Workshop on Reliability & Risk Management of SSSVs for UGS Applications

Battelle/Sandia National Laboratories

Denver, CO; March 4-5, 2020

Andrew Duguid - Battelle/Giorgia Bettin - Sandia

Sandia National Laboratories is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC., a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Battelle

- World's largest nonprofit research & development organization.
- Business pillars: Contract Research, Laboratory Management, STEM Education
- Serving Health & Consumer; Environment & Infrastructure; Global & National Security and Laboratory Management
- Our Mission: to translate scientific discovery and technology advances into societal benefits
- 501(c)3 charitable trust formed in 1923 by the will of Gordon Battelle to conduct R&D for the benefit of humankind
- Percentage of profit reinvested in science, technology, education, charity

BROOKHAVEN NATIONAL LABORATORY · INL Idaho National Laboratory · Lawrence Livermore National Laboratory · NREL National Renewable Energy Laboratory · OAK RIDGE National Laboratory · Pacific Northwest NATIONAL LABORATORY · NBACC

Battelle's mission

Our mission is: to translate scientific discovery & technology advances into societal benefits

- We are independent
- We have broad engineering and scientific expertise
- We want to do the right thing

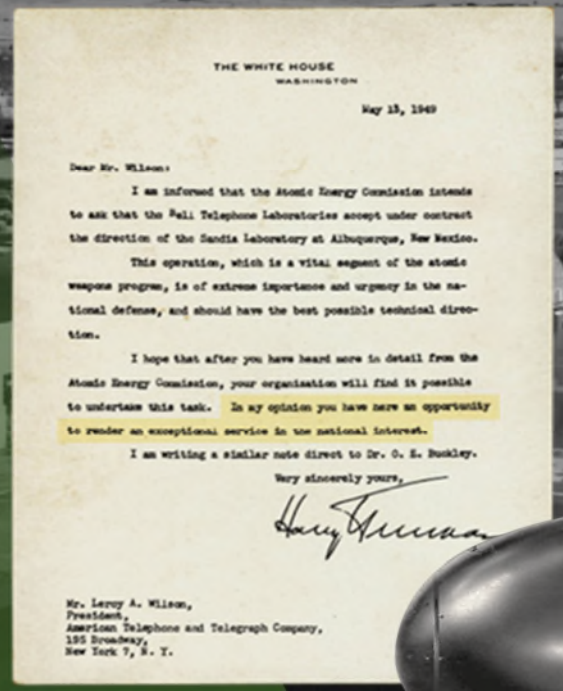
Battelle.org

YouTube video: Battelle History

SANDIA'S HISTORY IS TRACED TO THE MANHATTAN PROJECT

…In my opinion you have here an opportunity to render an exceptional service in the national interest.

- July 1945
  Los Alamos creates Z Division
- Nonnuclear component engineering
- November 1, 1949
  Sandia Laboratory established
- AT&T: 1949–1993
- Martin Marietta: 1993–1995
- Lockheed Martin: 1995–2017
- Honeywell: 2017–present



THE WHITE HOUSE
WASHINGTON

May 13, 1949

Dear Mr. Wilson:

I am informed that the Atomic Energy Commission intends to ask that the Bell Telephone Laboratories accept under contract the direction of the Sandia Laboratory at Albuquerque, New Mexico.

This operation, which is a vital segment of the atomic weapons program, is of extreme importance and urgency in the national defense, and should have the best possible technical direction.

I hope that after you have heard more in detail from the Atomic Energy Commission, your organization will find it possible to undertake this task. In my opinion you have here an opportunity to render an exceptional service in the national interest.

I am writing a similar note direct to Dr. O. E. Buckley.

Very sincerely yours,

Harry Truman

Mr. Leroy A. Wilson,
President,
American Telephone and Telegraph Company,
195 Broadway,
New York 7, N. Y.

SAND 2018-4900 PE

SANDIA HAS FACILITIES ACROSS THE NATION

Activity locations

- Kauai, Hawaii
- Waste Isolation Pilot Plant, Carlsbad, New Mexico
- Pantex Plant, Amarillo, Texas
- Tonopah, Nevada

Main sites

- Albuquerque, New Mexico
- Livermore, California

SAND 2018-4900 PE

Thank you PHMSA!

