padded to prevent the forks from damaging the pipe surface. Bumper rings were used to prevent contact between the tubulars when on the racks. Tuboscope removed the Tectyl 846 coating on the OD and ID surface. The NDE work did not locate any flaws in the tubing or casing that were relevant to the RCA. The results of the inspection are detailed in the *SS-25 Tubing and Casing NDE Analysis* report [5].

4.3 7 in. OD and ID 3D Laser Scan

The ID and OD surfaces of the 7 in. casing were exposed to different environments during the life of the well. The presence or absence of features provides evidence to the metallurgical investigation and to the RCA as a whole. The Tuboscope inspections were used to identify linear indications in both the longitudinal and circumferential orientations. Laser scanning cannot detect crack-like features but can identify and characterize corrosion, pitting, erosion, wire line damage, mechanical damage, and ovality.

4.3.1 7 in. Casing Inside Diameter Laser Scan

Laserstream was hired by Blade to scan the ID surface of the 7 in. casing body and connections. The tool uses laser technology to create an accurate profile of the ID surface. The tool acts as a non-contact caliper tool. Pipe body and connections were scanned at different times. Connections were scanned on the following days:

- March 14, 2018: C020B, C019B, C018B, C017B, C016B, C015B, C014B, C013B, C012B, C011B, C010B, C009B, C008B, and C007B
- March 15, 2018: C006B, C005B, C004C, C004B, C003B, C002B, and C021B

Pipe bodies were scanned on the following days:

- July 08, 2018: C019A1, C015A1, C020A1, and C017A1
- July 10, 2018: C018A1, C003A1, C002A1, and C007A1
- July 11, 2018: C010A1, C009A1, C006A1, C005A1, and C008A1
- July 12, 2018: C011A1, C012A1, C016A1, C013A1, C014A1, and C001B

The following steps were taken when scanning the pipe bodies and connections:

- A repeatability test was conducted after each scan using a validation ring.
- The ring was checked before each scan, with three different machined inner diameters and showed agreement to 0.005 in.
- Each joint was scanned from pin to box. The linear position 0 began at the pin end, and the rotary position 0 was aligned with the stamp on the OD.
- A launch tube was used to ensure the entire joint length was scanned.
- The scanning resolution was 0.030 in. longitudinally and 0.011 degrees circumferentially.

Figure 13 shows the 7 in. casing connection ID laser scan setup. The image shows the tube used to launch the Laserstream tool into the pipe bodies and connections.

Figure 13: Laserstream Connection Scan

Laserstream provided scan data, which included the following:

- Bore diameter measurements at every 5 in. and 5°
- Ovality measurements every 5 in.
- Images of the pipe in both a color profile image and black and white laser video image (LVI)
- Feature detection outputs listing each individual feature that met the feature detection criteria, including a 1:1 aspect ratio of the image, full-length color profile, and feature detection mode with each feature labeled and identified

Figure 14 shows a plot of the bore diameter extracted from the Laserstream report for joint 7. Figure 15 shows the color profile image and LVI extracted from the Laserstream report for joint 7. These were typical outputs provided by Laserstream. Table 1 shows the feature detection results for the scanned pipe bodies.

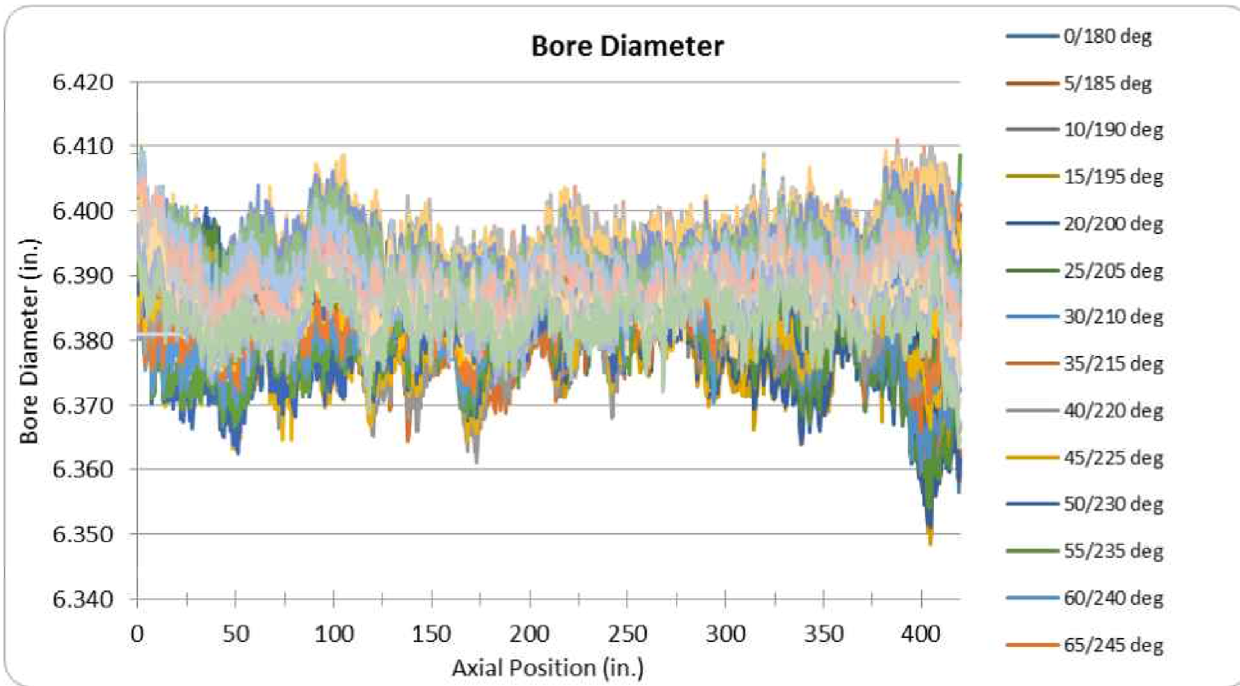


Figure 14: Bore Diameters for Joint 7

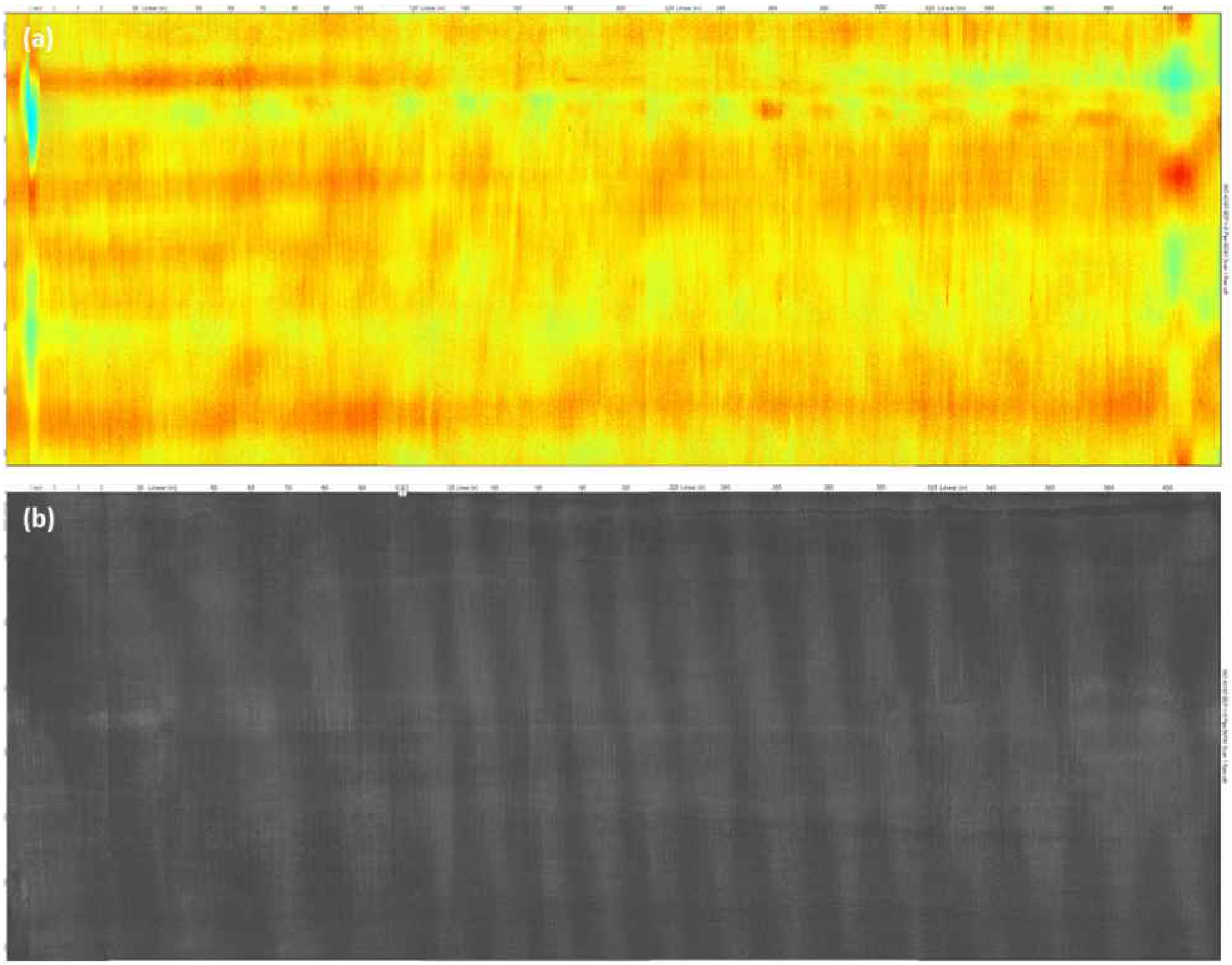


Figure 15: ID (a) Laser Scan and (b) LVI Image from Joint 7

Table 1: ID Laser Scan Feature Detection Results

Joint	Length (ft)	S/N	Min. Radius (in.)	Avg. Radius (in.)	Max. Radius (in.)	Qty. with ≥ 5% Wall Loss
1	34.90	C019A1	3.1555	3.1829	3.2056	27
2	34.99	C015A1	3.1160	3.1934	3.2173	26
3	33.84	C020A1	3.1610	3.1727	3.1829	0
4	35.45	C017A1	3.1586	3.1925	3.2109	7
5	28.78	C004A1	3.1515	3.1907	3.2128	378
6	31.00	C018A3	3.1174	3.1766	3.1919	1
7	35.24	C003A1	3.1629	3.1895	3.2112	312
8	35.56	C002A1	3.1205	3.1737	3.1994	1
9	34.60	C007A1	3.1657	3.1928	3.2055	2
10	36.12	C010A1	3.1702	3.1937	3.2125	125
11	34.31	C009A1	3.1622	3.1832	3.2044	40
12	34.70	C006A1	3.1800	3.1908	3.2003	1

Joint	Length (ft)	S/N	Min. Radius (in.)	Avg. Radius (in.)	Max. Radius (in.)	Qty. with ≥ 5% Wall Loss
13	32.69	C005A1	3.1294	3.1933	3.2387	15
14	33.45	C008A1	3.1472	3.1756	3.2002	39
15	35.75	C011A1	3.1678	3.1923	3.2127	152
16	35.17	C012A1	3.1589	3.1842	3.2018	99
17	34.35	C016A1	3.1725	3.1889	3.2106	10
18	32.25	C013A1	3.1608	3.1894	3.2738	42
19	35.52	C014A1	3.1642	3.1893	3.2167	107
20	4.99	C001B	3.1211	3.1584	3.2322	6

4.3.2 7 in. Casing Outside Diameter Laser Scan

Corrosion features appeared to have a correlation to depth, based on field observations made during Phase 3. The observations were qualitative rather than quantitative and did not provide an overall picture as to how the corrosion was distributed along the 7 in. casing. One of the main goals during Phase 4 was to generate numerical and graphical representations of the OD corrosion to help identify patterns associated with the distribution. The data were also used to cross reference with other observations and data sets.

The target output for showing the distribution was a 2D color map showing corrosion severity as a function of depth and circumferential position. Corrosion severity can be measured using many different metrics. This analysis used feature depth as an indication of severity. Features with larger depths were considered more severe than shallower features. Laser scan technology was used to produce the 2D corrosion color map.

The OD surface was scanned using the Creaform HandySCAN 700 laser scanner. The technology uses auto position stereo vision and positioning targets to create real-time rendering of objects. The rendered object is a 3D mesh of the OD surface. The mesh is then analyzed using Creaform's Pipecheck Software. The raw output of the software is depth measurements at longitudinal and circumferential coordinates in relation to a reference cylinder. The size of the mesh is determined by the scan resolution chosen by the operator.

Figure 16 shows an image of the HandySCAN 700 and the laser lines generated by the scanner. The scanner maintains its position in 3D space by using a known origin determined by the operator and reflective positioning dots. The laser lines contour to the surface of the pipe, which allows the scanner to capture and measure the deflection. The deflections are converted to points in 3D space and converted into a mesh. Figure 17 shows a rendered image of a section from joint 18. Corrosion can be seen on the OD surface of the pipe. The enlarged image in Figure 17 shows the underlying mesh that makes up the 3D model. The model can be manipulated and exported to other standard mesh formats for additional analysis in other software.

