Well SS 25
(Standard Sesnon 25)
Aliso Canyon Field

Southern California Gas Company

Los Angeles County, CA

Blowout

“Uncontrolled flow of gas, oil or other well fluids from a well”

Disclaimers

I work for Denbury as an engineer.

Opinions today are strictly my own and are not reflective of anything Denbury.

Denbury is not involved in this situation in any way.

All data was captured from public sources so there is nothing proprietary included here.

This presentation and commentary reflect only the thoughts of the presenter, and in no way represent or reflect upon his employer.

WHY???
This started as a safety "moment" for a meeting and grew into something more . . . .

“spewed”

“gushed uncontrollably”

“intermittent stench”

Introduction

What happened?

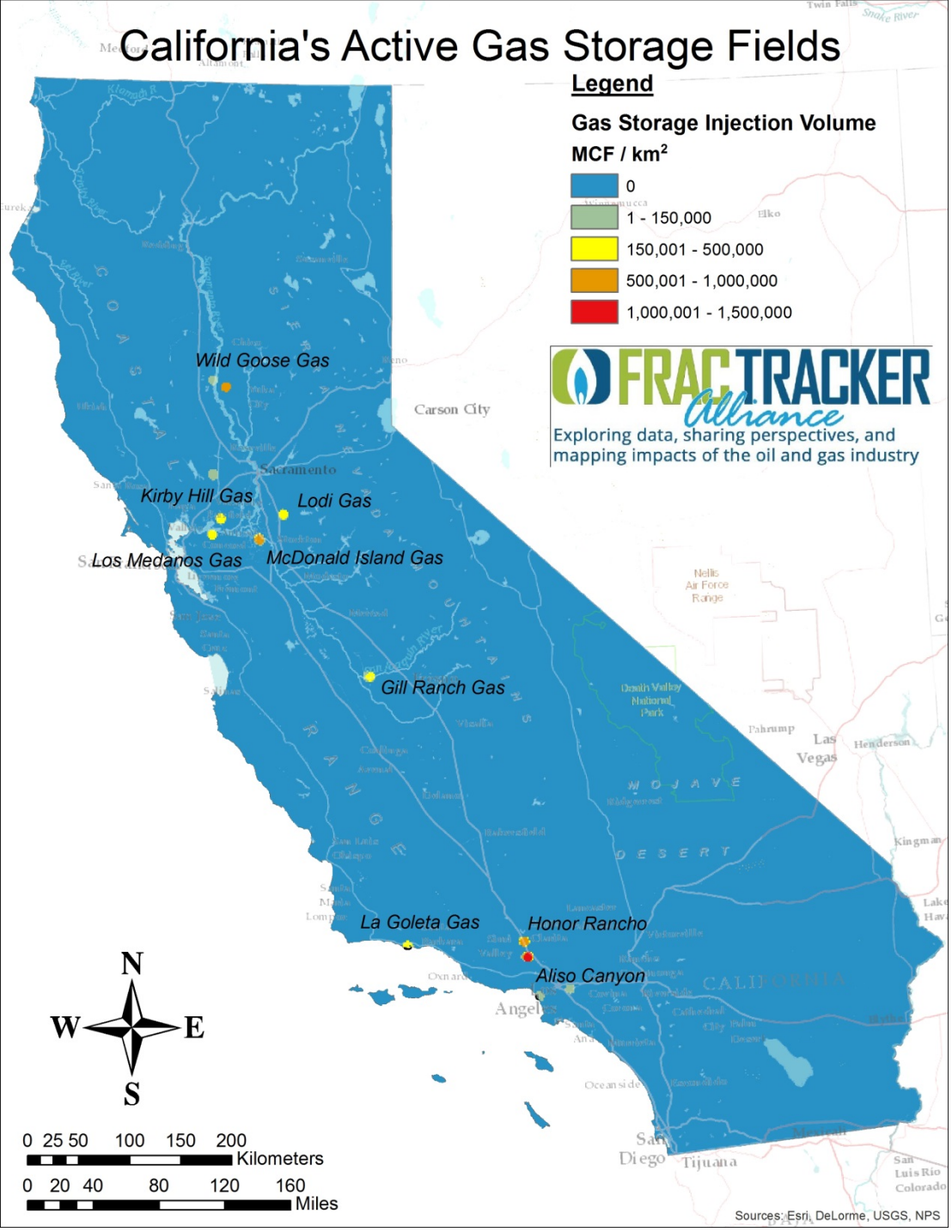
Aftermath

Well SS25


Aerial footage shows Aliso Canyon natural gas leak

Classic case of “It’s all good . . . .”

until it’s not . . . .