PHMSA
Pipeline and Hazardous Materials Safety Administration

Two projects sponsored by PHMSA:

- Reliability of Subsurface Safety Valves (Agreement No.693JK31810016)– cost/benefit analysis for SSSVs in UGS wells – main focus of this workshop

- Tubing and Packers Life-Cycle Analysis for UGS Applications (Agreement No.693JK31810015)– cost/benefit analysis for T&P in UGS wells – some information related to T&Ps will be presented

Aliso Canyon accident

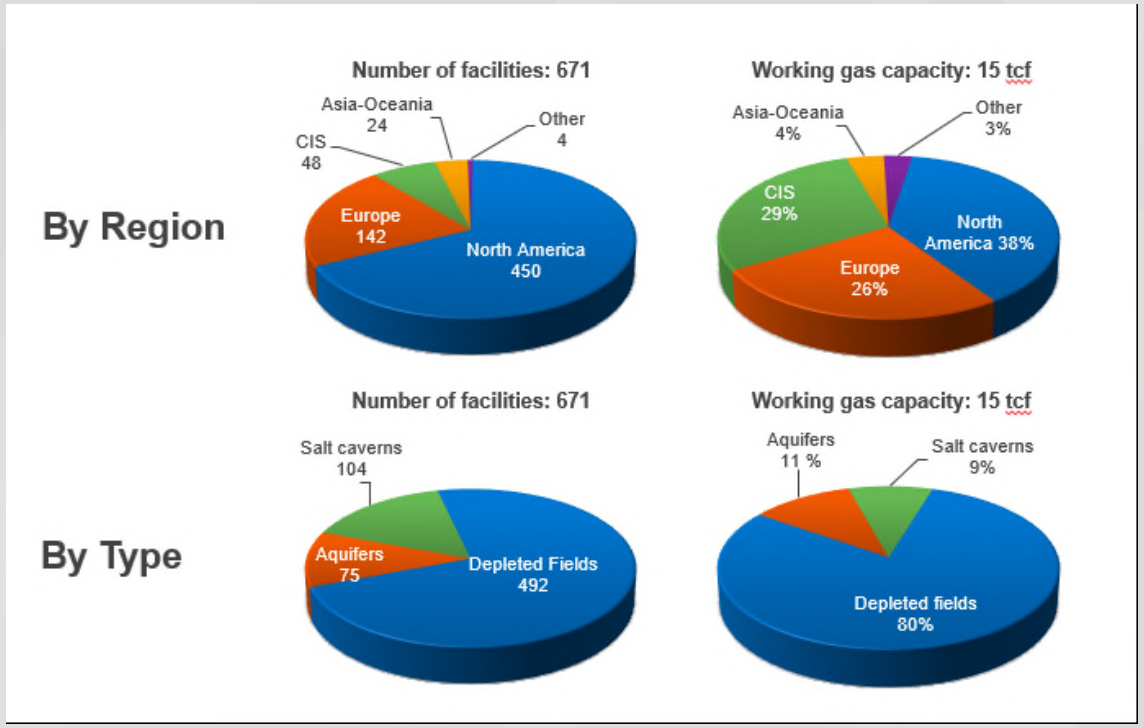
Reaction to large natural gas release:

- This work started in response to the 2015 Aliso Canyon accident where approximately 100,000 tones of natural gas were released over 4 months

- UGS facilities accidents, although rare, tend to release large amounts of natural gas and generate significant and environmental concerns

UGS incidents in the World

Worldwide UGS as of end 2017



Source: S. Carnot-Gandolphe, CEDIGAZ Insights no.22 (2017)

UGS Incidents

Storage Type	Worldwide	Non-US	US
Depleted field	**603**	75	**528**
Saline aquifer	40	11	29
Other	373	118	255
Unconfirmed Type	7	2	5
Totals	1,023	206	817

Source: D. Evans and R. Schultz, ARMA 17-265 (2017)

Rare but larger UGS accidents

Occasionally, the UGS industry experiences large loss of confinement accident:

- These events attract significant media attention and public concern
- New laws and regulations are frequently enacted
- UGS operators face long and costly legal consequences
- Public trust in UGS safety practices is eroded

2001 Yaggy Storage Field – salt cavern storage near Hutchinson, KS

2004 Moss Bluff Storage Facility – salt cavern storage in Liberty County, TX

What to expect

Workshop agenda:

- Discussion on UGS-related failure data availability
- Discussion on subsurface safety valve (SSSV) reliability
- Introduction of risk management model
  - Likelihood of well failure
  - Consequence of well failure
  - Can SSSV emplacement reduce risk?

<u>The goal is to collect industry comments and inputs related to these topics</u>

~1/2 time will be dedicated to presentations, ~1/2 to open discussion

Battelle/Sandia team

Battelle:

- Andrew Duguid – PI
- Kathryn Johnson – PM
- Mackenzie Scharenberg
- Glenn Larsen
- Darwin Argumedo
- Mark Moody
- Slawek Winecki

Sandia:

- Giorgia Bettin – Co-PI
- Anna Lord
- Dylan Moriarty

Nova Northstar LLC:

- Steve Nowaczewski

Battelle Data Collection Efforts

It is challenging to collect failure data for UGS wells, what can be done about this?