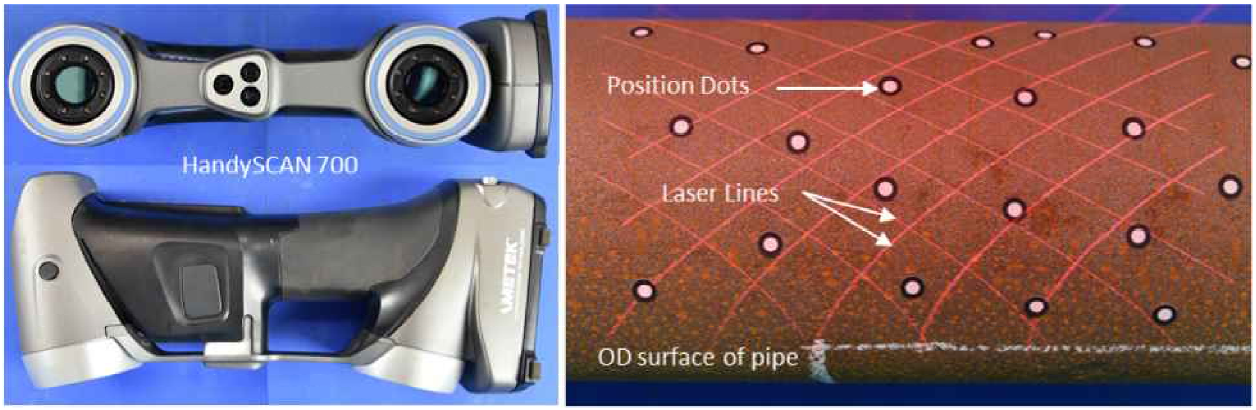


Figure 16: Creaform HandySCAN 700 Scanner and Laser Lines

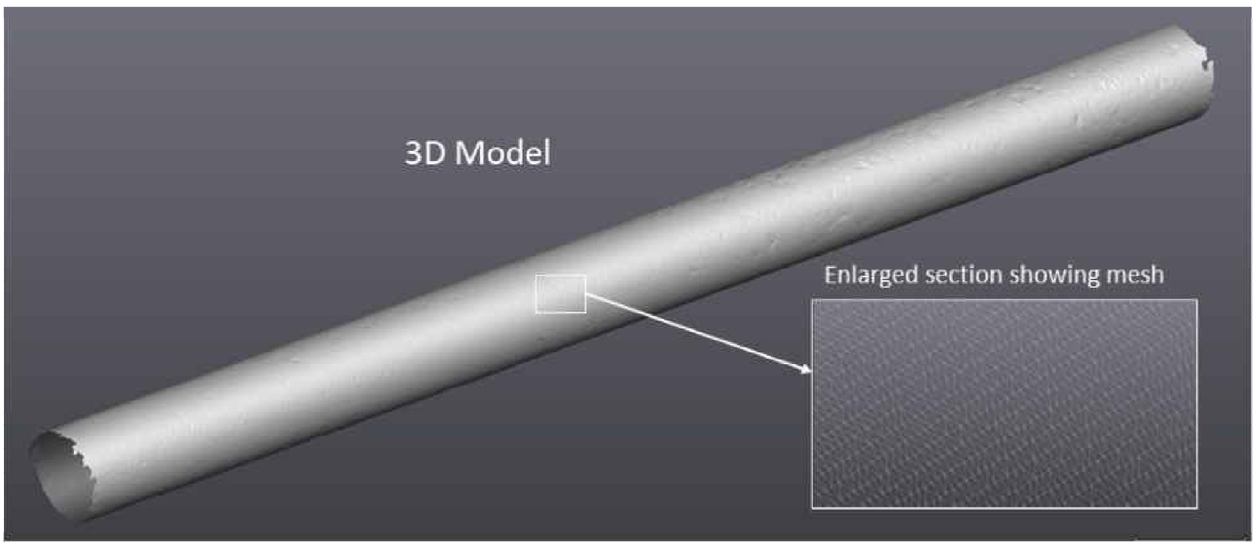


Figure 17: 3D Model of C018A OD Surface

The laser scanner is a non-contact measurement device that works on a line-of-sight basis. The scanner captures anything on the surface of the pipe. The surface must be sufficiently cleaned to prevent obscuring features. Features filled with scale or other products will not be detected by the scanner and may be identified as nominal OD surface. In some cases, pipe that is covered with a heavy scale may show many features that are not actually present. This phenomenon occurs because the scale creates a false nominal OD surface. Actual wall that shows through the scale in some areas is then identified as features rather than OD surface. The surface must be blasted with abrasive media to prevent false readings.

The joints were transported to Superior Shot Peening for abrasive blasting with Black Beauty Extra Fine blast media. Black Beauty Extra Fine is a coal slag media that is aggressive enough to provide a clean surface while simultaneously minimizing the amount of surface material that is removed. Extra Fine uses small particles designed for light duty brush-off blasting on surfaces that are generally clean. Small batches of joints were transported to Superior in the morning and returned to the warehouse in the evening over several days to maintain security. Transportation and blasting of the joints were monitored by Blade.

Reflective positioning dots were applied to the OD surface after cleaning. Dots were randomly spaced approximately 3–4 in. from one another. The laser scanner must see at least three dots at a time to maintain its position in 3D space. The random pattern prevented errors when analyzing scan data. Areas covered by the positioning dots are regions of no data; therefore, dots were not placed in regions of interest whenever possible. Dots were strategically placed within corrosion features when the corrosion was extensive enough that placement around the corrosion was not possible.

The scan length was limited by the software. Scans were limited to approximately 10 ft sections. The sections were later merged using the Pipecheck software. The scans required the operator to designate an origin for the scan. The origin is identified by a magnetic arrow with a known dot pattern. The pattern is recognized by the software and places the origin at the back of the arrow. The origin for the casing was designated as the orientation mark made in the field. The orientation mark corresponded to the west side of the pipe in relation to the SS-25 site. The arrow was always placed on the top side of the joint at the orientation mark. The direction of the arrow typically signifies flow direction when used for pipeline inspections. The arrow orientation was used, in this case, to signify the downhole direction. The software allows the analyst to apply offsets to the orientation for easy correlation to field data. The origin for each scan was adjusted to the appropriate depth to limit the amount of work during analysis.

The joints were scanned and analyzed using the Pipecheck corrosion module. Figure 18 shows joint 18 corrosion analysis. The color map divisions were determined by the analyst. The color map provides a graphical means of showing the corrosion distribution for each scan. The lowest color map division, shown in green in Figure 18, represents all values below the critical factor which was defined by the analyst.

The nominal dimensions used for all the scans were 7 in. for the OD and 0.317 in. for the wall thickness. The analyst controls other variables, such as critical factor, filters, interaction criteria, and other parameters that define how corrosion is detected and defined.

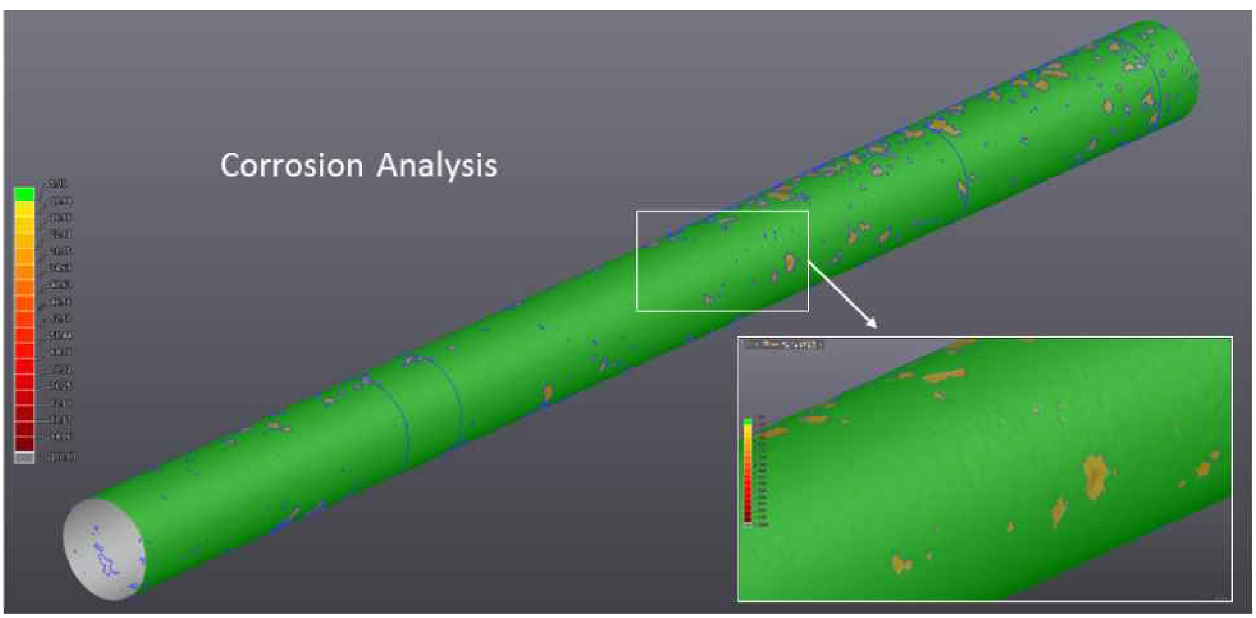


Figure 18: 3D Color Map of Corrosion Analysis Results for C018A

The software provided different views for the analyzed data. Figure 19 shows a 2D color map of the corrosion analysis for a section of joint 18. The 2D maps show the same image as the 3D map flattened to a 2D image. The plots on the bottom and right side of the image show the surface profile at the selected point for the longitudinal and circumferential directions, respectively. The point selected in Figure 19 is the maximum point of the current scan. The 2D plot shown in Figure 19 was the target output for all of the 7 in. casing joints. The corrosion analysis was carried out for each joint body.

Connections were also analyzed, but required parameter adjustments to obtain accurate results. For example, the nominal OD of the connections is 7.44 in. The connections were analyzed using the nominal OD of the connection and the NWT of the pipe body. This was done due to the complexity of the connection. Using the NWT of the body also provided a better means of comparing the pipe body and connection corrosion.

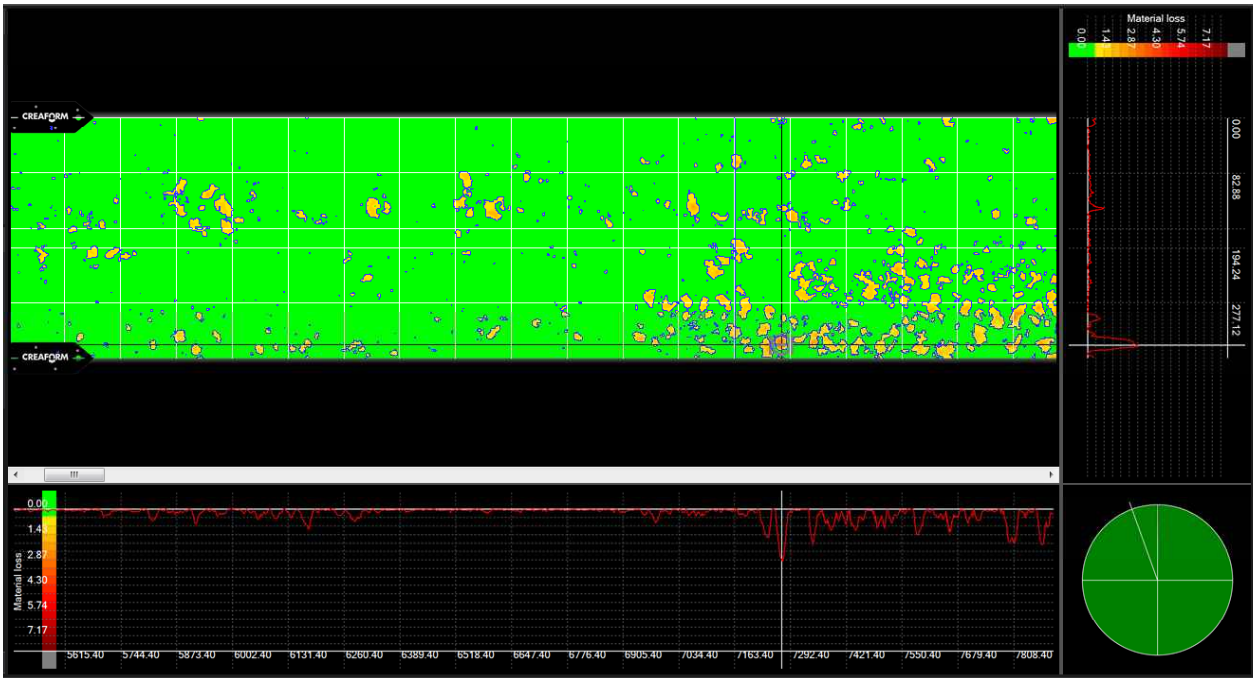


Figure 19: 2D Color Map of Corrosion Analysis Results for C018A

Figure 20 shows the 3D model and corrosion analysis color map for connection 18. Figure 21 shows the corresponding 2D color map. The adjacent pipe body was excluded from the analysis due to the differences in nominal OD. The pipe body was included in a separate analysis. Tapered regions adjacent to the connections cannot be analyzed by the software. These regions were excluded from the analysis.