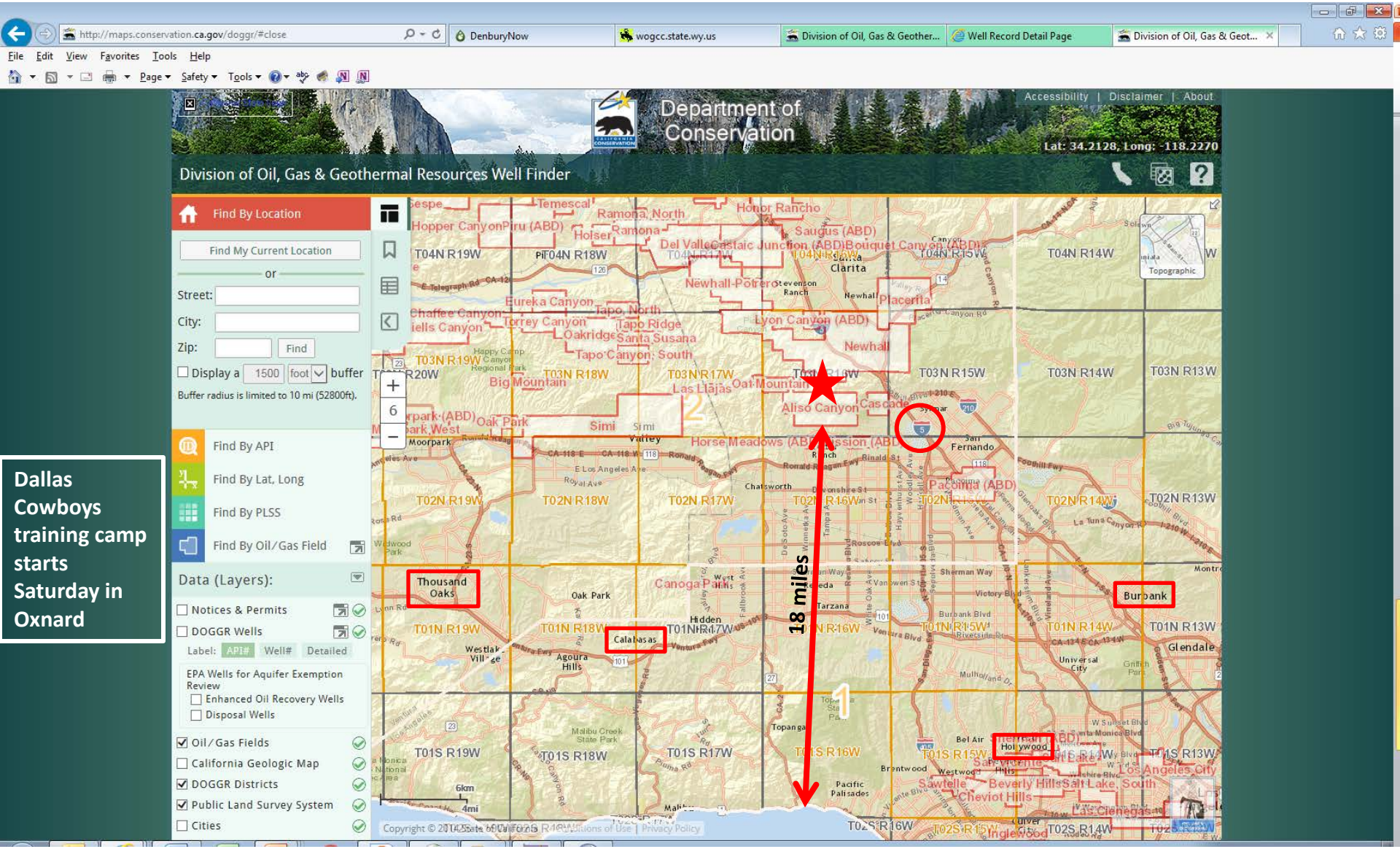


Aliso Canyon Natural Gas Storage Facility

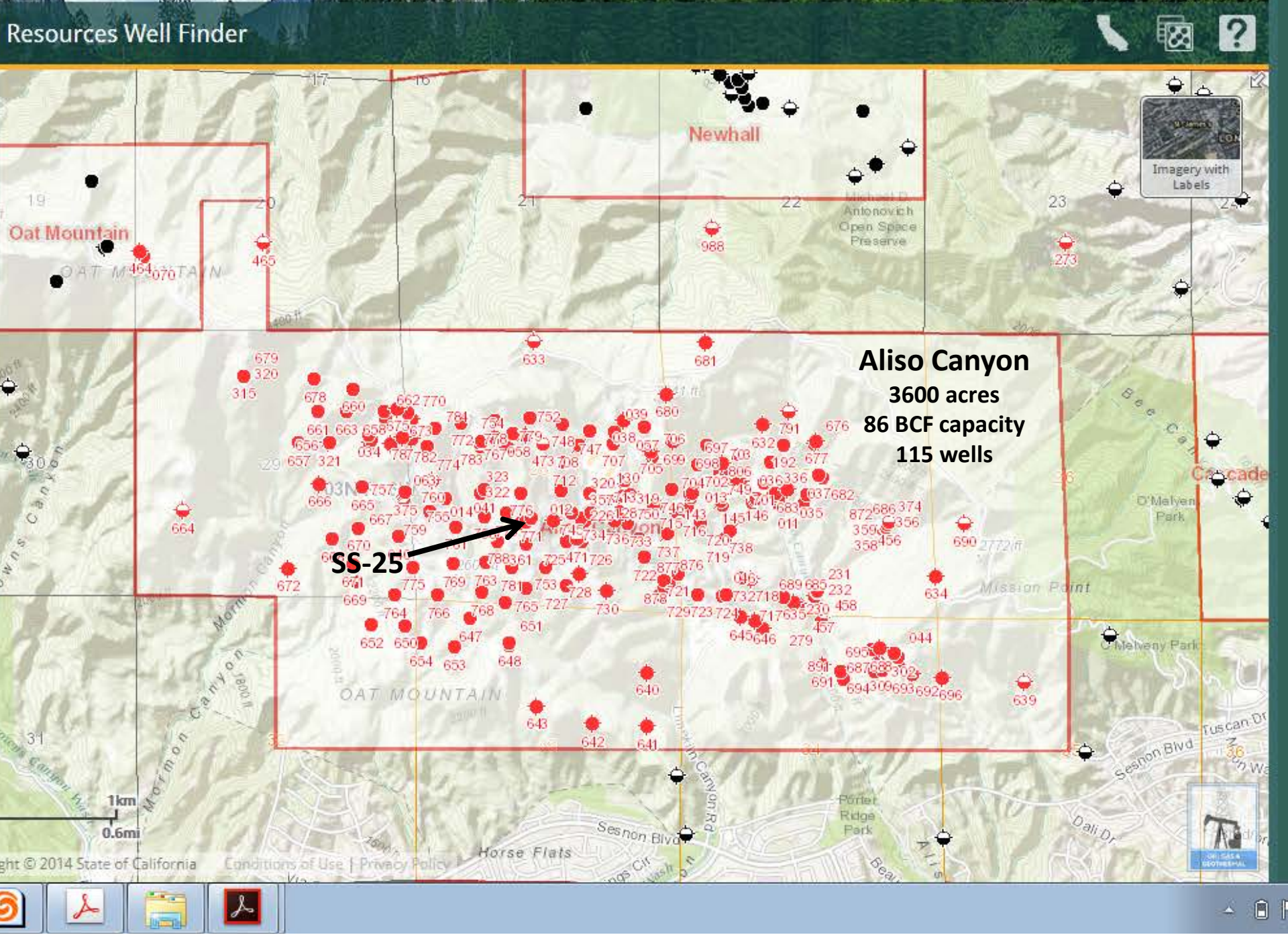
1) Two-mile long depleted oil reserve
2) Largest natural gas storage operation
   A. In California
   B. West of the Mississippi River
3) Fourth largest natural gas storage operation in the country
4) Each fall: filled with 86 BCF of natural gas
   A. Purchase inexpensive gas from around the country
   B. Run power plants
   C. Heat homes in Los Angeles during the winter
   D. Power plants also use the gas to generate electricity on days of peak demand like during summer heat waves

From Science magazine website

Santa Susana Mountains north of Los Angeles; northern part of San Fernando Valley in LA County



Dallas Cowboys training camp starts Saturday in Oxnard

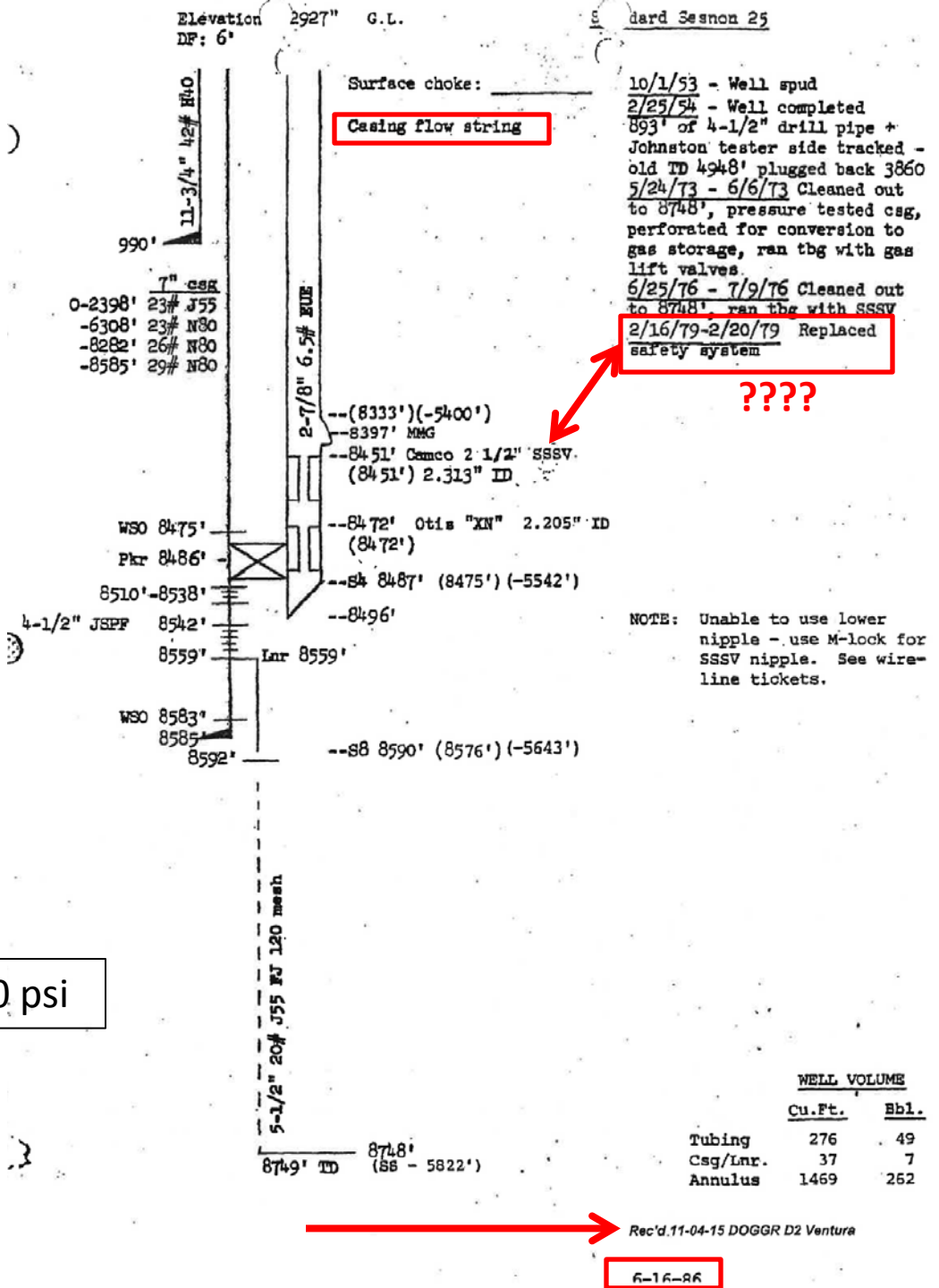

Resources Well Finder
Aliso Canyon
3600 acres
86 BCF capacity
115 wells
SS-25
Newhall
Oat Mountain
OAT MOUNTAIN
Horse Flats
Mission Point
Porter Ridge Park
Michael D. Antonovich Open Space Preserve
Imagery with Labels
Sesnon Blvd
Mormon Canyon
1km
0.6mi

10/23/15 Well SS-25 is discovered to be leaking methane at the surface

- Well was drilled in 1953 (63 years ago)
  - Tide Water Associated Oil Company
    - J. Paul Getty company
  - Was on gas lift from inception
- Converted from gas lift oil well to gas storage well in 1973
- Last workover performed in 1979 (37 yrs ago)
  - The year I graduated from high school
- Original tree was (is) still on well?
  - Only one valve in main run
- Now operated by Southern California Gas Co.
  - A subsidiary of Sempra Energy

- “initially had a safety valve, which was removed in 1979 as it was old and leaking”
- Because the well was not considered "critical, that is, one within 100 feet of a road or a park, or within 300 feet of a home", the valve was merely removed and not replaced

Burst rating of 7” 23# J-55 casing = 4360 psi



Summary of Tests Conducted on "Standard Sesnon" 25, API 037-00776

The project approval of the gas storage project in 1989 required an annual mechanical integrity test for all injection-withdrawal (gas storage) wells.