Slawek Winecki
Battelle

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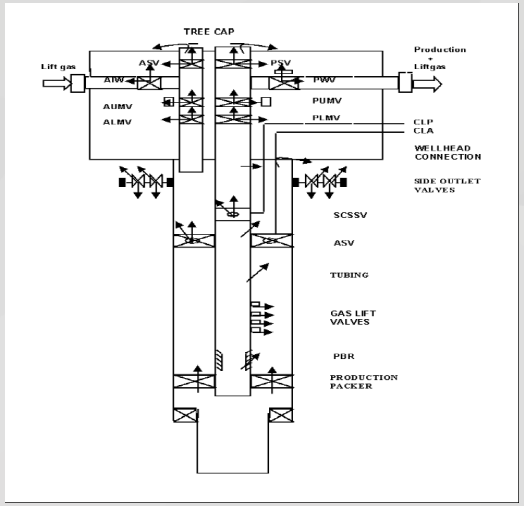
Outline

The goal of this part of our presentation is to describe Battelle's initial attempts to collect UGS-related failure rates, and how this experience redirected our efforts:

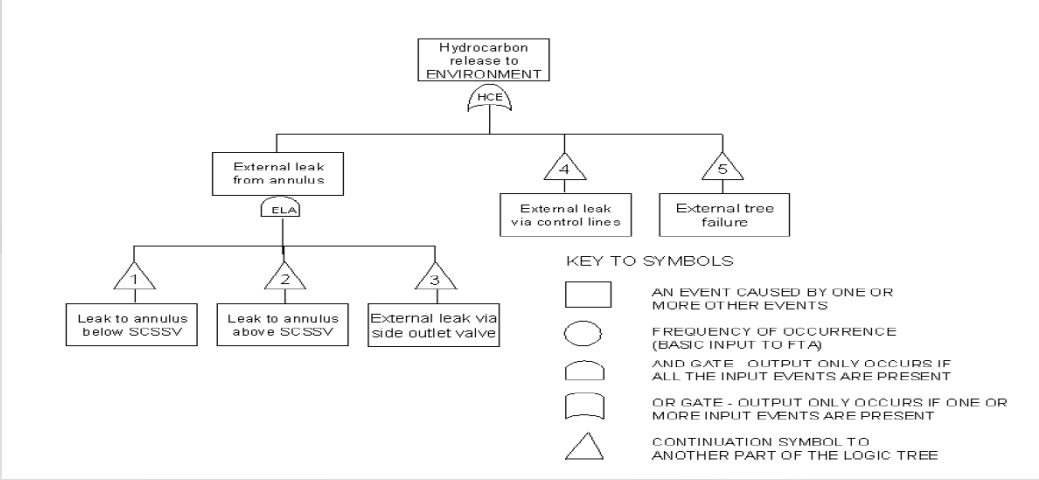
- Types of failure data needed for probabilistic failure models
- Published reports and databases offer very limited UGS-specific information
- Non-UGS failure data can be used with caution
- Legal and liability barriers restrict data collection and sharing by UGS operators

Probabilistic failure models require detailed failure rate data

Well schematic:



Fault tree:



Failure frequency calculations based on known failure rates:

$$A_{SIS}(t) = 1 - \prod_{I}^{N} (1 - A_i)$$

Failure rate predictions:

TABLE 7- HYDROCARBON RELEASE FREQUENCY (CASE I)

Case	Production (per year)	Workover (per year)	Combined (per year)
No ASV	7.74×10^{-5}	8.76×10^{-5}	1.53×10^{-4}
With ASV	6.59×10^{-5}	1.82×10^{-4}	2.59×10^{-4}
difference	-15%	+52%	+40%

Source: C.J. Durham et al. *Radical Solutions Required: Completions Without Packers and Downhole Safety Valves Can Be Safe* (1999) (SPE 56934)

Types of data required for detailed probabilistic model

Probabilistic model describing use of SSSVs in UGS well would require:

- Data sufficient to calculate failure rates (expressed in failures/well×year) with failure modes
- Differentiation between different valve locations: surface, subsurface, deep-seat
- Frequency of required maintenance
- Failure rates during workover or maintenance
- Types of SSSVs used