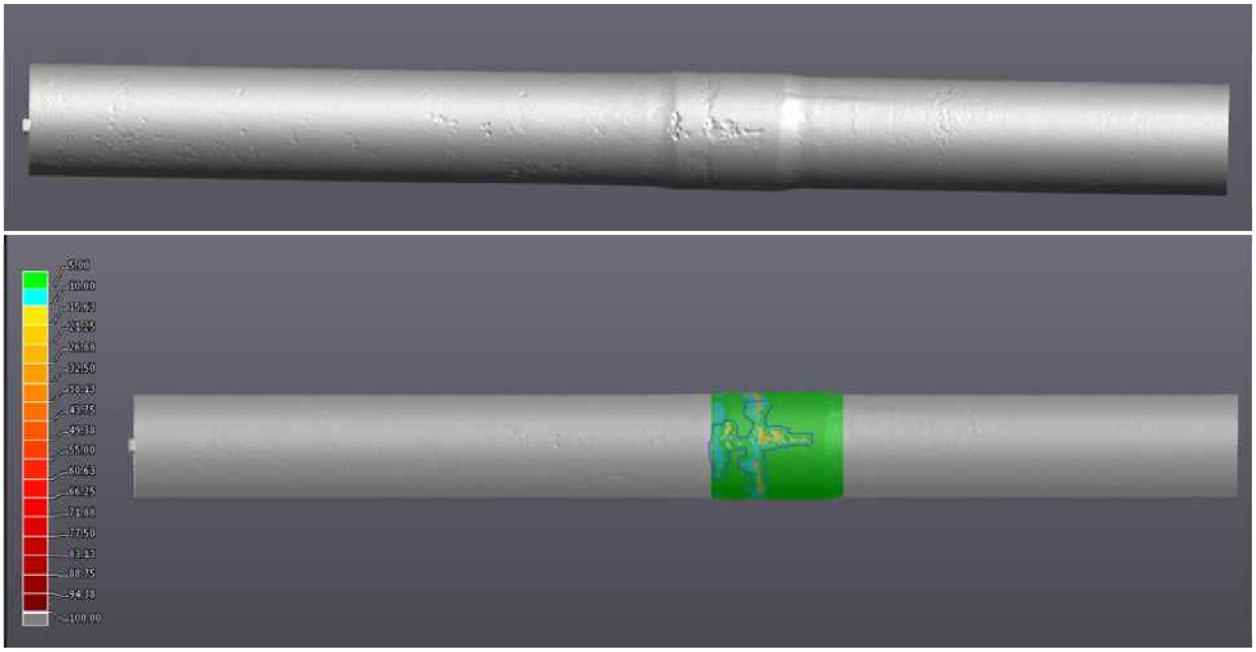


Figure 20: 3D Model and 3D Corrosion Color Map for Connection 18

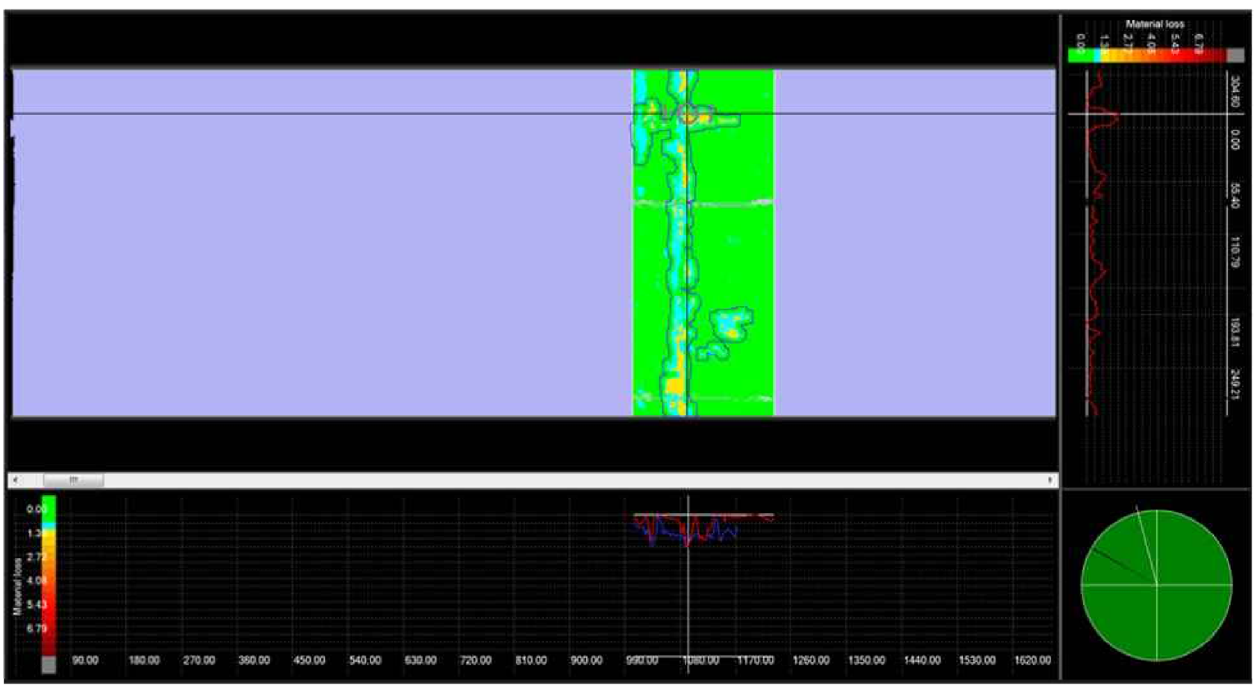


Figure 21: 2D Color Map of Corrosion Analysis Results for Connection 18

Table 2 shows some of the specifications for the Creaform HandySCAN 700 laser scanner. The resolution of the scanner is 0.0020 in. with an accuracy up to 0.0012 in. This is sufficient for identifying and measuring corrosion features. The scanner performs well when scanning general corrosion or corrosion with features that are not both narrow and deep, such as small pits. The scanner may report depths that are shallower than the actual feature when scanning narrow and deep pits. This is caused by scanner limitations due to the line-of-sight operation. The features observed on the 7 in. casing did not appear both narrow and deep, suggesting that the scan data was accurately reporting feature depths. The scanner was operated in the controlled warehouse environment. The temperature and humidity were within the operating temperature and humidity ranges.

Table 2: Creaform HandySCAN 700 Laser Scanner Specifications

Measurement Rate	480,000 measurements/s
Light Source	7 lasers crosses (+1 extra line)
Laser Class	2M (eye-safe)
Resolution	0.050 mm (0.0020 in.)
Accuracy	Up to 0.030 mm (0.0012 in.)
Operating Temperature Range	5-40°C (41-104°F)
Operating Humidity Range (Non-Condensing)	10-90%

The raw data for all the joints were exported from Creaform and combined to create a corrosion distribution for the entire extracted 7 in. casing string. The distribution is discussed and compared to logging data in the 7 in. casing failure report [4].

4.4 7 in. Connection Testing

Connection testing was conducted at the Blade warehouse to determine if any of the connections leaked gas during operation. The connection testing report [6] described the connection testing setup, procedure, and results in detail. A brief discussion of the connection testing is provided in this section as it pertains to the metallurgical investigation. The environment in the 11 3/4 in. × 7 in. annulus was important to the metallurgical investigation from a biological and chemical aspect. Gas leaking from the 7 in. × 2 7/8 in. annulus to the 11 3/4 in. × 7 in. annulus altered the 11 3/4 in. × 7 in. annulus environment, which impacted the biological and chemical interpretations.

Nitrogen gas was used to apply an internal pressure of 3,300 psi. The maximum internal pressure was based on the maximum operating pressure that the 7 in. casing was exposed to during withdrawal and injection. The internal pressure was ramped up incrementally with holds between each pressure increase. Holds were used to confirm the status of the connection at each internal pressure increment. Table 3 shows the load schedule for the connection testing, including the pressures and hold times. The internal pressure generated axial and hoop stresses. The axial stresses were generated from pressure acting on the plugs at the end of the connection. The hoop stresses were a direct consequence of the internal pressure.

Table 4 shows the nominal loads applied during the connection testing.

API RP 5C5 [7] was used as a guideline for the connection testing, as described in the connection testing report [6]. Some aspects of API RP 5C5 [7] were not incorporated into the connection protocol because the recommended practice is intended to test the performance limits of new connections. The goal of the 7 in. connection testing was to determine whether the connections leaked during normal gas storage operating conditions. A leak was defined as a quasi-steady state and repeatable volume of gas exiting the connection testing boot. This definition differs from the API RP 5C5 [7] definition because of the difference in objectives between the two testing procedures.

Table 3: Connection Test Load Schedule

Pressure (psi)	Hold Time (minutes)
500	15
1,000	5
1,500	5
2,000	5
2,500	2
3,300	240

Table 4: Connection Test Nominal Loads

Internal Pressure	3,300	psi
Axial Load	105.04	kips
Axial Stress	15,780	psi
Hoop Stress	34,790	psi
VME Stress	33,050	psi

Testing was conducted at the Blade warehouse inside of a Conex container for safety. A Blade testing system was used to execute the leak test per the load schedule (Table 4). Pressure transducers, thermocouples, strain gauges, flow meters, actuated valves, and other devices were used by the system during the connection testing. Pressure transducers monitored the pressure status of the entire system. The specimen pressure transducer monitored the specimen pressure and served as the primary feedback signal used to control the system. Thermocouples monitored temperatures throughout the system, including the specimen temperature. The specimen thermocouple was used to identify significant cooling in the event of a leak. Severe cooling of a specimen under internal pressure has a risk of catastrophic failure due to reduced ductility.

Strain gauges monitored the stress state of the connection at various locations. Strain gauges acted primarily as a safety feature by monitoring for pipe body or connection yielding, which could also lead to catastrophic failure. Flow meters were used to measure the flow rate and volume of gas that leaked through the connection. Several flow meters were used due to the range of flow rates encountered during testing. The minimum and maximum flow rates that could be measured by the flow meters were 4 SCCM and 50,000 SCCM, respectively.

A flexible boot was constructed around the OD seal using neoprene, glue, sealant, and tape. The purpose of the boot was to capture leaking gas and direct it through the flow meter. The system recorded data from all sensors, but the critical output was the instantaneous flow rate, which indicated a leak. Figure 22 shows some of the components of the connection test setup. The main components included the control box, pressure cabinet, and test stand. The control box contained the data acquisition system used to monitor and control the entire system. The pressure cabinet contained pressure transducers and valves, which controlled the flow of the nitrogen gas. The test stand was used to secure the test specimen during testing. The test stand had wooden restraints, which secured the test specimen to a table. The system contained many safety features, such as oxygen monitoring, end plug safety clamps, and end plug movement sensors.

Connection testing showed that nine of the 25 tested connections leaked. Leaking connections included C002B, C004B, C011B, C012B, C016B, C019B, C021B, C023A1C, and C025B. The highest leak rates came from C016B and C023A1C, which leaked at 1,120 SCCM (57 SCFD) and 196 SLM (9,967 SCFD), respectively. The results show that the connections did leak and contributed to the 11 3/4 in. × 7 in. annulus environment. The connection testing report [6] discusses additional tests administered to the connections, including break out and bluing. The results from the supplementary testing are not discussed in this report.

Figure 22: Connecting Test Setup

5 Status of RCA Evidence

With few exceptions, all of the evidence collected for the RCA is, at the time of this writing, stored at the Blade warehouse in Houston. This includes all of the tubing, casing, and wellhead components that were extracted from SS-25, and the casing extracted from P-34, SS-44A, P-45, and P-35. Metallurgical test samples, scale samples, and liquid samples examined at outside labs that were not consumed during analysis have been returned to the warehouse. The only evidence not stored in the warehouse is currently stored at the PS-20 site at Aliso Canyon, and consists of the following:

- Five sea containers that have been used to store the tubing string and wellhead components from SS-25A. Each of these containers is sealed with a padlock and a Blade numbered zip tie. A single common key will open each padlock, and Blade has possession of the key. Appendix A lists the contents of each of the containers. Details around the SS-25A tubulars extraction work can be found in the SS-25A TP&A and RCA Operations report [8].
- One large Conex trailer that was used to store evidence items during Phases 1–3. All of the items that Blade required for Phase 4 were removed and transported to Houston. The Conex still contains various duplicate soil and liquid samples in a refrigerator, core samples from the SS-25 boreholes, and other miscellaneous items. The Conex is locked and sealed with a padlock and a Blade numbered zip tie. Blade has possession of the Conex and padlock keys.

6 References

[1] Blade Energy Partners, "Aliso Canyon RCA: SS-25 Phase 3 Wellsite Tubulars Handling Protocol," Houston, TX, 2017.

[2] Blade Energy Partners, "Phase 3 Summary," Houston, TX, 2019.

[3] Blade Energy Partners, "Aliso Canyon RCA Phase 4 Protocol for Metallurgical Investigation of the SS-25 Failure," Houston, TX, 2018.

[4] Blade Energy Partners, "SS-25 Casing Failure Analysis," Houston, TX, 2019.

[5] Blade Energy Partners, "SS-25 Tubulars NDE Analyses," Houston, TX, 2019.

[6] Blade Energy Partners, "SS-25 7 in. Speedtite Connection Testing and 11 3/4 in. STC Assessment," Houston, TX, 2019.

[7] *Recommended Practice on Procedures for Testing Casing and Tubing Connections,* API RP 5C5, 2010.

[8] Blade Energy Partners, "SS-25A TP&A Operations Review," Houston, TX, 2019.

Appendix A Field JSNs and Cut Locations

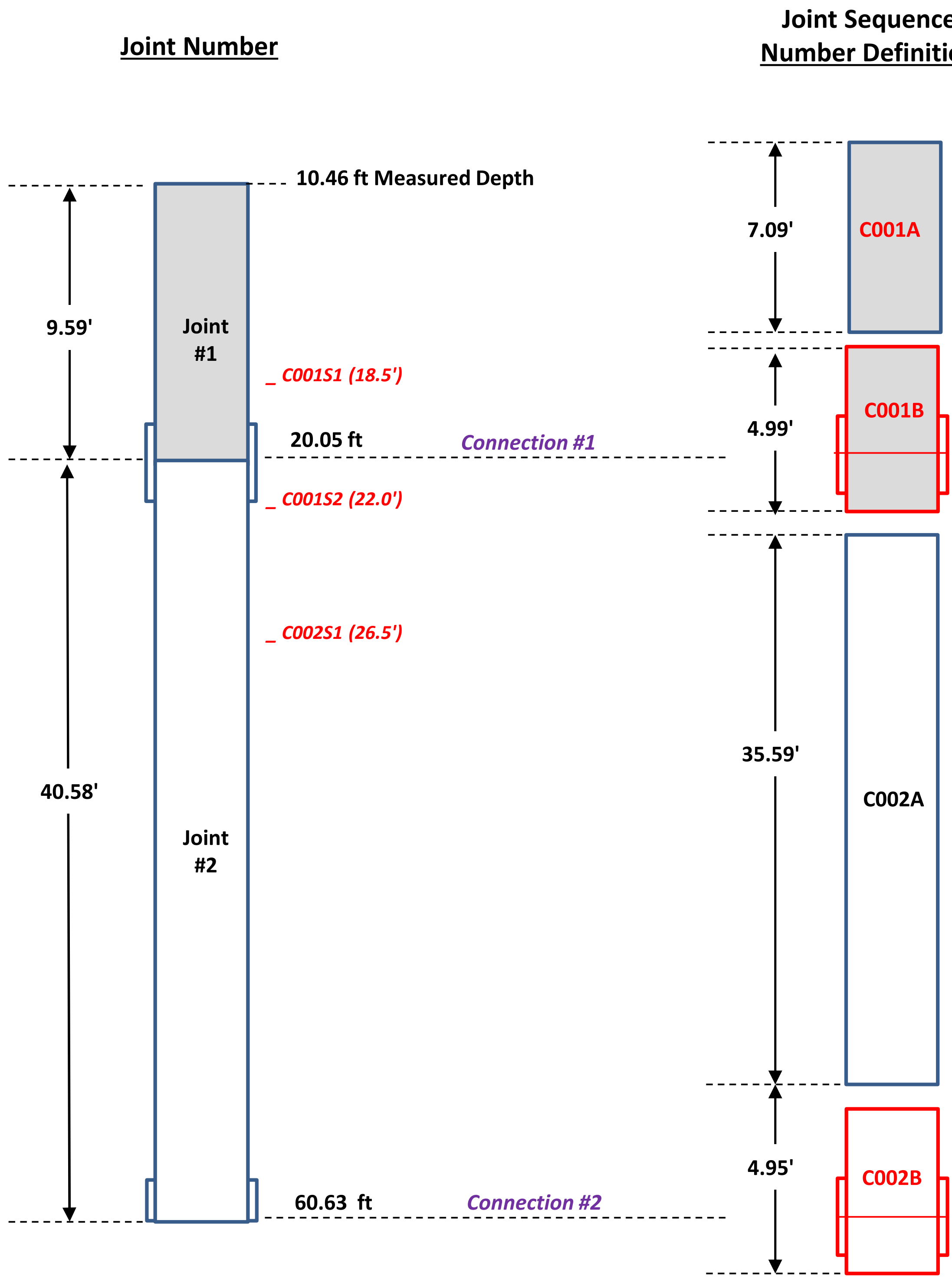
BLADE ENERGY PARTNERS

Aliso Canyon RCA
7" Casing SS-25
Joint Number to Joint Sequence Number Translation