"Standard-Sesnon" 25 was tested yearly from 1989 to 2014 (the latest test). The table below summarizes these tests. The production casing during all these tests, (excluding those on 1994 and 2005 where there was no casing pressure reported during the test) tested OK. There were no leaks recorded in the well during the test.

Date of Test	Type of Survey	Casing Pressure (psi)	Tubing Pressure (psi)	Comment
04-06-1989	Shut-in Temperature Log	1640	1640	Casing held pressure – no leak
09-06-1989	Shut-in Temperature Log	2310	2310	Casing held pressure – no leak
04-12-1990	Shut-in Temperature Log	1770	1770	Casing held pressure – no leak
09-20-1990	Shut-in Temperature Log	2470	2470	Casing held pressure – no leak
04-23-1991	Shut-in Temperature Log	2060	2050	Casing held pressure – no leak
08-12-1991	Shut-in Temperature Log	2810	2790	Casing held pressure – no leak
11-07-1991	Noise Log with Shut-in Temperature Log	2460	2600	Casing held pressure – no leak. Noise log indicated distant noise at 1200'.
04-30-1992	Shut-in Temperature Log	1460	1460	Casing held pressure – no leak
08-04-1992	Shut-in Temperature Log	2395	2390	Casing held pressure – no leak
09-16-1993	Shut-in Temperature Log	2540	2540	Casing held pressure – no leak
01-25-1994	Shut-in Temperature Log	No data	No data	
09-21-1994	Shut-in Temperature Log	2550	2540	Casing held pressure – no leak
10-12-1995	Shut-in Temperature Log	2560	2560	Casing held pressure – no leak
09-24-1996	Shut-in Temperature Log	1580	1580	Casing held pressure – no leak
11-05-1997	Shut-in Temperature Log	2520	2520	Casing held pressure – no leak. Temperature profile may be affected by asphaltenes from about 8000'-8400'
11-06-1998	Shut-in Temperature Log	2680	2680	Casing held pressure – no leak
02-05-1999	Shut-in Temperature Log	1600	1600	Casing held pressure – no leak
09-14-2000	Shut-in Temperature Log	2020	2020	Casing held pressure – no leak
08-07-2001	Shut-in Temperature Log	2400	2400	Casing held pressure – no leak
08-30-2002	Shut-in Temperature Log	2570	2570	Casing held pressure – no leak
08-27-2003	Shut-in Temperature Log	2350	2350	Casing held pressure – no leak
07-27-2004	Shut-in Temperature Log	2350	2340	Casing held pressure – no leak
08-10-2005	Shut-in Temperature and Pressure Log	No data	2637	
07-25-2006	Shut-in Temperature and Pressure Log	2339	2336	Casing held pressure – no leak
12-05-2007	Shut-in Temperature Log	2650	2650	Casing held pressure – no leak
07-23-2008	Shut-in Temperature Log	2490	2490	Casing held pressure – no leak
10-05-2009	Shut-in Temperature Log	2490	2490	Casing held pressure – no leak
12-14-2010	Shut-in Temperature Log	2397	2395	Casing held pressure – no leak
09-12-2011	Shut-in Temperature Log	2430	2430	Casing held pressure - no leak
05-29-2012	Shut-in Temperature Log	2572	2572	Casing held pressure – no leak
10-02-2013	Shut-in Temperature Log	2624	2624	Casing held pressure – no leak
10-21-2014	Shut-in Temperature Log	2647	2659	Casing held pressure – no leak

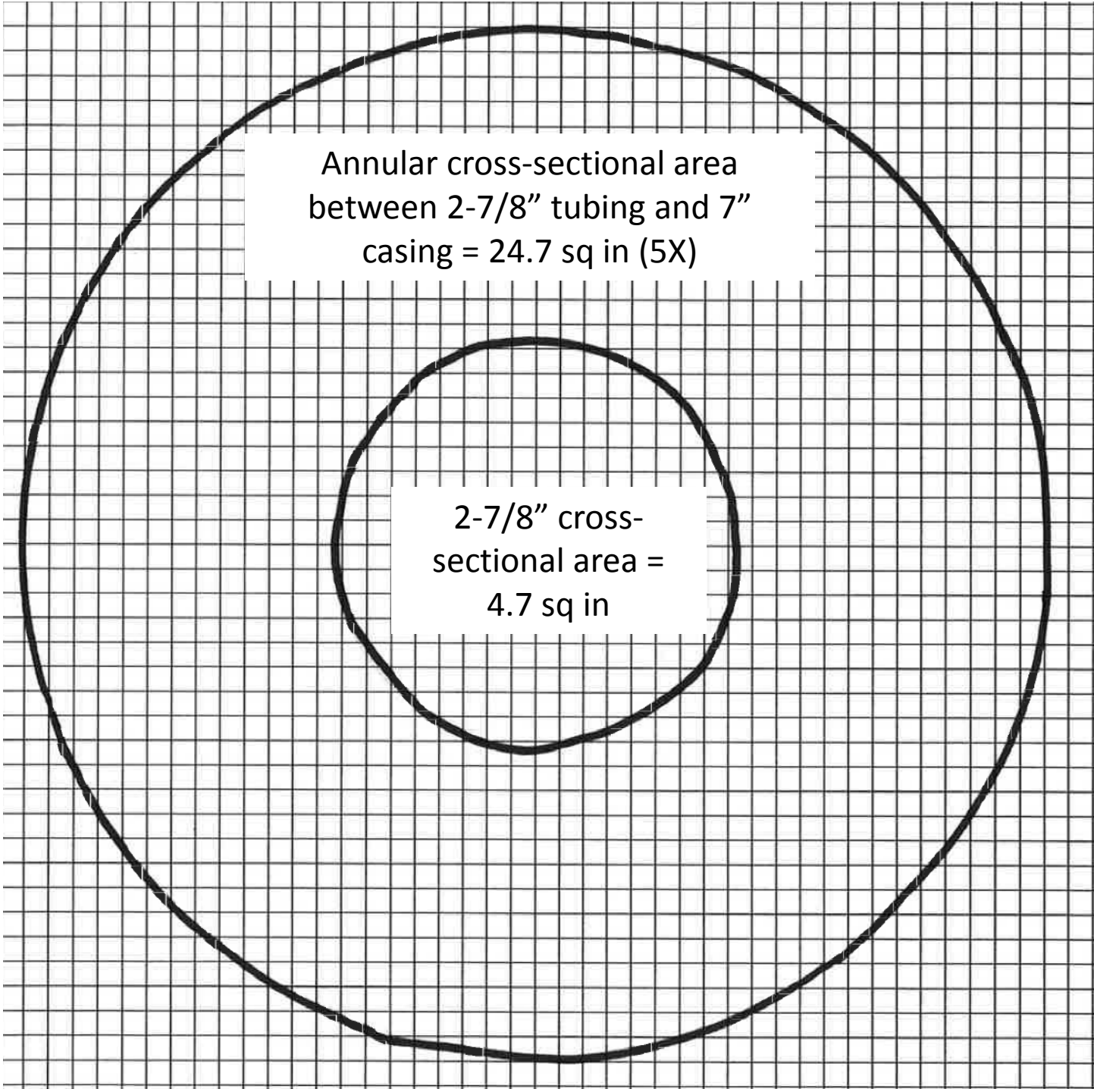
Reservoir Pressure

The project approval also required that the reservoir pressure shall not exceed 3600 psi. The data indicated during these tests conducted during shut-in, that is, maximum pressure at the zone, all showed the zone pressures were substantially less than 3600 psi.

3600 / 8600 = 0.42 psi/ft

One reason for the casing failure may have been gas flow not just through the tubing, but also through the casing **"in order to meet the demand of a customer“**

Not sure how they actually used the annulus for production . . . .