Well	Age of well	Workover operations				Regular operations				Additional well information (if available)
		T&P failures (if any)	T&P failures mode	SSSV failures (if any)	SSSV failures mode	T&P failures (if any) with time	T&P failures mode	SSSV failures (if any) with time	SSSV failures mode	

Very limited UGS-related failure rate can be obtained from available sources

Battelle identified two data bases; both have very limited information:

- WellMaster:
  - 160 UGS + T&P wells, mostly offshore, with some failures recorded
  - 3 UGS + SSSV wells, all offshore, no failures for these
- PHMSA annual report database:
  - Helpful for identification of UGS operators using T&P or SSSVs; however, no specific failure information given

There are several journal articles and reports focusing on UGS safety:

- The API-INGAA-AGA 2016 white paper “Underground Natural Gas Storage – Integrity & Safe Operations“ appears to be the best source of UGS-specific failure rates
- Reports describing UGS safety record provide information about accidents; however, it is challenging to extract component-specific failure rates

How about non-UGS failure rates, can these be used instead?

If used with caution, non-UGS failure rates can be used to describe UGS reliability:

- Battelle/Sandia team tested the non-UGS failure data and found relevance to UGS wells
- We also used reliability ranges wider than what the offshore data suggest, so we did encompass ranges of reliability that are reasonable
- We used well workover loss of containment potential from oil and gas well failure rates
- We used a comparison of SV reliability from industry data and from other world data bases (SINTEF)
- A sustained effort to increase reliability of offshore SSSVs significantly improved performance of these devices, the same type of effort in the UGS field

Failure rates from UGS operators

INGAA helped to organize a group of UGS companies:

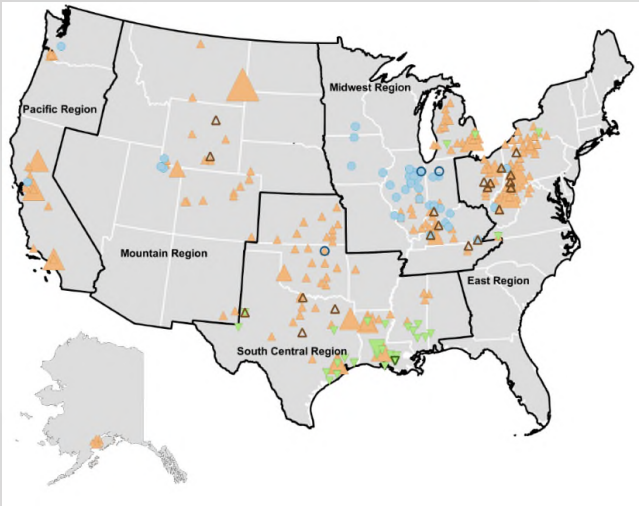
- Several major UGS operators were represented
- Specific data needs of the Battelle/Sandia projects were discussed over a period of a few months
- Transfer of limited data was agreed to, with the restriction that it will be anonymous. INGAA handled and compiled the data, Battelle/Sandia is not aware what operators supplied this information.
- Battelle/Sandia received the data describing operations of several hundreds of UGS wells – this data are consistent with the failure rates given in the API-INGAA-AGA 2016 white paper
- Battelle/Sandia team wants to thank INGAA and all operator companies who participated in this process. Although, the collected data did not provide new rate information beyond already published results, is clearly showed the challenges of sharing real-world risk industry information. Battelle/Sandia team realized that the unavailability of failure data is the data point by itself.

Why is it so difficult to collect UGS failure data?

There are several factors preventing collection and sharing of :

- UGS operations in US are regulated by a mosaic of state and federal regulations
- Accident and failure data are generally sensitive due to liability and legal restrictions
- UGS operators may consider these data proprietary because of commercial reasons
- Public relation considerations tend to restrict release of any accident information
- UGS industry may not see data collection and sharing as necessary, even beneficial

Component reliability data collection should be encouraged



SAND2020-2738 PE

Analysis of State Data

Dylan Moriarty
Sandia

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Purpose

Analyze failure statistics of SSSV's & extract trends from state data.