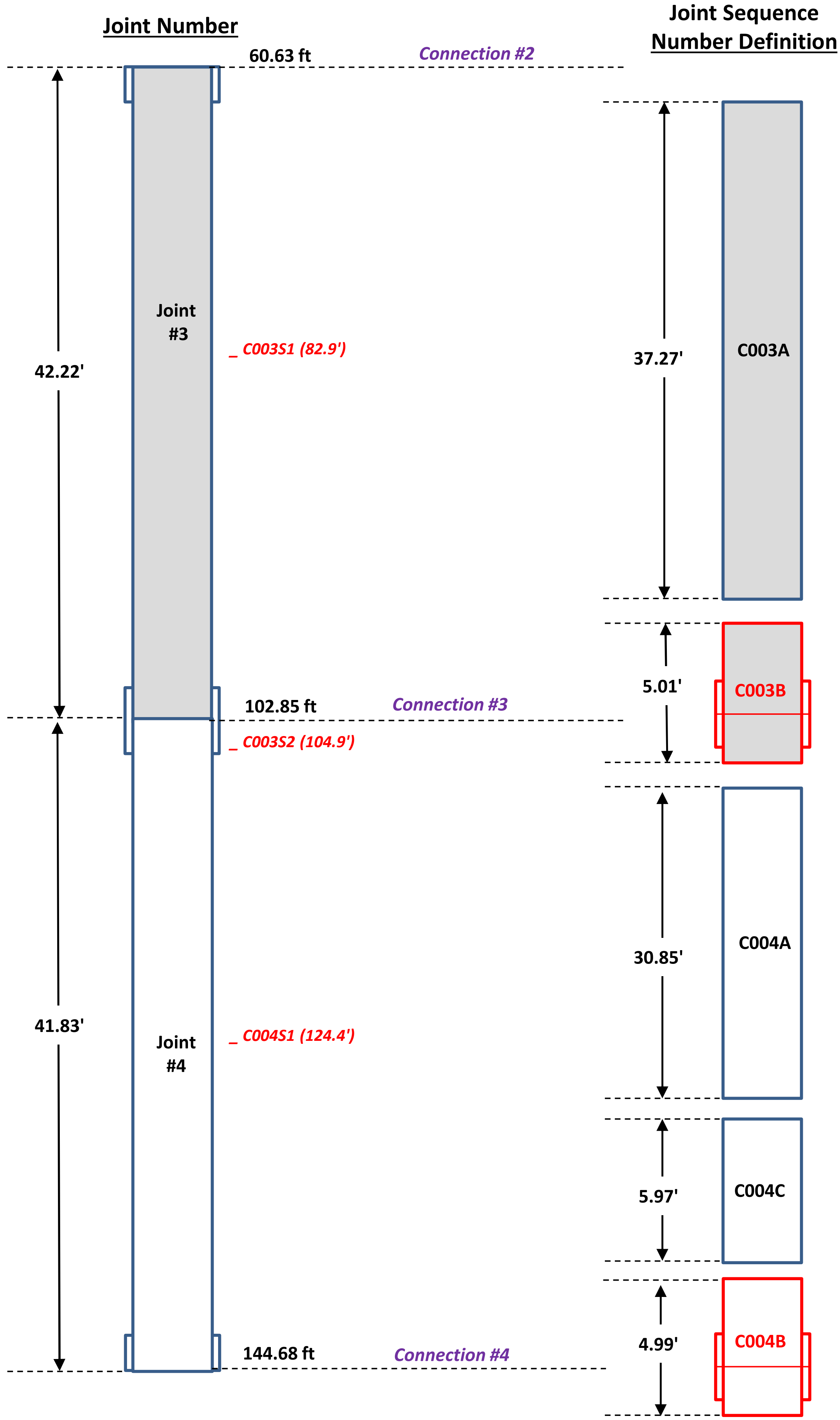
***Note**: This document provides a translation between the Joint Number (i.e. representing the location of a joint in the well), and the Joint Sequence Number (JSN) which is used for evidence traceability purposes.*

Version	Issue Date	Issued As	Author
A	12-Jan, 2018	Initial Draft	WSW
000	17-Jan, 2018	Final Version	WSW/RLR
001	26-Jan, 2018	Revised to Include Sample Depths	WSW
002	26-Sept, 2018	Revised in include last 2 jts extracted in Aug-18	WSW

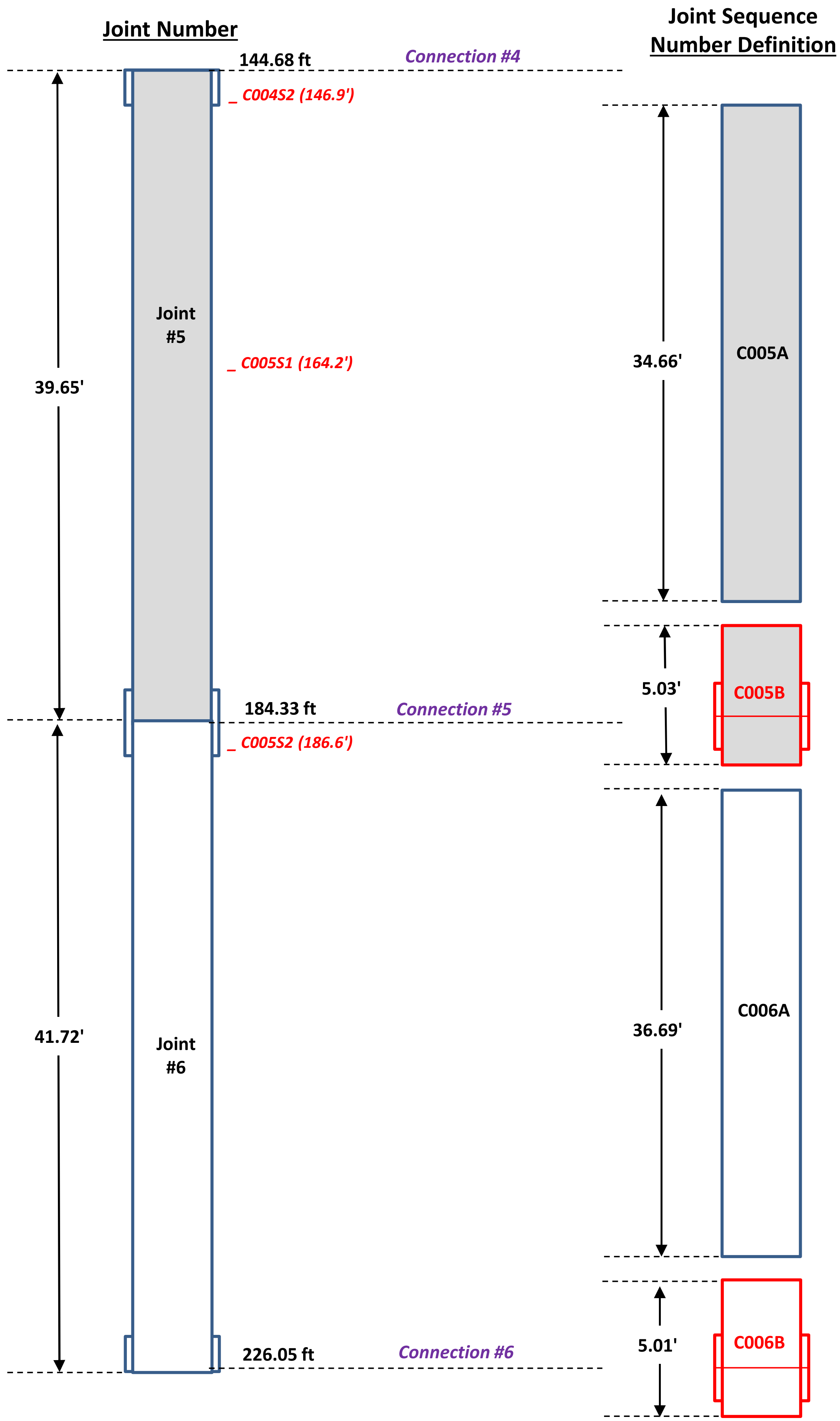
Note:
- Joint Number represents where the joints were originally located in the well.
- Joint Sequence Number represents how the joints were extracted and sectioned in the field, and is used for evidence traceability.
- *"C001S2 (18.5')"* represent the ID number of scale, etc. samples that were taken and their corresponding depths in the well.



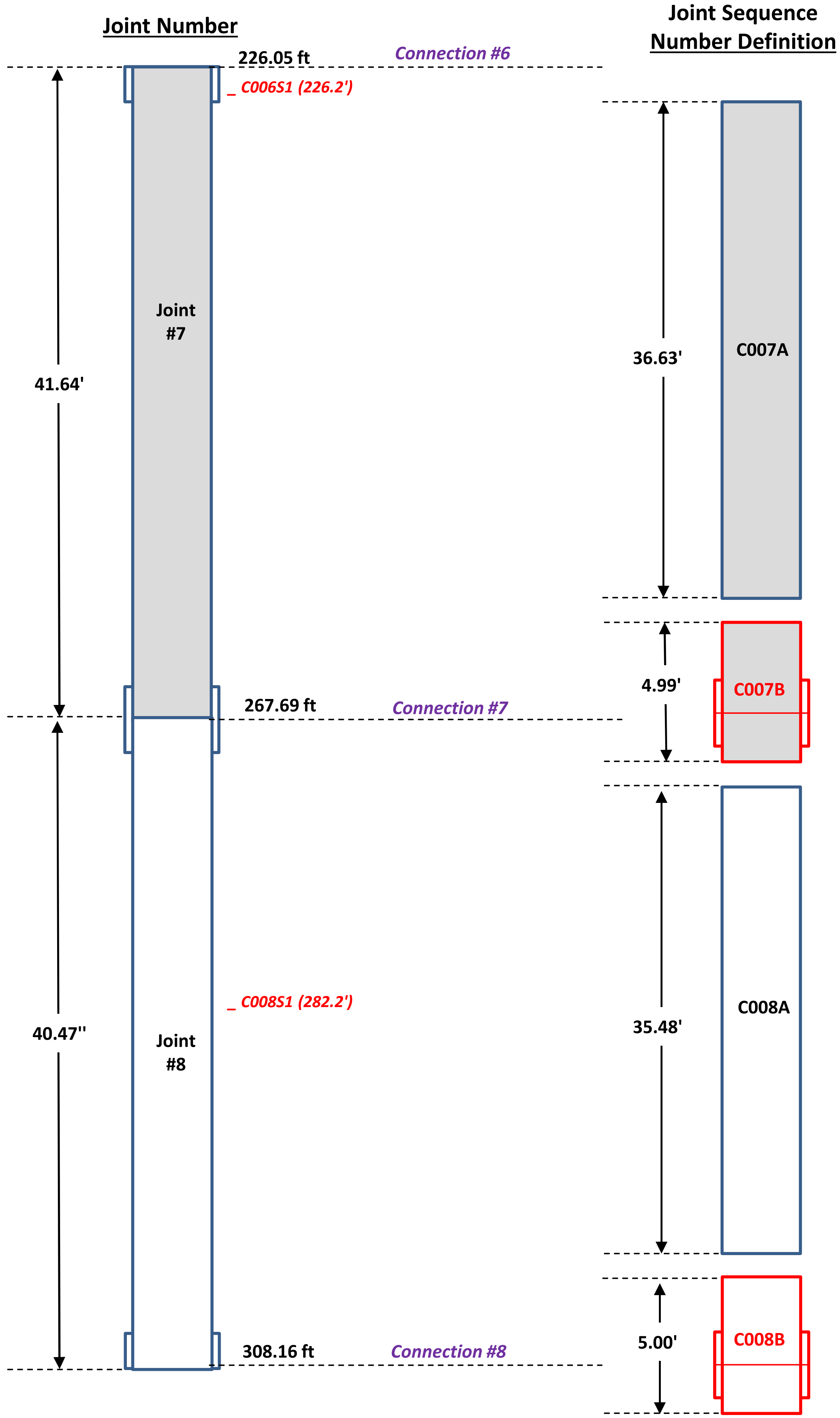
SS-25: Translation Between 7" Casing Joint Number and 7" Joint Sequence Number