COILED TUBING

WELL CEMENTING SUMMARY

WELL NO.	SH	CASING SIZE	HOLE SIZE	CALCULATED CEMENT FILL	CEMENT FILL BOND LOG	WSO AND SQUEEZE HISTORY	G=Good P=Poor F=Fair N=No cement QUALITY OF CEMENT BOND	REMARKS
S.S. #25	8487	7" 8585 5-1/2" 8748	10-5/8 6"	600 sacks cmt, 7600	6960'	8475 WSO OK	F-P 8737'-8560' G 8560'-6960' N 6960'-6950'	(Top of lo
S.S. #29	8428	7" 8170 5" 9077 cpld 8725' top 8075'	10-5/8 6-1/8	550 sacks cmt, 6360' 100 sacks cmt, topliner	8235'	8170 WSO OK 8705 - WSO 8170 - 8075 splice WSO on splice	P 9054'-8735' F-G 8735'-8235' N 8235'-7950'	(Top of lo

API No. 037-00776 DIVISION OF OIL, GAS, AND GEOTHERMAL RESOURCES [illegible] 00790

BLOWOUT PREVENTION EQUIPMENT MEMO #11, 1

Operator So Cal Gas Well Sesnon 25 Sec. 28 T. 03N R. 16W

Field Aliso Cyn. County Los Angeles Spud Date

ISITS:	Date	Engineer	Time	Operator's Rep.	Title
st	11/4/15	K. Constatzon	(0700 to 1730)	Todd Vander Pluta	Company Man
nc	11/5/15	"	(0900 to 1700)		

Contractor Boots & Coots Rig # CTU #4 Contractor's Rep. & Title Jack Abata PSS

Casing record of well: Danny Clayton PSS

OPERATION: Testing (inspecting) the blowout prevention equipment and installation. Critical well? Y ☐ N ☒

DECISION: The blowout prevention equipment and its installation on the 7 " casing are approved.

Proposed Well Opns: Kill the well . MACP: psi

Hole size: " fr. ' to ', " to ' & " to '

REQUIRED BOPE CLASS: III SM

CASING RECORD OF BOPE ANCHOR STRING					Cement Details	Top of Cement	
Size	Weight(s)	Grade(s)	Shoe at	CP at		Casing	Annulus
11 3/4	42	H-40					
7	23, 26, 29#	K-55, N-80					

Coiled Tubing Workover Program

DATE: November 4, 2015

OPERATOR: Southern California Gas Company

FIELD: Aliso Canyon

WELL: Standard Sesnon 25

CONTRACTOR: Halliburton 1-1/2" Coiled Tubing Unit

OBJECTIVE: Wash a bridge/blockage from the 2-7/8" completion tubing string and kill/secure the well.

API Number: 037-00776

ELEVATION: Take all measurements from the original KB = 6' above GL (GL@ 2927').

SURFACE LOCATION: Sec 28, T3N, R16W, S.B. B&M (GPS NAD 83: 34.315083, -118.564069)

WELLBORE CONDITIONS (See attached wellbore schematic):

0'- 990'	11-3/4"	42#	H-40	Cemented
0'- 2398'	7"	23#	J-55	
2398'- 6308'		23#	N-80	
6308'- 8282'		26#	N-80	
8282' – 8585'		29#	N-80	Cemented / WSO @ 8475', 8583' ; Perf w/ 4, ½" jspf from 8510'-8538', 8542'-8559'
8559' – 8748'	5-1/2"	20#	J-55	120 Mesh from 8592'- 8748' / TD = 8749'

- Methane gas had been leaking since Oct. 23
- "We think it's probably leaking above the thousand-foot level," Gas Co. spokeswoman Melissa Bailey said Monday *(surface casing shoe at 990')*
- She added utility workers will continue to drill *(relief well)* to the well's bottom, where they'll plug it. That work could take until March *(early estimate).*

The proposed work is as follows: (A complete program is preferred and may be attached.)

(See Attached Program) : Nipple up a 5M Class III BOPE and pressure test.
Move in and rig up a 1-1/2" coiled tubing unit. Pressure test all lines and equipment.
Pump glycol in the 2-7/8" tubing to above the master valve and if necessary attempt to displace/wash to 467' with 10.8 ppg brine while maintaining a 2700-3000 psig back pressure on the tubing. Wash down the 2-7/8" with 10.8 ppg brine while maintaining 2700-3000 psig back pressure and work coiled tubing to approximately 8496' MD. Kill/secure the well and monitor wellhead pressures. A 14.8 ppg + ,Class "G" cement plug may be pumped into the 5-1/2" liner to secure the well.

If well is to be redrilled or deepened, show proposed coordinates (from surface location) and true vertical depth

at total depth: _____ feet _____ (Direction) and _____ feet _____ (Direction) Estimated true vertical depth: _____

Will the Field and/or Area change? Yes☐ No☐ If yes, specify New Field: _____ New Area: _____

The Division must be notified immediately of changes to the proposed operations. Failure to provide a true and accurate representation of the well and proposed operations may cause rescission of the permit.

Name of Operator Southern California Gas Company			
Address 12801 Tampa Ave.		City/State Northridge, CA	Zip Code 91326-1045
Name of Person Filing Notice Todd Van de Putte	Telephone Number: 661-305-5387	Signature Todd R Van de Putte	Date 11-4-2015
Individual to contact for technical questions: Todd Van de Putte	Telephone Number: 661-305-5387	E-Mail Address: tvandeputte@semprautilities.com	

11/8/15 Completion Profile Analysis (Gamma Ray; Pressure/Temperature Combo; Induction Collar Locator; Fluid Density; Fluid Dielectric; Spinner Flowmeter)

Observations:

1. The log data indicates the following observations and gas flow path evaluation:
   - There is no gas flow inside the tubing down to ~8435'
   - Temperature profile appears to be a normal flowing response with the source below log depth and assumed to be from the gas storage zone.
   - At ~8435' the spinner appears to indicate flow up through the tubing and exiting to the annulus (tubing x prod casing).
   - A cooling anomaly appears to detect a leak through the surface casing at ~890' (depth confirmed with both down and up log pass temperatures). The reported bottom of the surface casing is at 990'. The temperature is ~26.9 degF (down pass) at this depth and continues to cool up to a warming anomaly that changes from ~365' during the down pass and ~65' during the up pass. This change in depth may indicate the gas flow path has changed between the passes. The warming interval would likely indicate that the gas flow has moved away from the near-wellbore zone and beyond the ability for the temperature sensor inside the tubing to detect cooling caused by the gas flow.
   - Summary: gas flow appears to be flowing up the tubing and exiting through a tubing failure at ~8435'. Gas flows up the tubing x production casing annulus until it exits through the surface casing at ~890'. Gas flow up the surface casing annulus and moves away for the near-wellbore region at changing depths based on the temperature warm-back response. Note: An ice plug was drilled out with coiled tubing just prior to this log run. The ice plug was reported around ~450', which is in the maximum cooling zone.

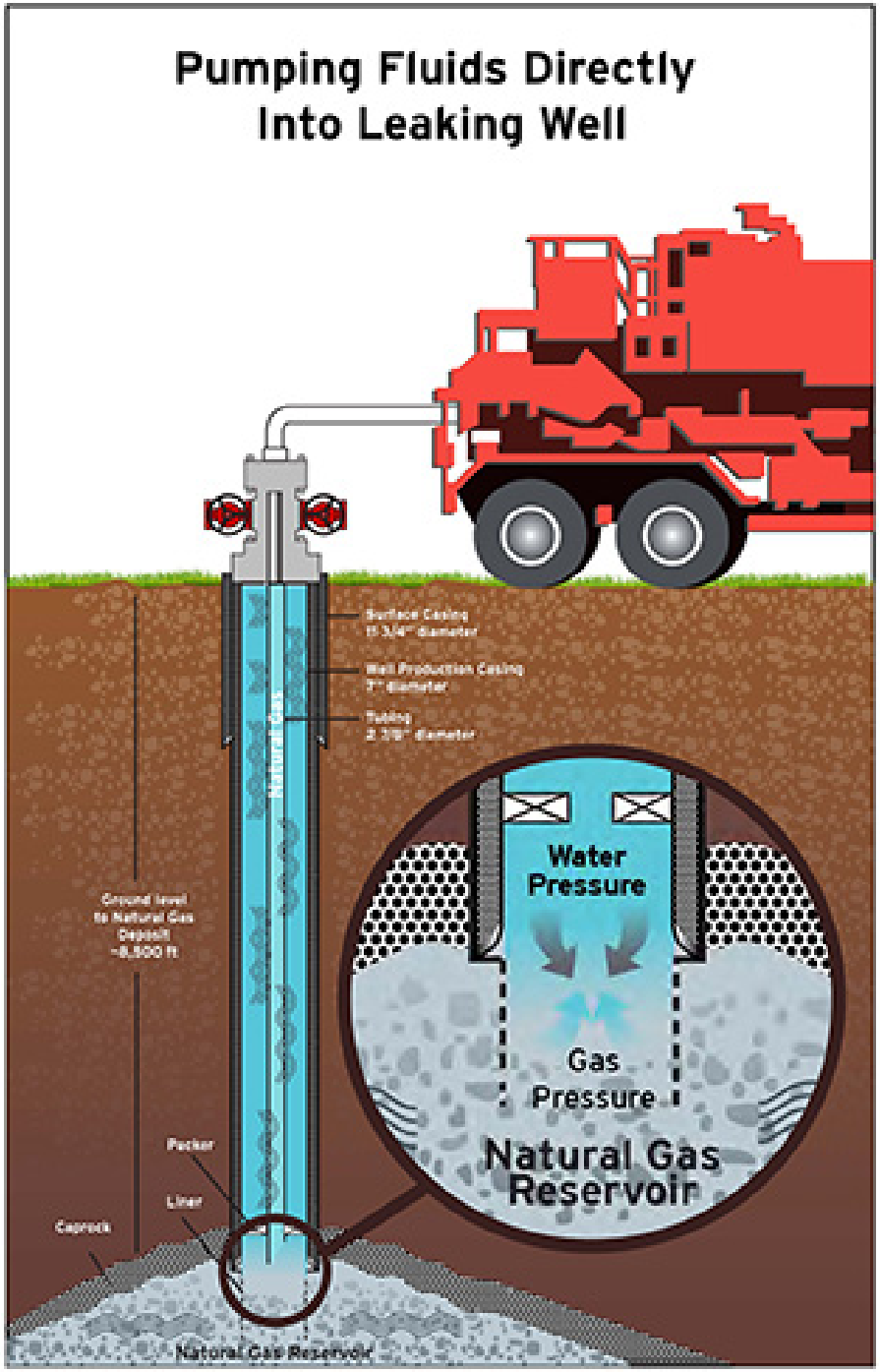
????