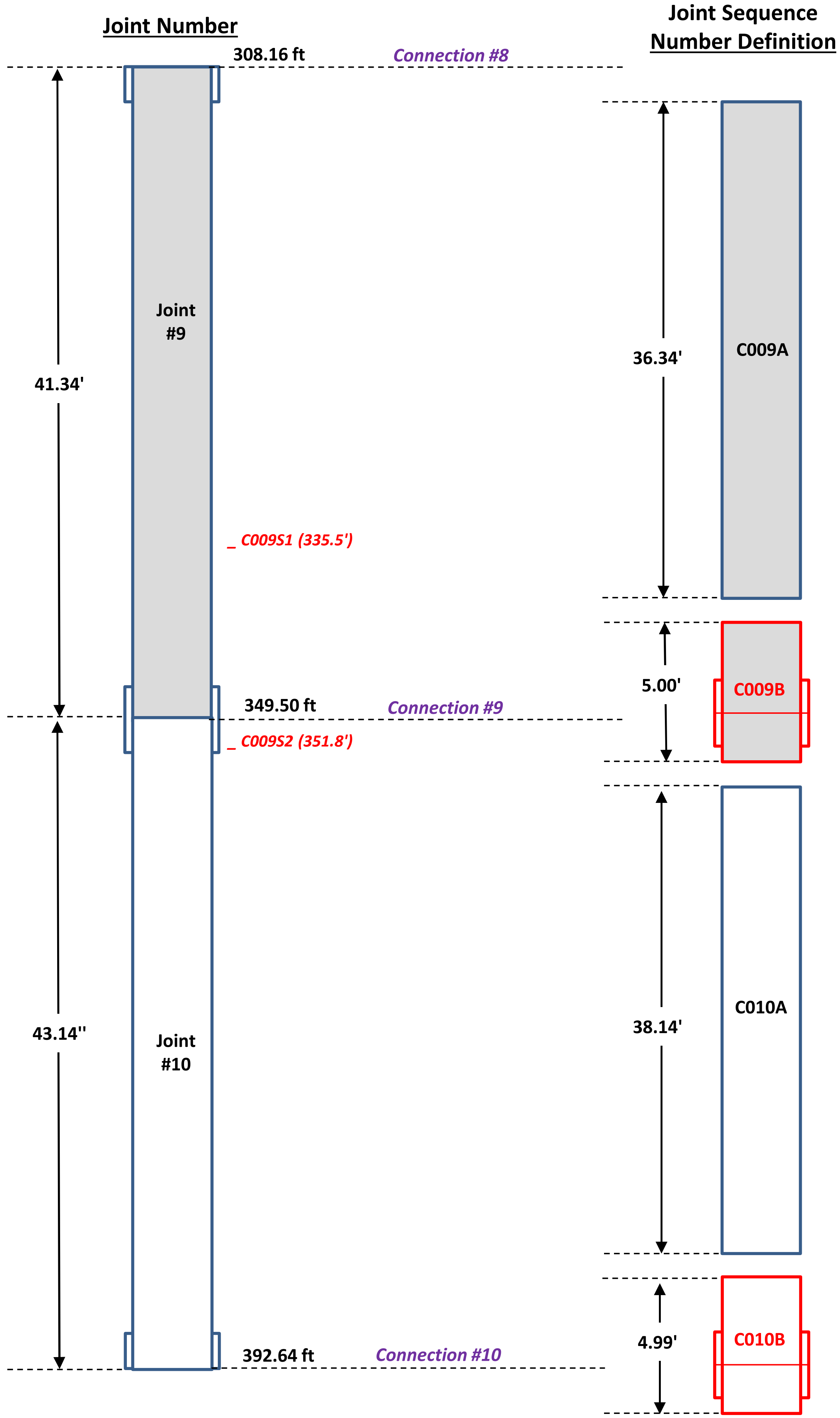
SS-25: Translation Between 7" Casing Joint Number and 7" Joint Sequence Number



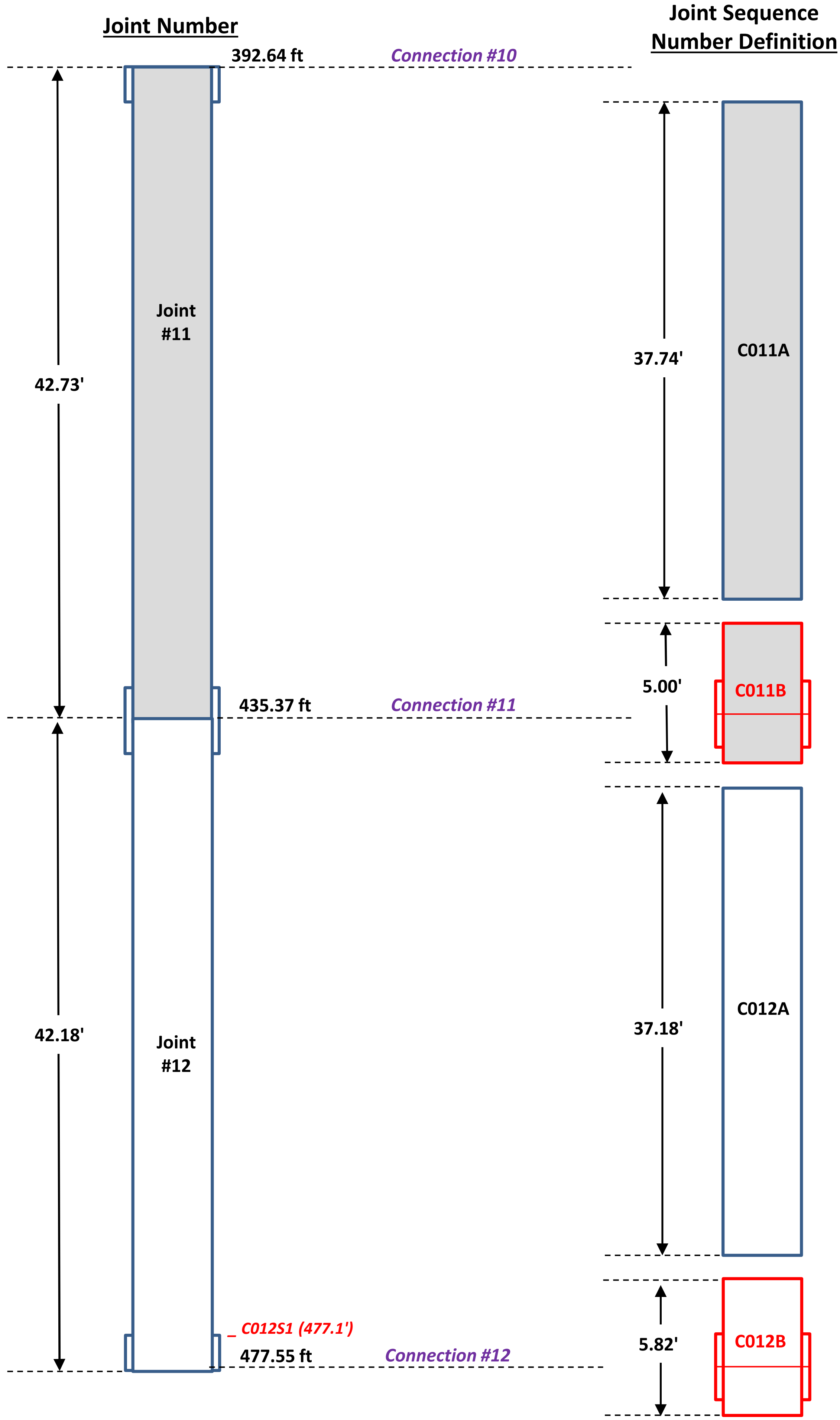
SS-25: Translation Between 7" Casing Joint Number and 7" Joint Sequence Number



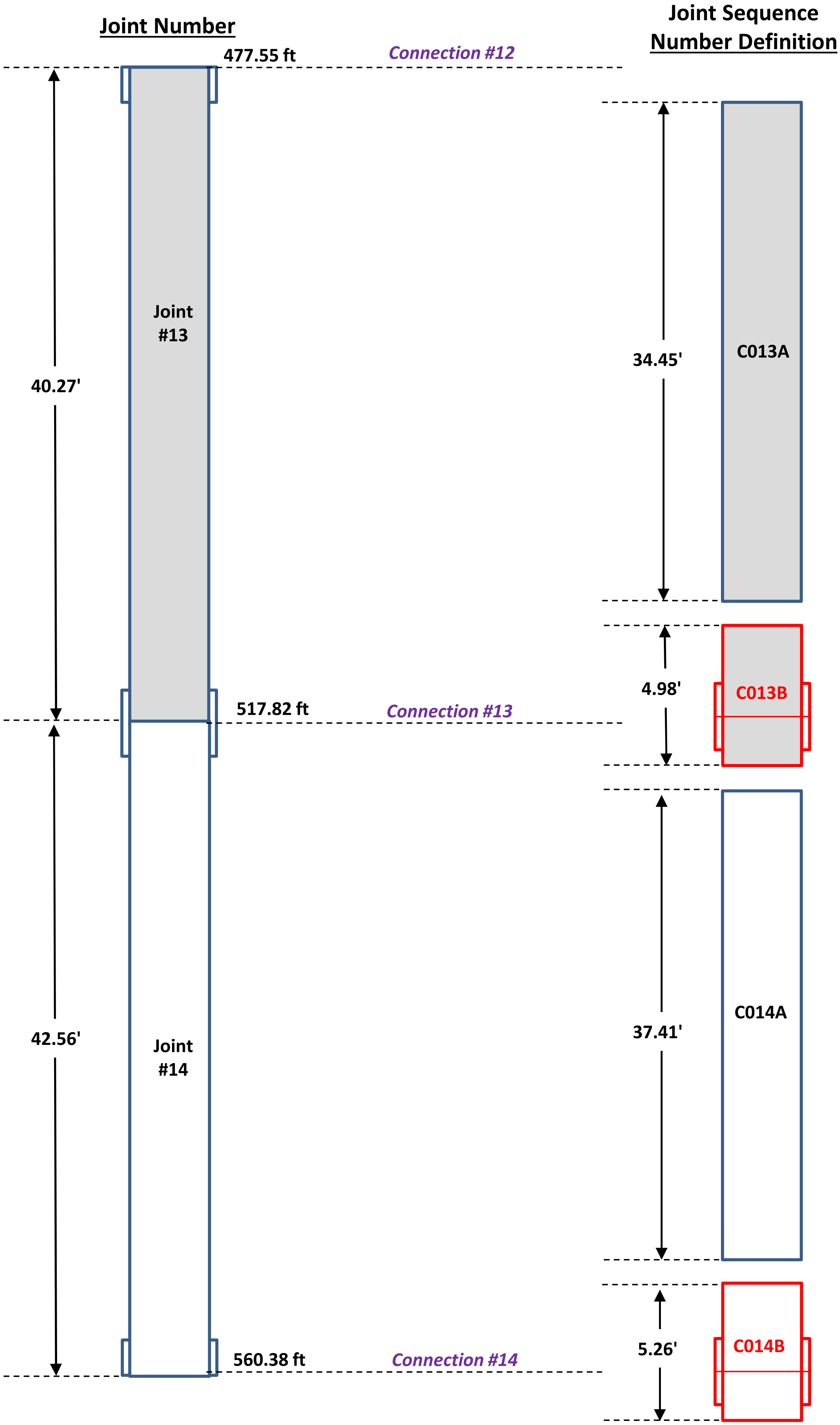
SS-25: Translation Between 7" Casing Joint Number and 7" Joint Sequence Number



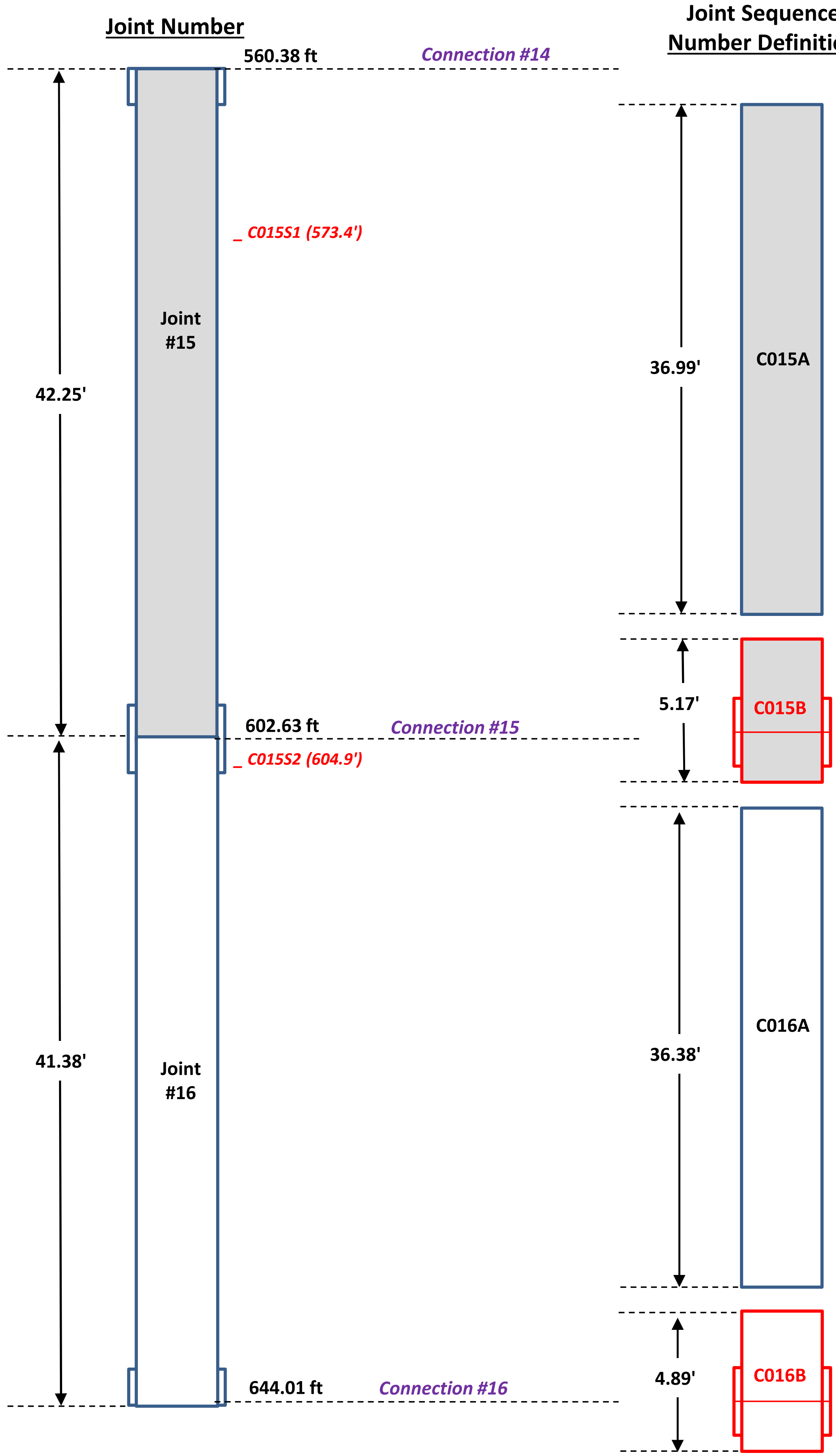
SS-25: Translation Between 7" Casing Joint Number and 7" Joint Sequence Number



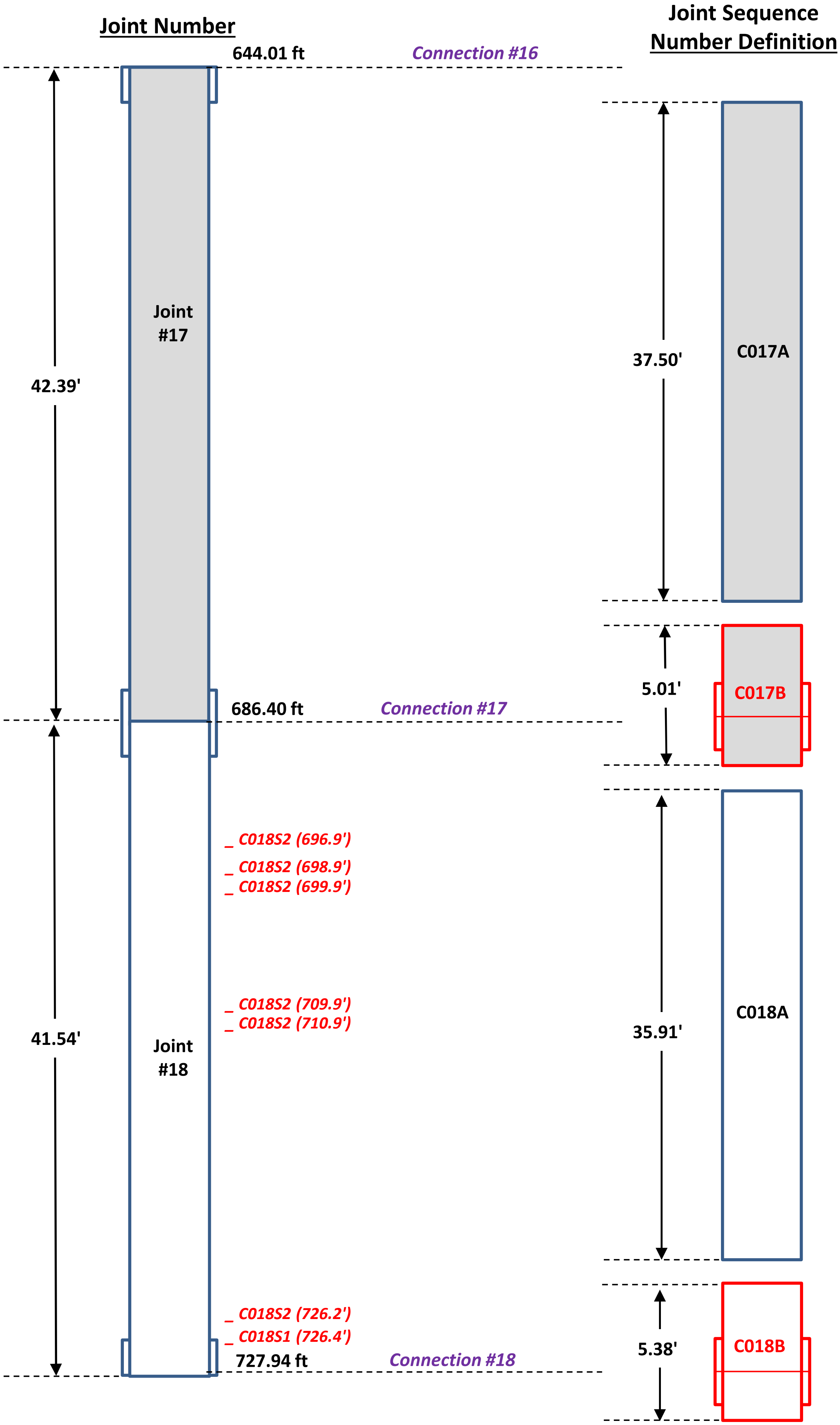
SS-25: Translation Between 7" Casing Joint Number and 7" Joint Sequence Number



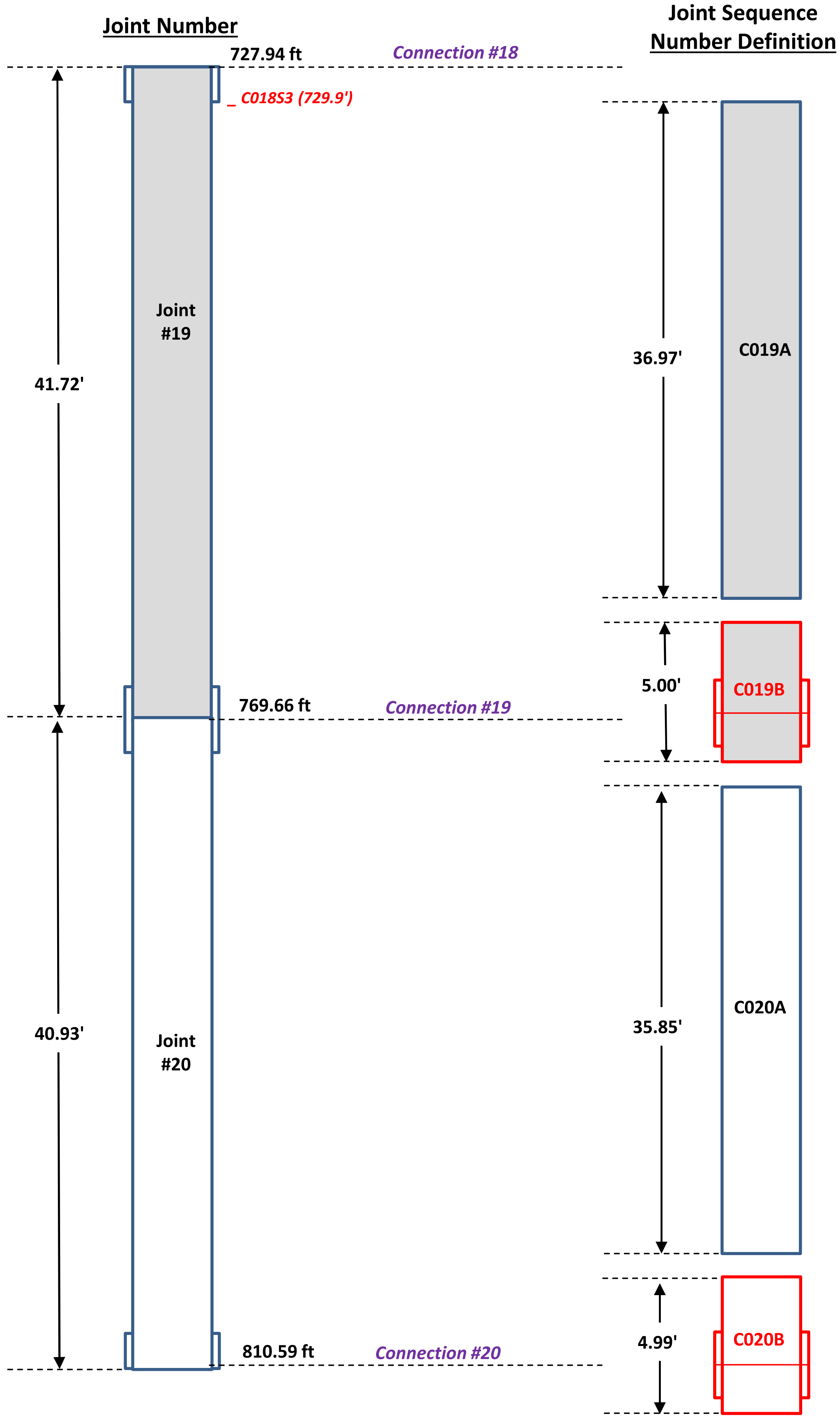
SS-25: Translation Between 7" Casing Joint Number and 7" Joint Sequence Number



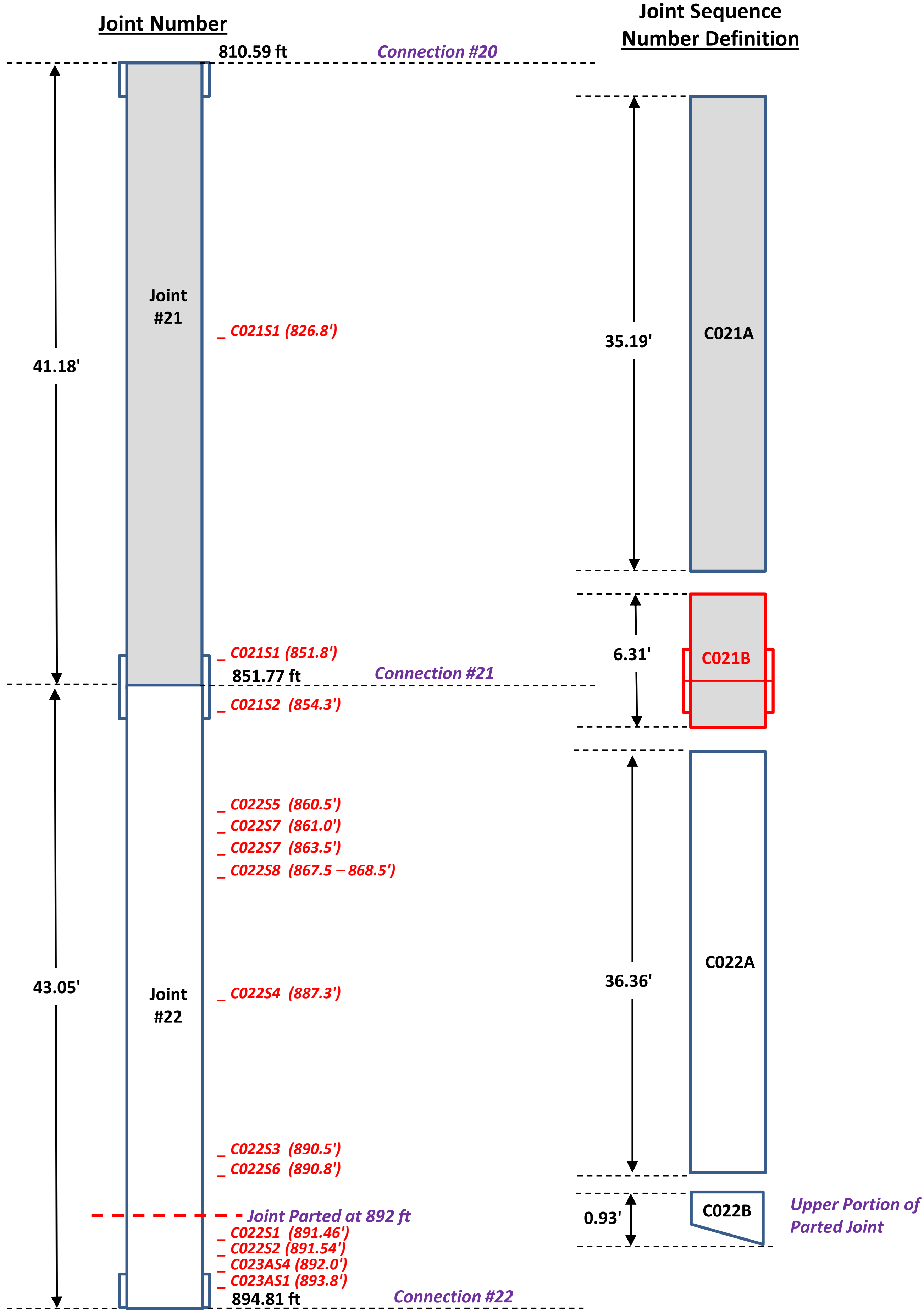
SS-25: Translation Between 7" Casing Joint Number and 7" Joint Sequence Number



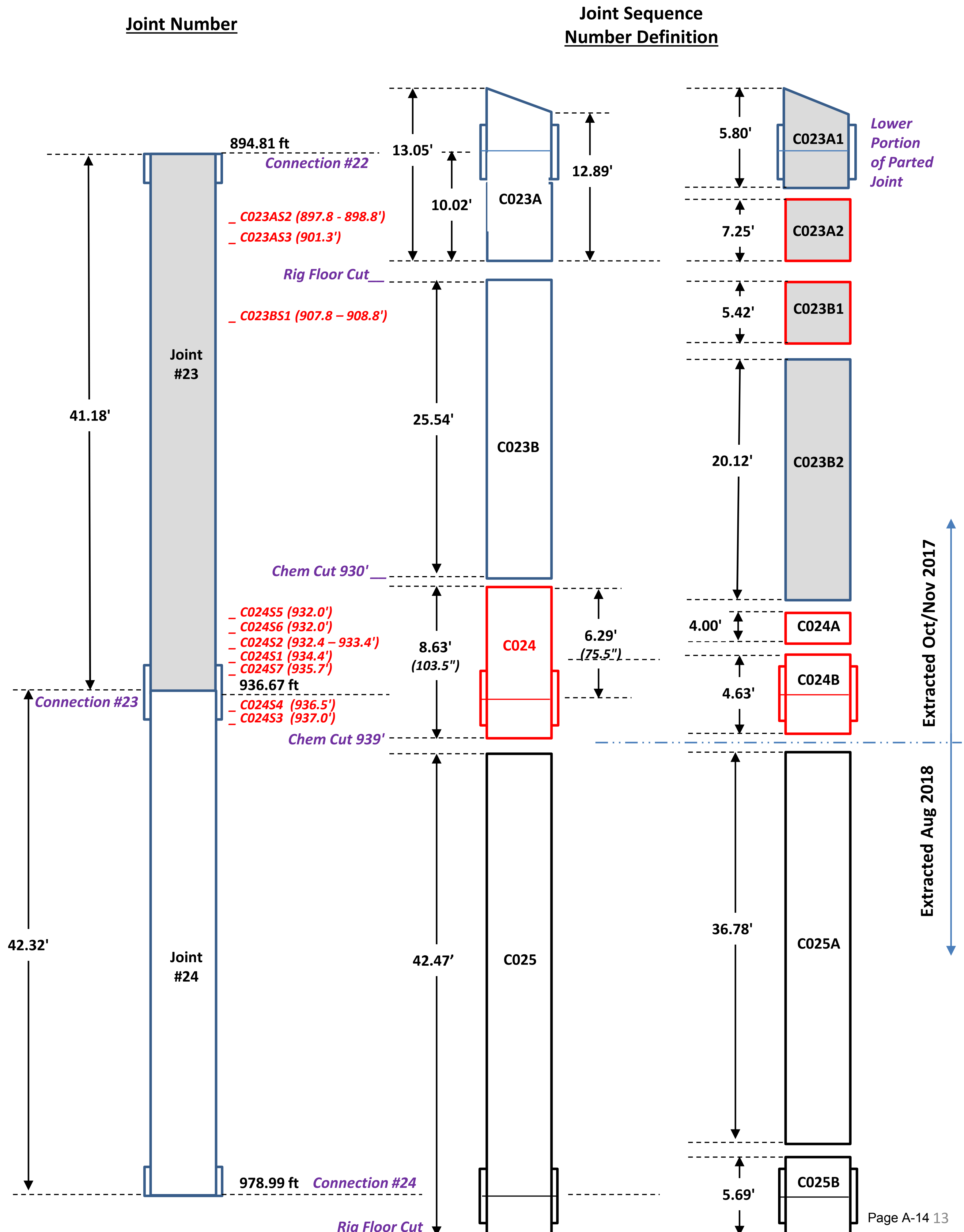
SS-25: Translation Between 7" Casing Joint Number and 7" Joint Sequence Number