The log was depth correlated to a supplied gamma ray which only cover a short interval of the bottom of the log. The depth correlation up around the surface leak area could be off depth but should be relatively close. If a complete pipe record was available additional depth correlation checks could be conducted.

What they were trying to do:

- Pump heavy mud down tubing
- Push gas back into formation
- Fill wellbore with liquid
- Heavy enough column to keep gas from flowing

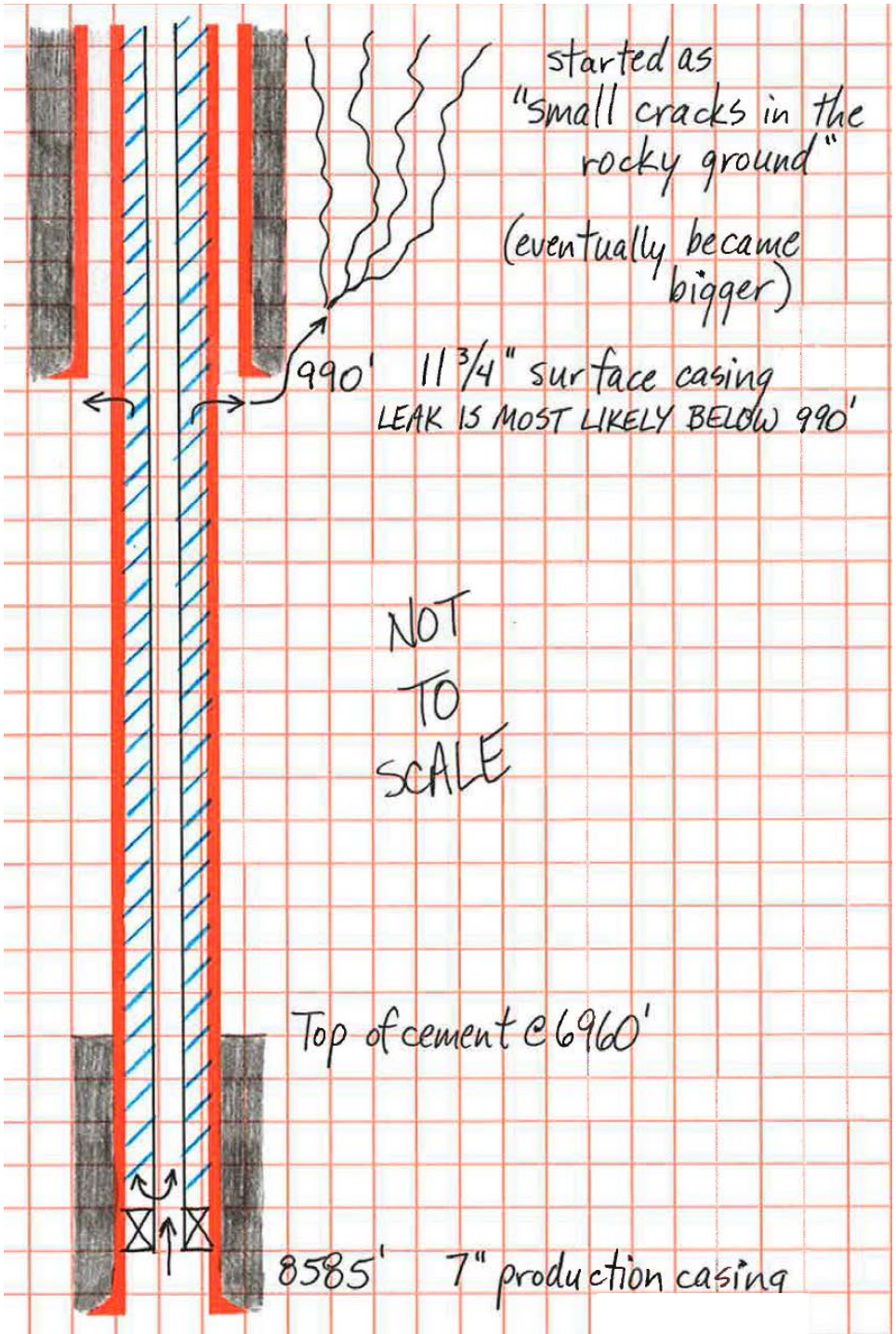
- Path of least resistance was not down into the formation, but rather out the production casing and into the ground
  - Circulated thru built in device?
  - Circulated thru hole in tubing?
    - Seems more likely



Tubing-casing annulus is usually filled with water-based fluid designed to minimize corrosion. The tubing-casing annulus in this well has never been filled with anything but methane, for 63 years (I think).

A leak below 990’ means a hole in the production casing.

A leak above 990’ means a hole in the production casing AND a hole in the surface casing.



- A Texas well control company *(Boots & Coots)* was attempting to plug a suspected hole in the 7-inch well casing by pumping it with increasingly heavier slurries of mud
- The mud was pushed against pressurized gas in the well, and the slurry began to find its own escape routes, gouging out a growing hole around the well
- During one of those attempts Nov. 13, a hole in the ground opened 20 feet north of the well
- Gas that had seeped through diffuse rock fissures on the western side of the narrow ridge began streaming instead from the new vent
- "A large column of gas, aerated mud, and rock formed a geyser around the wellhead,“
- "Mud brine also began to flow from around the wellhead fissures"
- The vent allowed a "serious amount of gas" to escape, *at which point the state began requiring a state regulatory official to be at the site every day*
- *Three more efforts to plug the well were made in November*, with increasing amounts of backwash and scouring along the wellhead itself that left the well jutting out of a deep hole, without surface support

SoCalGas Will Not Install a Gas Capture System

- Design of a gas capture system was initiated in November of 2015
- In consultation with AQMD and other agencies, we've decided not to install the gas capture system
- No design could be identified that would attain the safety level that SoCalGas believes would have been necessary to proceed

Well SS25 crater around wellhead

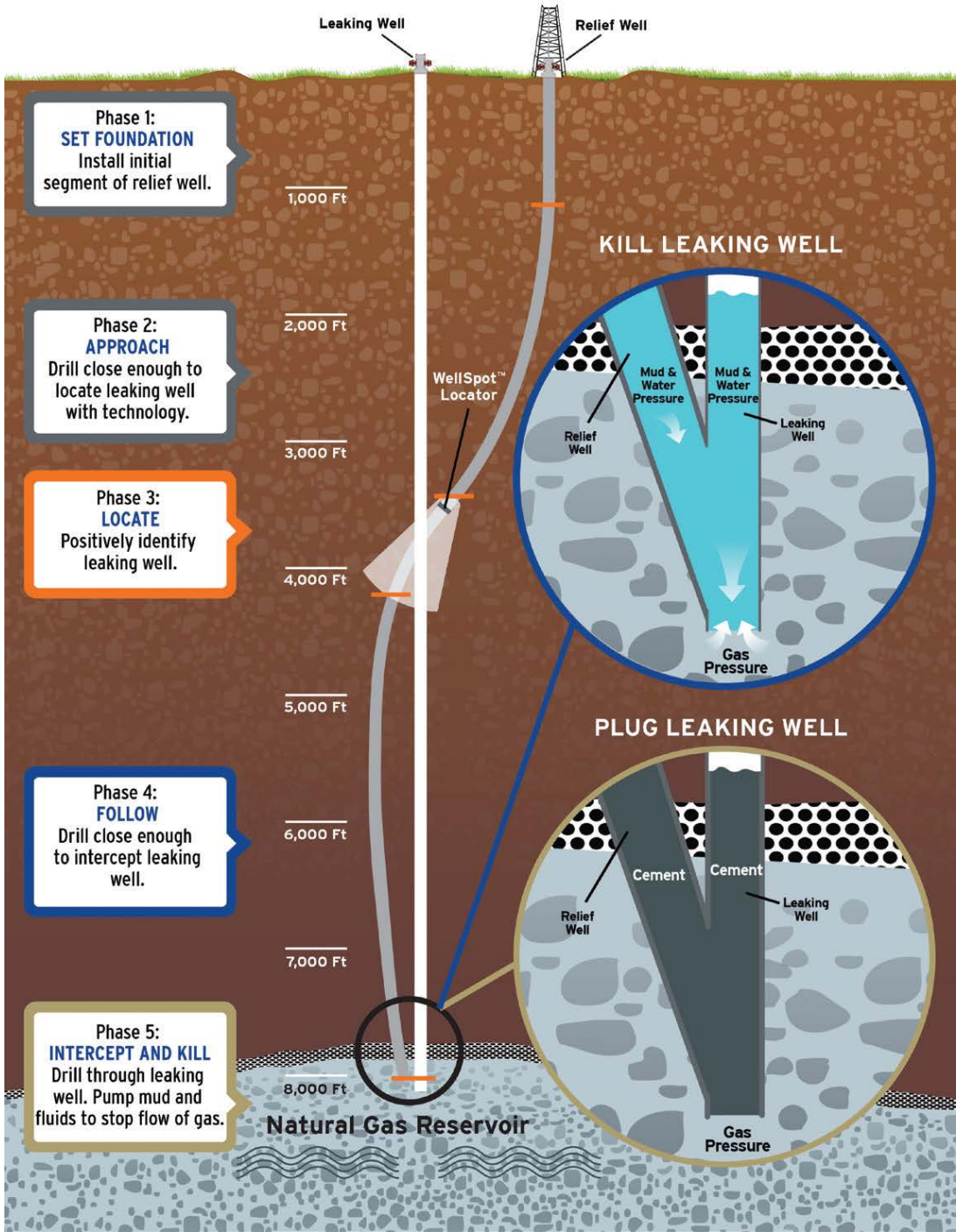
- **“site and wellhead were made more unstable by the gas company's attempts to stop the leak by pumping a slurry directly into the well”**
- **“The last of those efforts, which stretched over several days beginning Dec. 22, expanded a crater around the wellhead, state and gas company officials said”**
- **“The crater is now 25 feet deep, 80 feet long and 30 feet wide, those officials said.”**
- **“ The wellhead sits exposed within the cavernous space, held in place with cables attached after it wobbled during the plugging attempt”**
- **“The well pipe and its control valves are exposed and unsupported within that hole, atop a deep field of pressurized gas”**

RELIEF WELLS

Two relief wells were conceived. Second well was insurance policy against first well not reaching target.

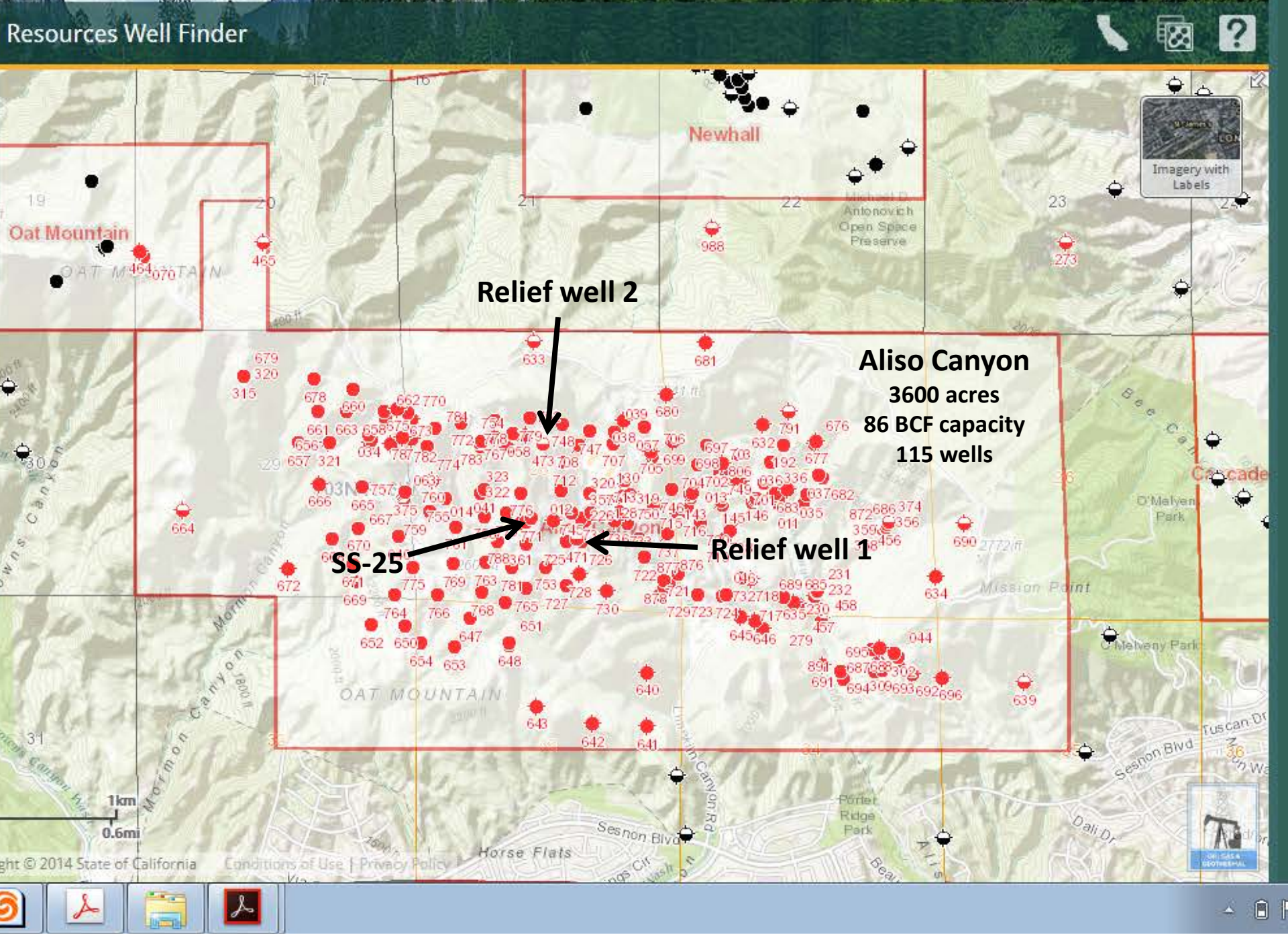
2/11/16 First relief well allowed killing gas flow with mud.

2/18/16 First relief well allowed permanently abandoning original well with cement.



Porter 39A Relief Well #1 got the job done.

Porter Sesnon 20A Relief Well #2 has no public records; no idea how far it got.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P216-0021

SUPPLEMENTARY NOTICE

Detailed instructions can be found at: www.conservation.ca.gov/dog/

A notice to the Division of Oil, Gas, and Geothermal Resources, dated November 24, 2015, stating the intention to

Drill (Drill, Rework, Abandon) well "Porter" 39A, API No. 03730471

Sec. 28, T. 3N, R. 16W, S.B. B.&M., Aliso Canyon Storage Field Field, Los Angeles County

should be amended because of changed conditions.

The complete casing record of the well (present hole), including plugs and perforations, is as follows: (Attach wellbore schematics diagram also.)

13-3/8", 54.5#, J-55 at 1218' cemented to surface
9-5/8", 47#, L-80 at 3682', cemented to surface
7", 26#, L-80 liner from 3353' to 8401' cemented
6-1/8" hole drilled from 8401' to 8615'
Milled window in the SS-25 7" production casing from 8615' to 8623'.

7" casing shoe = 8585'

The total depth is: 8623 feet. The effective depth is: 8623 feet.

Present completion zone(s): N/A (Name) Anticipated completion zone(s): N/A (Name)

Present zone pressure: N/A psi. Anticipated/existing new zone pressure: N/A psi.