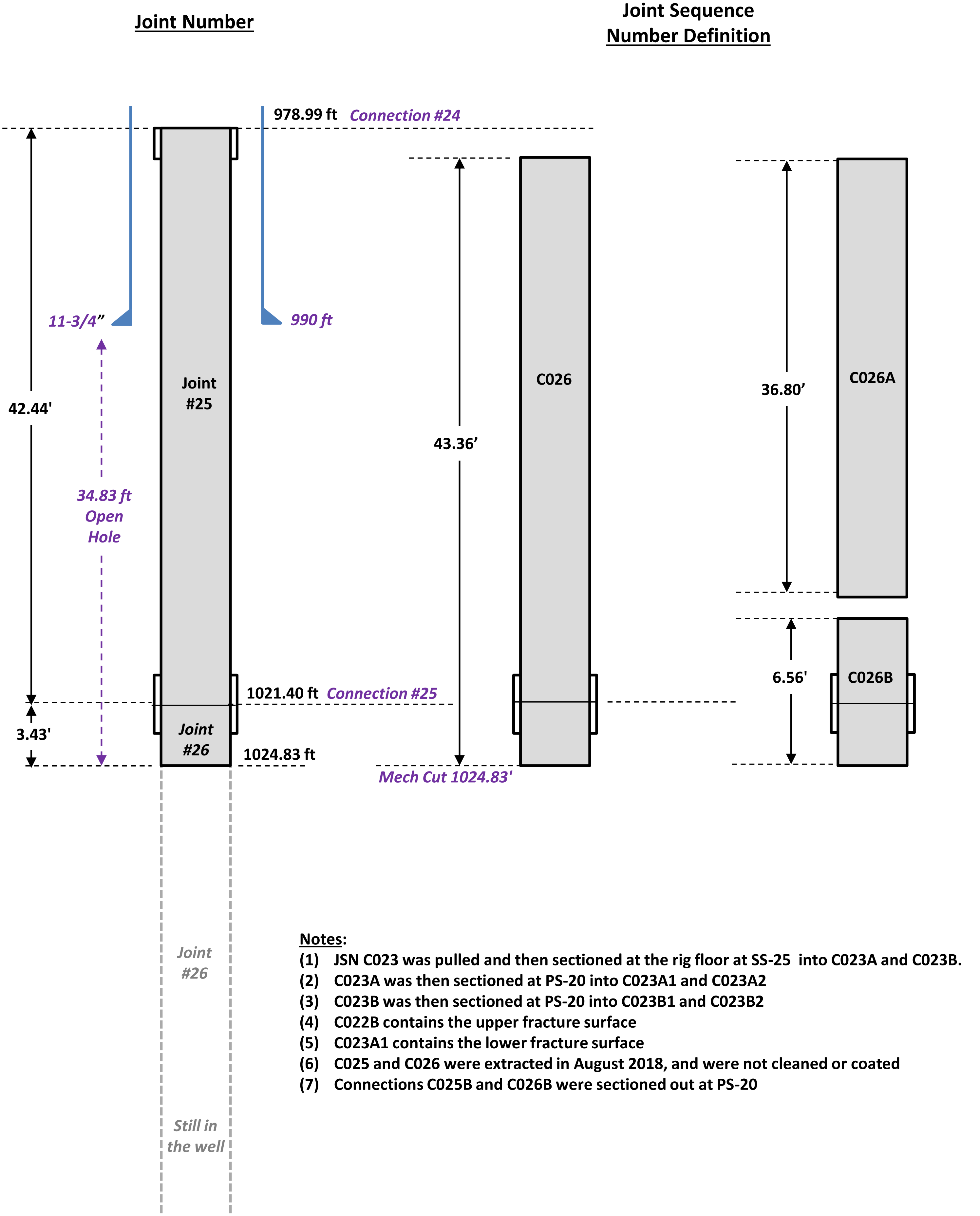


SS-25: Translation Between 7" Casing Joint Number and 7" Joint Sequence Number



SS-25: Translation Between 7" Casing Joint Number and 7" Joint Sequence Number





Notes:

(1) JSN C023 was pulled and then sectioned at the rig floor at SS-25 into C023A and C023B.
(2) C023A was then sectioned at PS-20 into C023A1 and C023A2
(3) C023B was then sectioned at PS-20 into C023B1 and C023B2
(4) C022B contains the upper fracture surface
(5) C023A1 contains the lower fracture surface
(6) C025 and C026 were extracted in August 2018, and were not cleaned or coated
(7) Connections C025B and C026B were sectioned out at PS-20

Appendix B SS-25A Tubulars Storage Detail

After cleaning and coating, the tubing was bolstered. The bolsters were placed in a sea container. The joints were individually transferred from the pipe rack to the container with a fork lift, and a pulley system was used to place the joint in the bolster. The tree components were crated and also stored in a container.

The following is a list of the contents of each bolster that were stored in each of the five sealed containers.

Container: 480702-5

JSN	Description	PS-20 Container SN
W001A	Tree Cap	480702-5 (EUSU)
W001B	Flow Cross	480702-5 (EUSU)
W001C	Manual Valve with Blind Flange	480702-5 (EUSU)
W001D	Actuated Valve with Blind Flange	480702-5 (EUSU)
W001E	Manual Valve	480702-5 (EUSU)
W001F	Master Valve	480702-5 (EUSU)
W001G	Tubing Head Adaptor	480702-5 (EUSU)
W002	Tubing Hanger with Pup Joint	480702-5 (EUSU)

Container: 900439-8

JSN	Description			Tally	Joint	Bolster	PS-20 Container SN
	OD	Wt/ft	Grade	Length	Weight	Number	
T002	5.5	20	N80	39.52	790.4	1 of 2	900439-8 (IRNU)
T003	5.5	20	N80	38.61	772.2	1 of 2	900439-8 (IRNU)
T004	5.5	20	N80	36.88	737.6	1 of 2	900439-8 (IRNU)
T005	5.5	20	N80	38.50	770.0	1 of 2	900439-8 (IRNU)
T006	5.5	20	N80	38.79	775.8	1 of 2	900439-8 (IRNU)
T007	5.5	20	N80	38.72	774.4	1 of 2	900439-8 (IRNU)
T008	5.5	20	N80	37.71	754.2	1 of 2	900439-8 (IRNU)
T009	5.5	20	N80	37.52	750.4	1 of 2	900439-8 (IRNU)
T010	5.5	20	N80	38.45	769.0	1 of 2	900439-8 (IRNU)
T011	5.5	20	N80	38.80	776.0	1 of 2	900439-8 (IRNU)
T012	5.5	20	N80	37.71	754.2	1 of 2	900439-8 (IRNU)
T013	5.5	20	N80	37.60	752.0	1 of 2	900439-8 (IRNU)
T014	5.5	20	N80	36.89	737.8	1 of 2	900439-8 (IRNU)
T015	5.5	20	N80	38.23	764.6	1 of 2	900439-8 (IRNU)
T016	5.5	20	N80	37.15	743.0	1 of 2	900439-8 (IRNU)
T017	5.5	20	N80	37.65	753.0	1 of 2	900439-8 (IRNU)
				Bolster Weight =	12,175 lb		

JSN	Description			Tally	Joint	Bolster	PS-20 Container SN
	OD	Wt/ft	Grade	Length	Weight	Number	
T018	5.5	20	N80	36.38	727.6	2 of 2	900439-8 (IRNU)
T019	5.5	20	N80	38.70	774.0	2 of 2	900439-8 (IRNU)
T020	5.5	20	N80	43.48	869.6	2 of 2	900439-8 (IRNU)
T021	5.5	20	N80	37.46	749.2	2 of 2	900439-8 (IRNU)
T022	5.5	20	N80	37.38	747.6	2 of 2	900439-8 (IRNU)
T023	5.5	20	N80	38.31	766.2	2 of 2	900439-8 (IRNU)
T024	5.5	20	N80	44.05	881.0	2 of 2	900439-8 (IRNU)
T025	5.5	20	N80	38.20	764.0	2 of 2	900439-8 (IRNU)
T026	5.5	20	N80	38.10	762.0	2 of 2	900439-8 (IRNU)
T027	5.5	20	N80	39.40	788.0	2 of 2	900439-8 (IRNU)
T028	5.5	20	N80	42.15	843.0	2 of 2	900439-8 (IRNU)
T029	5.5	20	N80	39.83	796.6	2 of 2	900439-8 (IRNU)
T030	5.5	20	N80	39.75	795.0	2 of 2	900439-8 (IRNU)
T031	5.5	20	N80	40.77	815.4	2 of 2	900439-8 (IRNU)
T032	5.5	20	N80	39.29	785.8	2 of 2	900439-8 (IRNU)
T033	5.5	20	N80	39.06	781.2	2 of 2	900439-8 (IRNU)
				Bolster Weight =	12,646 lb		

Container: 482291-9

JSN	Description			Tally	Joint	Bolster	PS-20 Container SN
	OD	Wt/ft	Grade	Length	Weight	Number	
T034	5.5	20	N80	41.88	837.6	**1 of 4**	482291-9 (UESU)
T035	5.5	20	N80	38.74	774.8	1 of 4	482291-9 (UESU)
T036	5.5	20	N80	40.08	801.6	1 of 4	482291-9 (UESU)
T037	5.5	20	N80	39.18	783.6	1 of 4	482291-9 (UESU)
T038	5.5	20	N80	35.63	712.6	1 of 4	482291-9 (UESU)
T039	5.5	20	N80	38.29	765.8	1 of 4	482291-9 (UESU)
T040	5.5	20	N80	38.30	766.0	1 of 4	482291-9 (UESU)
T041	5.5	20	N80	38.78	775.6	1 of 4	482291-9 (UESU)
T042	5.5	20	N80	36.93	738.6	1 of 4	482291-9 (UESU)
T043	5.5	20	N80	42.00	840.0	1 of 4	482291-9 (UESU)
T044	5.5	20	N80	38.35	767.0	1 of 4	482291-9 (UESU)
T045	5.5	20	N80	38.79	775.8	1 of 4	482291-9 (UESU)
T046	5.5	20	N80	38.28	765.6	1 of 4	482291-9 (UESU)
T047	5.5	20	N80	38.73	774.6	1 of 4	482291-9 (UESU)
T048	5.5	20	N80	38.72	774.4	1 of 4	482291-9 (UESU)
T049	5.5	20	N80	38.45	769.0	1 of 4	482291-9 (UESU)
				Bolster Weight =	**12,423**	**lb**	
T066	5.5	20	N80	38.53	770.6	**3 of 4**	482291-9 (UESU)
T067	5.5	20	N80	38.51	770.2	3 of 4	482291-9 (UESU)
T068	5.5	20	N80	38.42	768.4	3 of 4	482291-9 (UESU)
T069	5.5	20	N80	36.94	738.8	3 of 4	482291-9 (UESU)
T070	5.5	20	N80	38.73	774.6	3 of 4	482291-9 (UESU)
T071	5.5	20	N80	38.76	775.2	3 of 4	482291-9 (UESU)
T072	5.5	20	N80	37.36	747.2	3 of 4	482291-9 (UESU)
T073	5.5	20	N80	37.35	747.0	3 of 4	482291-9 (UESU)
T074	5.5	20	N80	38.94	778.8	3 of 4	482291-9 (UESU)
T075	5.5	20	N80	38.31	766.2	3 of 4	482291-9 (UESU)
T076	5.5	20	N80	37.99	759.8	3 of 4	482291-9 (UESU)
T077	5.5	20	N80	38.61	772.2	3 of 4	482291-9 (UESU)
T078	5.5	20	N80	39.00	780.0	3 of 4	482291-9 (UESU)
T079	5.5	20	N80	38.14	762.8	3 of 4	482291-9 (UESU)
T080	5.5	20	N80	37.16	743.2	3 of 4	482291-9 (UESU)
T081	5.5	20	N80	42.67	853.4	3 of 4	482291-9 (UESU)
				Bolster Weight =	**12,308**	**lb**	