We now propose: (A complete program is preferred and may be attached.)

(See attached program) The Standard Sesnon 25 "SS-25" wellbore was intercepted at a measured depth of 8615' (+/-) MD in Porter 39A which is located below the permanent packer in SS-25 at 8486' MD, the previously submitted mud pumping procedure was implemented and a static pressure condition exists in both the Porter 39A and the Standard Sesnon 25 wellbores. A window was milled in the SS-25 7" casing from 8615' to 8623'. Plug back cementing will be performed to secure the SS-25 wellbore from the storage zone pending the final abandonment of the SS-25 well per the previously submitted Standard Sesnon 25 Abandonment Plan. The attached well cement plug back outline and the draft cement plug blend describes the anticipated work activities and supercedes the previous cement plug/cement blend in the Supplementary Notice filed on 2-7-2016.

If well is to be redrilled or deepened, show proposed

Current Status: The casing in the SS25 well has been milled into and the SS25 well flow terminated by pumping mud from the Porter 39A relief well. Milling into the casing of the SS25 well has been completed creating an 8 foot length of cut in the casing where tubing might be successfully inserted into the original well bore of the SS25. Cement can then be placed through the tubing in the original SS25 well bore in the bottom of the well.

Second Cement Job on Porter 39A and SS25
Don W. Shackelford, 2/14/2016 9:31 AM

Anticipated Well Situation: The Porter 39A and SS25 wells are stable and static. A cement plug has been placed in the lower section of the SS25 well bore up to a depth of 8657 ft MD in the Porter 39A. Both wells contain 8.8 ppg mud with a possibility of traces of fresh water. Wireline is prepared to rig up on the SS25 well with a combination temperature and CBL tool.

7" casing shoe = 8585'

PUBLIC NOTICE CONFIRMING the SEALING of the LEAKING WELL

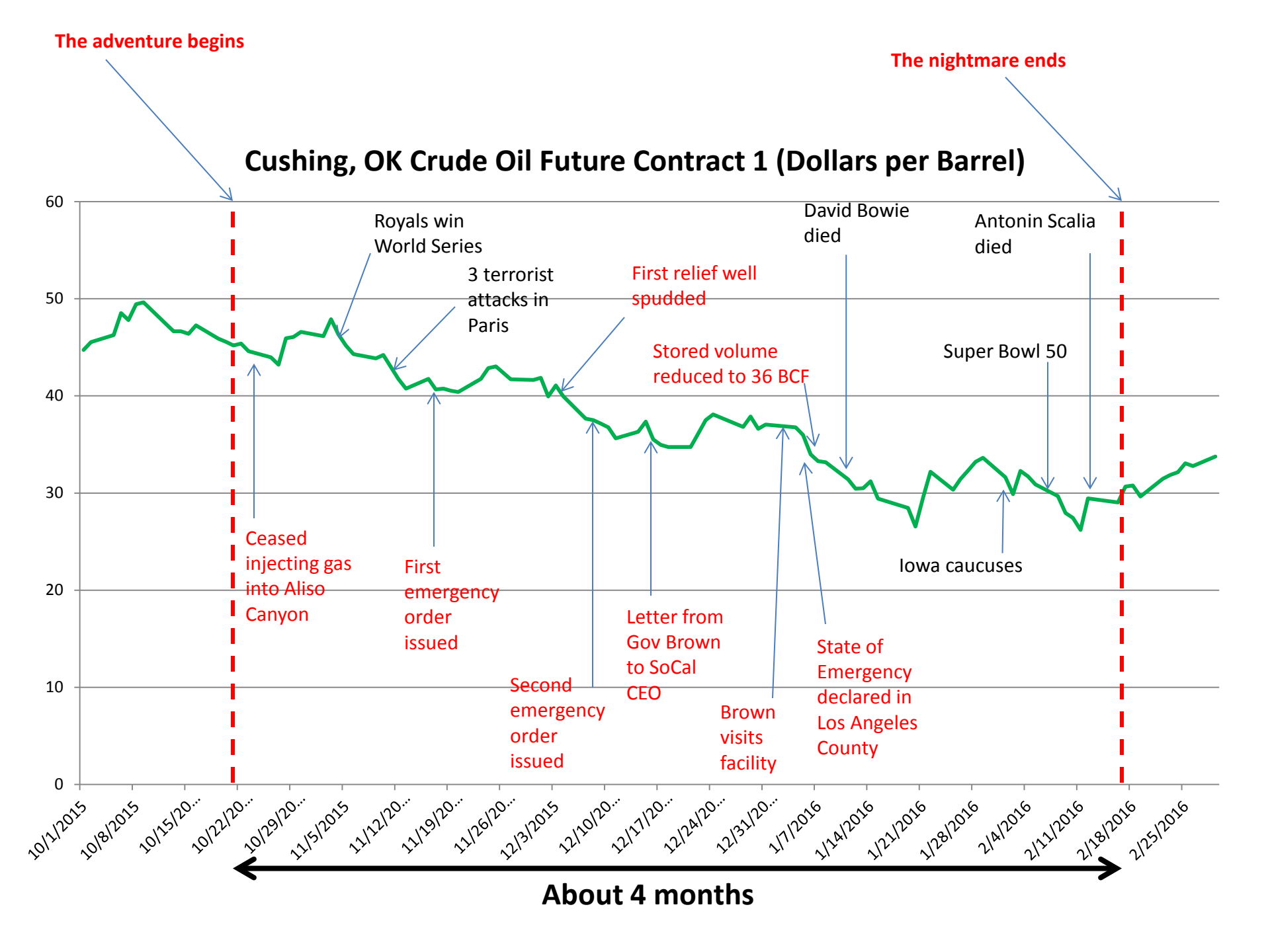
at the ALISO CANYON GAS STORAGE FACILITY

Date: February 18, 2016

NOTICE IS HEREBY PROVIDED that the leaking well (SS25) at the Aliso Canyon Gas Storage Facility has been successfully sealed.

The Department of Conservation's Division of Oil, Gas and Geothermal Resources (Division) bases this determination on its review of the results of a battery of post-cementing tests conducted by the Southern California Gas Company (SoCalGas). These tests were conducted at the Division's direction and under the Division's supervision. Each test was witnessed by a Senior Oil and Gas Engineer from the Division. This set of confirmation tests was formulated in consultation with technical experts from the Lawrence Berkeley, Lawrence Livermore and Sandia National Laboratories. The tests measure specific criteria to determine if any gas is still leaking from the gas storage reservoir through the cement plug in SS25. The results of the tests, set forth below, indicate that the sealing of the well was successful. Detailed descriptions of these tests can be found on the Department's website .

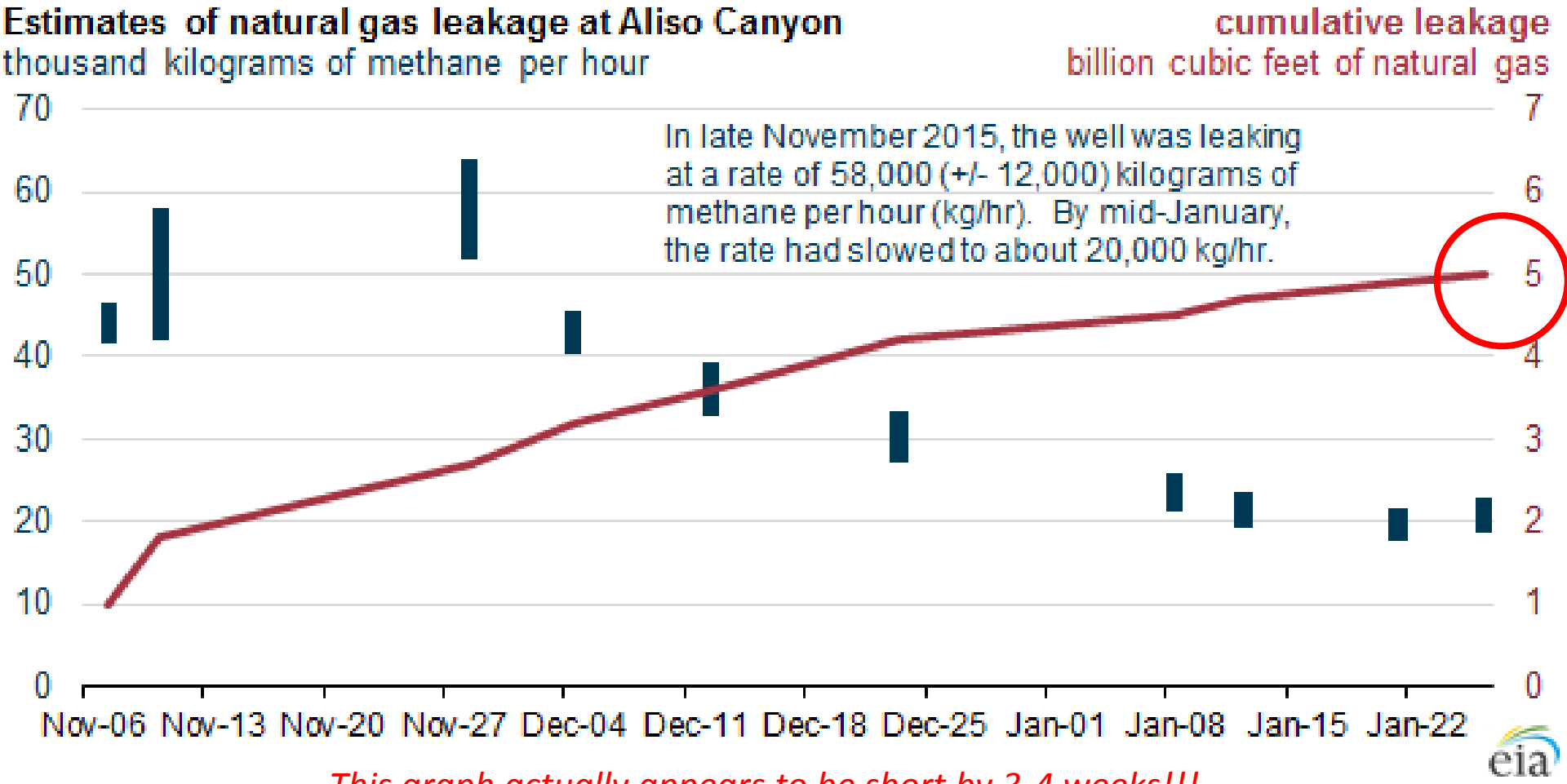
1) Temperature log/test: no leak of gas around cement seal.
2) Noise log/test: no sound of moving gas.
3) Fluid level monitoring: fluid in tubing not leaking past the cement.
4) Cement bond test/log: completely bonded between those two metal barriers.
5) Positive pressure test: perforated 4 holes in tubing below top of cement.


The adventure begins
The nightmare ends
Cushing, OK Crude Oil Future Contract 1 (Dollars per Barrel)
60
50
40
30
20
10
0
Royals win World Series
3 terrorist attacks in Paris
First relief well spudded
David Bowie died
Antonin Scalia died
Stored volume reduced to 36 BCF
Super Bowl 50
Ceased injecting gas into Aliso Canyon
First emergency order issued
Second emergency order issued
Letter from Gov Brown to SoCal CEO
Brown visits facility
State of Emergency declared in Los Angeles County
Iowa caucuses
10/1/2015
10/8/2015
10/15/20...
10/22/20...
10/29/20...
11/5/2015
11/12/20...
11/19/20...
11/26/20...
12/3/2015
12/10/20...
12/17/20...
12/24/20...
12/31/20...
1/7/2016
1/14/2016
1/21/2016
1/28/2016
2/4/2016
2/11/2016
2/18/2016
2/25/2016
About 4 months

Google Earth Imagery Date is 2/8/16 for this area, which is three days before Relief Well #1 was able to kill Well SS-25.

1) Well SS-25
2) Relief Well #1
3) Relief Well #2
4) Porter Ranch neighborhood

In the neighborhood of 5 BCF was released to atmosphere?
5000 MMCF / 120 days = 42 MMCFD average???



This graph actually appears to be short by 3-4 weeks!!!

California Environmental Protection Agency
Air Resources Board

Aliso Canyon Update
March 28, 2015

attached to this letter for your information. The Division's Order also mandates that all wells in the Aliso Canyon facility injecting gas will be required to:

Real-time pressure monitoring

1. Install real-time pressure monitors that provide immediate notification to the facility operator when pressures deviate from normal in the well's interior tubing and its annular space between the interior tubing and exterior casing of the well;

Ixnay on tubing-casing annulus use

2. Operate with lowest possible operating pressure on the tubing-casing annulus;

3. Inject and withdrawal gas only through interior metal tubing; under no circumstances will injection and withdrawal through tubing and casing be approved for any wells;

Stringent testing on downhole devices

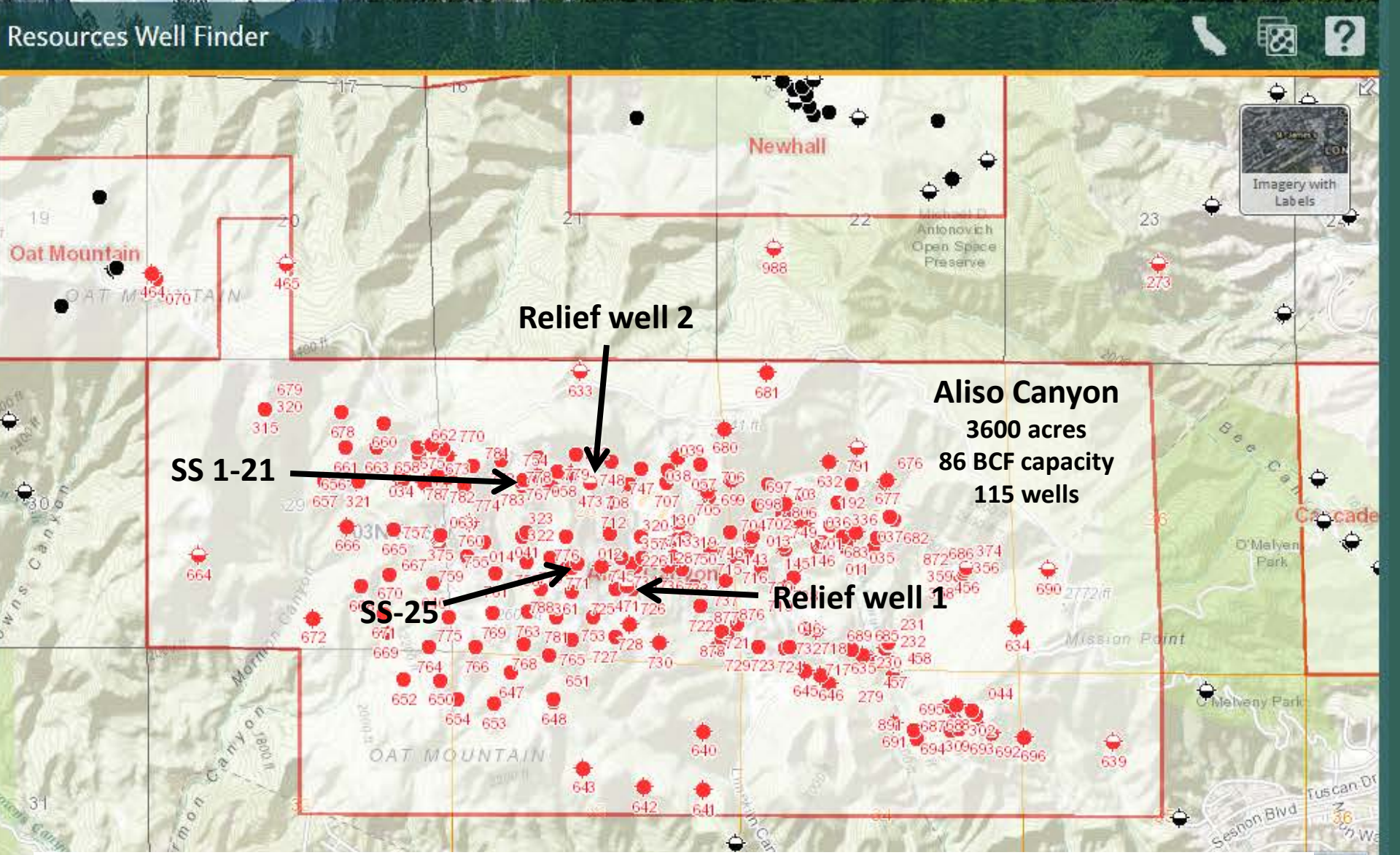
4. Complete testing of any downhole devices (e.g., valves, diverters) after the device has been installed and prior to the well resuming operation;

5. Complete testing of any downhole devices every six months;

More paperwork!

6. Comply with the state's Underground Injection Control regulations, which are a broad set of regulations applying to all oil and gas wells in the state; and,

7. Complete an updated risk management plan that includes a facility-wide emergency response plan, a safety and spill contingency plan, and geologic hazards mitigation protocols that includes assessing seismic risks to the facility.



Well SS 1-21, another 1953-vintage well in Aliso Gas Storage facility, operated by Crimson Resource Management, was found to be "leaking" on 4/16/16. Bad timing.

The End

Thanks for coming today

Smoke ‘em if you got ‘em (any questions?)