JSN	Description			Tally	Joint	Bolster	PS-20 Container SN
	OD	Wt/ft	Grade	Length	Weight	Number	
T050	5.5	20	N80	38.66	773.2	**2 of 4**	482291-9 (UESU)
T051	5.5	20	N80	37.90	758.0	2 of 4	482291-9 (UESU)
T052	5.5	20	N80	38.79	775.8	2 of 4	482291-9 (UESU)
T053	5.5	20	N80	38.69	773.8	2 of 4	482291-9 (UESU)
T054	5.5	20	N80	38.73	774.6	2 of 4	482291-9 (UESU)
T055	5.5	20	N80	38.80	776.0	2 of 4	482291-9 (UESU)
T056	5.5	20	N80	38.19	763.8	2 of 4	482291-9 (UESU)
T057	5.5	20	N80	37.15	743.0	2 of 4	482291-9 (UESU)
T058	5.5	20	N80	38.57	771.4	2 of 4	482291-9 (UESU)
T059	5.5	20	N80	38.32	766.4	2 of 4	482291-9 (UESU)
T060	5.5	20	N80	38.45	769.0	2 of 4	482291-9 (UESU)
T061	5.5	20	N80	38.62	772.4	2 of 4	482291-9 (UESU)
T062	5.5	20	N80	38.01	760.2	2 of 4	482291-9 (UESU)
T063	5.5	20	N80	38.55	771.0	2 of 4	482291-9 (UESU)
T064	5.5	20	N80	37.26	745.2	2 of 4	482291-9 (UESU)
T065	5.5	20	N80	38.52	770.4	2 of 4	482291-9 (UESU)
				Bolster Weight =	**12,264**	**lb**	
T082	5.5	20	N80	37.91	758.2	**4 of 4**	482291-9 (UESU)
T083	5.5	20	N80	38.89	777.8	4 of 4	482291-9 (UESU)
T084	5.5	20	N80	38.18	763.6	4 of 4	482291-9 (UESU)
T085	5.5	20	N80	34.72	694.4	4 of 4	482291-9 (UESU)
T086	5.5	20	N80	37.95	759.0	4 of 4	482291-9 (UESU)
T087	5.5	20	N80	38.63	772.6	4 of 4	482291-9 (UESU)
T088	5.5	20	N80	37.52	750.4	4 of 4	482291-9 (UESU)
T089	5.5	20	N80	39.99	799.8	4 of 4	482291-9 (UESU)
T090	5.5	20	N80	38.32	766.4	4 of 4	482291-9 (UESU)
T091	5.5	20	N80	41.56	831.2	4 of 4	482291-9 (UESU)
T092	5.5	20	N80	36.15	723.0	4 of 4	482291-9 (UESU)
T093	5.5	20	N80	39.89	797.8	4 of 4	482291-9 (UESU)
T094	5.5	20	N80	40.26	805.2	4 of 4	482291-9 (UESU)
T095	5.5	20	N80	40.31	806.2	4 of 4	482291-9 (UESU)
T096	5.5	20	N80	37.51	750.2	4 of 4	482291-9 (UESU)
T097	5.5	20	N80	40.71	814.2	4 of 4	482291-9 (UESU)
				Bolster Weight =	**12,370**	**lb**	

Container: 482393-6

JSN	Description			Tally	Joint	Bolster	PS-20 Container SN	JSN	Description			Tally	Joint	Bolster	PS-20 Container SN
	OD	Wt/ft	Grade	Length	Weight	Number			OD	Wt/ft	Grade	Length	Weight	Number	
T098	5.5	20	N80	41.64	832.8	1 of 4	482393-6 (UESU)	T114	5.5	20	N80	38.49	769.8	2 of 4	482393-6 (UESU)
T099	5.5	20	N80	42.36	847.2	1 of 4	482393-6 (UESU)	T115	5.5	20	N80	36.71	734.2	2 of 4	482393-6 (UESU)
T100	5.5	20	N80	38.66	773.2	1 of 4	482393-6 (UESU)	T116	5.5	20	N80	37.20	744.0	2 of 4	482393-6 (UESU)
T101	5.5	20	N80	38.73	774.6	1 of 4	482393-6 (UESU)	T117	5.5	20	N80	38.47	769.4	2 of 4	482393-6 (UESU)
T102	5.5	20	N80	38.75	775.0	1 of 4	482393-6 (UESU)	T118	5.5	20	N80	38.53	770.6	2 of 4	482393-6 (UESU)
T103	5.5	20	N80	38.74	774.8	1 of 4	482393-6 (UESU)	T119	5.5	20	N80	38.50	770.0	2 of 4	482393-6 (UESU)
T104	5.5	20	N80	38.65	773.0	1 of 4	482393-6 (UESU)	T120	5.5	20	N80	36.05	721.0	2 of 4	482393-6 (UESU)
T105	5.5	20	N80	38.77	775.4	1 of 4	482393-6 (UESU)	T121	5.5	20	N80	40.78	815.6	2 of 4	482393-6 (UESU)
T106	5.5	20	N80	38.79	775.8	1 of 4	482393-6 (UESU)	T122	5.5	20	N80	38.79	775.8	2 of 4	482393-6 (UESU)
T107	5.5	20	N80	38.81	776.2	1 of 4	482393-6 (UESU)	T123	5.5	20	N80	38.74	774.8	2 of 4	482393-6 (UESU)
T108	5.5	20	N80	37.84	756.8	1 of 4	482393-6 (UESU)	T124	5.5	20	N80	37.49	749.8	2 of 4	482393-6 (UESU)
T109	5.5	20	N80	38.69	773.8	1 of 4	482393-6 (UESU)	T125	5.5	20	N80	38.12	762.4	2 of 4	482393-6 (UESU)
T110	5.5	20	N80	39.06	781.2	1 of 4	482393-6 (UESU)	T126	5.5	20	N80	40.04	800.8	2 of 4	482393-6 (UESU)
T111	5.5	20	N80	38.48	769.6	1 of 4	482393-6 (UESU)	T127	5.5	20	N80	40.89	817.8	2 of 4	482393-6 (UESU)
T112	5.5	20	N80	38.79	775.8	1 of 4	482393-6 (UESU)	T128	5.5	20	N80	42.33	846.6	2 of 4	482393-6 (UESU)
T113	5.5	20	N80	38.72	774.4	1 of 4	482393-6 (UESU)	T129	5.5	20	N80	38.38	767.6	2 of 4	482393-6 (UESU)
				Bolster Weight =	12,510 lb							Bolster Weight =	12,390 lb		
T130	5.5	20	N80	38.99	779.8	3 of 4	482393-6 (UESU)	T146	5.5	20	N80	38.01	760.2	4 of 4	482393-6 (UESU)
T131	5.5	20	N80	38.48	769.6	3 of 4	482393-6 (UESU)	T147	5.5	20	N80	38.79	775.8	4 of 4	482393-6 (UESU)
T132	5.5	20	N80	38.45	769.0	3 of 4	482393-6 (UESU)	T148	5.5	20	N80	37.99	759.8	4 of 4	482393-6 (UESU)
T133	5.5	20	N80	38.79	775.8	3 of 4	482393-6 (UESU)	T149	5.5	20	N80	38.70	774.0	4 of 4	482393-6 (UESU)
T134	5.5	20	N80	43.11	862.2	3 of 4	482393-6 (UESU)	T150	5.5	20	N80	36.65	733.0	4 of 4	482393-6 (UESU)
T135	5.5	20	N80	38.88	777.6	3 of 4	482393-6 (UESU)	T151	5.5	20	N80	38.77	775.4	4 of 4	482393-6 (UESU)
T136	5.5	20	N80	36.61	732.2	3 of 4	482393-6 (UESU)	T152	5.5	20	N80	36.75	735.0	4 of 4	482393-6 (UESU)
T137	5.5	20	N80	42.32	846.4	3 of 4	482393-6 (UESU)	T153	5.5	20	N80	36.99	739.8	4 of 4	482393-6 (UESU)
T138	5.5	20	N80	42.61	852.2	3 of 4	482393-6 (UESU)	T154	5.5	20	N80	38.42	768.4	4 of 4	482393-6 (UESU)
T139	5.5	20	N80	38.10	762.0	3 of 4	482393-6 (UESU)	T155	5.5	20	N80	35.96	719.2	4 of 4	482393-6 (UESU)
T140	5.5	20	N80	37.85	757.0	3 of 4	482393-6 (UESU)	T156	5.5	20	N80	37.10	742.0	4 of 4	482393-6 (UESU)
T141	5.5	20	N80	37.65	753.0	3 of 4	482393-6 (UESU)	T157	5.5	20	N80	38.56	771.2	4 of 4	482393-6 (UESU)
T142	5.5	20	N80	37.51	750.2	3 of 4	482393-6 (UESU)	T158	5.5	20	N80	38.78	775.6	4 of 4	482393-6 (UESU)
T143	5.5	20	N80	38.60	772.0	3 of 4	482393-6 (UESU)	T159	5.5	20	N80	38.75	775.0	4 of 4	482393-6 (UESU)
T144	5.5	20	N80	38.59	771.8	3 of 4	482393-6 (UESU)	T160	5.5	20	N80	38.72	774.4	4 of 4	482393-6 (UESU)
T145	5.5	20	N80	35.73	714.6	3 of 4	482393-6 (UESU)	T161	5.5	20	N80	38.41	768.2	4 of 4	482393-6 (UESU)
				Bolster Weight =	12,445 lb							Bolster Weight =	12,147 lb		

Container: 482271-3

JSN	Description			Tally	Joint	Bolster	PS-20 Container SN
	OD	Wt/ft	Grade	Length	Weight	Number	
T162	5.5	20	N80	37.88	757.6	**1 of 4**	482271-3 (UESU)
T163	5.5	20	N80	42.13	842.6	1 of 4	482271-3 (UESU)
T164	5.5	20	N80	40.05	801.0	1 of 4	482271-3 (UESU)
T165	5.5	20	N80	34.68	693.6	1 of 4	482271-3 (UESU)
T166	5.5	20	N80	40.65	813.0	1 of 4	482271-3 (UESU)
T167	5.5	20	N80	38.41	768.2	1 of 4	482271-3 (UESU)
T168	5.5	20	N80	38.72	774.4	1 of 4	482271-3 (UESU)
T169	5.5	20	N80	37.98	759.6	1 of 4	482271-3 (UESU)
T170	5.5	20	N80	38.70	774.0	1 of 4	482271-3 (UESU)
T171	5.5	20	N80	38.72	774.4	1 of 4	482271-3 (UESU)
T172	5.5	20	N80	38.67	773.4	1 of 4	482271-3 (UESU)
T173	5.5	20	N80	38.50	770.0	1 of 4	482271-3 (UESU)
T174	5.5	20	N80	42.06	841.2	1 of 4	482271-3 (UESU)
T175	5.5	20	N80	36.11	722.2	1 of 4	482271-3 (UESU)
T176	5.5	20	N80	37.66	753.2	1 of 4	482271-3 (UESU)
T177	5.5	20	N80	37.69	753.8	1 of 4	482271-3 (UESU)
				Bolster Weight =	**12,372 lb**		
T194	5.5	20	N80	38.78	775.6	**3 of 4**	482271-3 (UESU)
T195	5.5	20	N80	38.76	775.2	3 of 4	482271-3 (UESU)
T196	5.5	20	N80	38.32	766.4	3 of 4	482271-3 (UESU)
T197	5.5	20	N80	38.75	775.0	3 of 4	482271-3 (UESU)
T198	5.5	20	N80	38.65	773.0	3 of 4	482271-3 (UESU)
T199	5.5	20	N80	38.24	764.8	3 of 4	482271-3 (UESU)
T200	5.5	20	N80	38.15	763.0	3 of 4	482271-3 (UESU)
T201	5.5	20	N80	42.20	844.0	3 of 4	482271-3 (UESU)
T202	5.5	20	N80	40.14	802.8	3 of 4	482271-3 (UESU)
T203	5.5	20	N80	38.81	776.2	3 of 4	482271-3 (UESU)
T216	5.5" Packer			7.46	300.0	3 of 4	482271-3 (UESU)
				Bolster Weight =	**8,116 lb**		

JSN	Description			Tally	Joint	Bolster	PS-20 Container SN
	OD	Wt/ft	Grade	Length	Weight	Number	
T178	5.5	20	N80	37.91	758.2	**2 of 4**	482271-3 (UESU)
T179	5.5	20	N80	38.36	767.2	2 of 4	482271-3 (UESU)
T180	5.5	20	N80	37.29	745.8	2 of 4	482271-3 (UESU)
T181	5.5	20	N80	38.35	767.0	2 of 4	482271-3 (UESU)
T182	5.5	20	N80	38.11	762.2	2 of 4	482271-3 (UESU)
T183	5.5	20	N80	38.29	765.8	2 of 4	482271-3 (UESU)
T184	5.5	20	N80	38.25	765.0	2 of 4	482271-3 (UESU)
T185	5.5	20	N80	36.85	737.0	2 of 4	482271-3 (UESU)
T186	5.5	20	N80	37.40	748.0	2 of 4	482271-3 (UESU)
T187	5.5	20	N80	37.99	759.8	2 of 4	482271-3 (UESU)
T188	5.5	20	N80	43.70	874.0	2 of 4	482271-3 (UESU)
T189	5.5	20	N80	37.72	754.4	2 of 4	482271-3 (UESU)
T190	5.5	20	N80	37.37	747.4	2 of 4	482271-3 (UESU)
T191	5.5	20	N80	38.73	774.6	2 of 4	482271-3 (UESU)
T192	5.5	20	N80	38.72	774.4	2 of 4	482271-3 (UESU)
T193	5.5	20	N80	38.76	775.2	2 of 4	482271-3 (UESU)
				Bolster Weight =	**12,276 lb**		
T204	3.5	9.3	N80	31.17	289.9	4 of 4	482271-3 (UESU)
T205	3.5	9.3	N80	14.45	134.4	4 of 4	482271-3 (UESU)
T206	3.5	9.3	N80	31.16	289.8	4 of 4	482271-3 (UESU)
T207	3.5	9.3	N80	31.17	289.9	4 of 4	482271-3 (UESU)
T208	3.5	9.3	N80	31.19	290.1	4 of 4	482271-3 (UESU)
T209	3.5	9.3	N80	31.15	289.7	4 of 4	482271-3 (UESU)
T210	3.5	9.3	N80	31.12	289.4	4 of 4	482271-3 (UESU)
T211	3.5	9.3	N80	31.20	290.2	4 of 4	482271-3 (UESU)
T212	3.5	9.3	N80	14.41	134.0	4 of 4	482271-3 (UESU)
T001	3.5	9.3	N80	31.15	289.7	4 of 4	482271-3 (UESU)
T213	3.5	9.3	N80	16.82	156.4	4 of 4	482271-3 (UESU)
T214	3.5	9.3	N80	35.44	329.6	4 of 4	482271-3 (UESU)
T215	3.5	9.3	N80	32.62	303.4	4 of 4	482271-3 (UESU)
T217	2.88	6.4	N80	30.69	196.4	4 of 4	482271-3 (UESU)
E1 0001	2.88	6.5	?	31.00	201.5	4 of 4	482271-3 (UESU)
E1 0002	2.88	6.5	?	31.00	201.5	4 of 4	482271-3 (UESU)
				Bolster Weight =	**3,976 lb**		

Notes:

- JSN T212 is the upper cut joint.
- JSN T213 is the lower cut joint.
- JSN T214 includes the sliding sleeve.
- JSN 215 includes the XN nipple.
- Two joints (E1-0001 and E1-0002) did not come from SS-25A, but instead from the SS-25 well site; they were set aside as evidence during Phase 1.