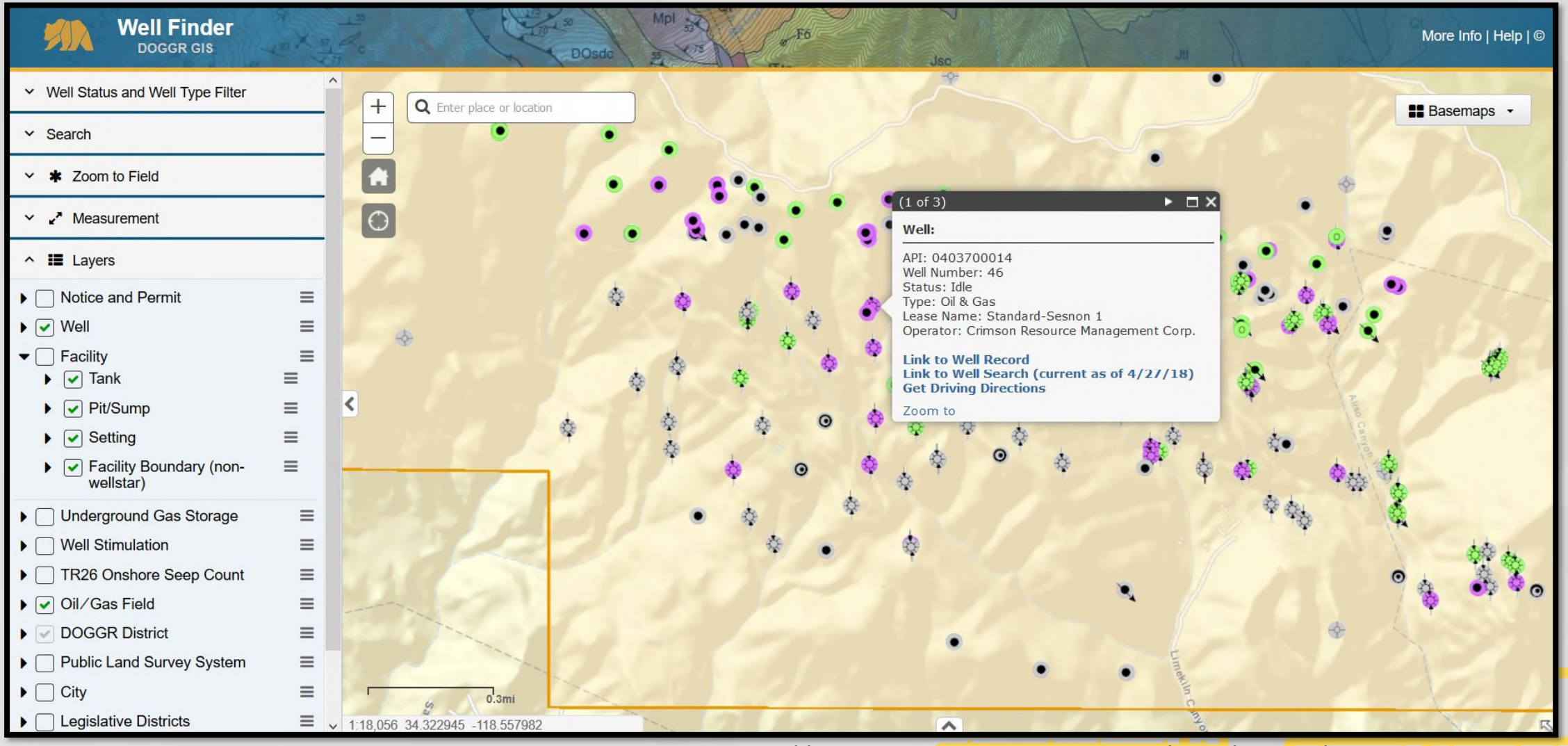
Takeaways

- Data are available
- Large undertaking to extract useful statistics
- *(Moving forward)* Need for standardized classification and collection

State Data Repositories

California

Department of Conservation (Well Finder App)



URL: https://www.conservation.ca.gov/dog/Pages/WellFinder.aspx

California

Information available by well, county, field, or operator

Division of Oil, Gas, and Geothermal Resources - Well Search

Production and injection data can be found at this location:
ftp://ftp.consrv.ca.gov/pub/oil/Online_Data/Production_Injection_Data

Well Details | Well Info | Well Records | Production Data | Injection Data | Production Charts | Injection Charts | Well Search

Well Information

API #	Lease	Well #	County	District
03700041	Standard Sesnon	29	Los Angeles [037]	2

Operator	Field	Area
Southern California Gas Company [S4700]	Aliso Canyon [010]	Any Area [00]

Section	Township	Range	Base Meridian	Well Status	Pool WellTypes	SPUD Date
28	03N	16W	SB	Active	GS	4/26/1953

GIS Source	Datum	Latitude	Longitude	Map
gps	83	34.315276	-118.566506	

Click to get Sum by County: **Los Angeles [037]** or Field: **Aliso Canyon [010]** or Operator: **Southern California Gas Company [S4700]**

Get sum by Field-Operator-Lease: **Standard Sesnon**

California

Detailed information available for download

Well Records

Show 25 entries

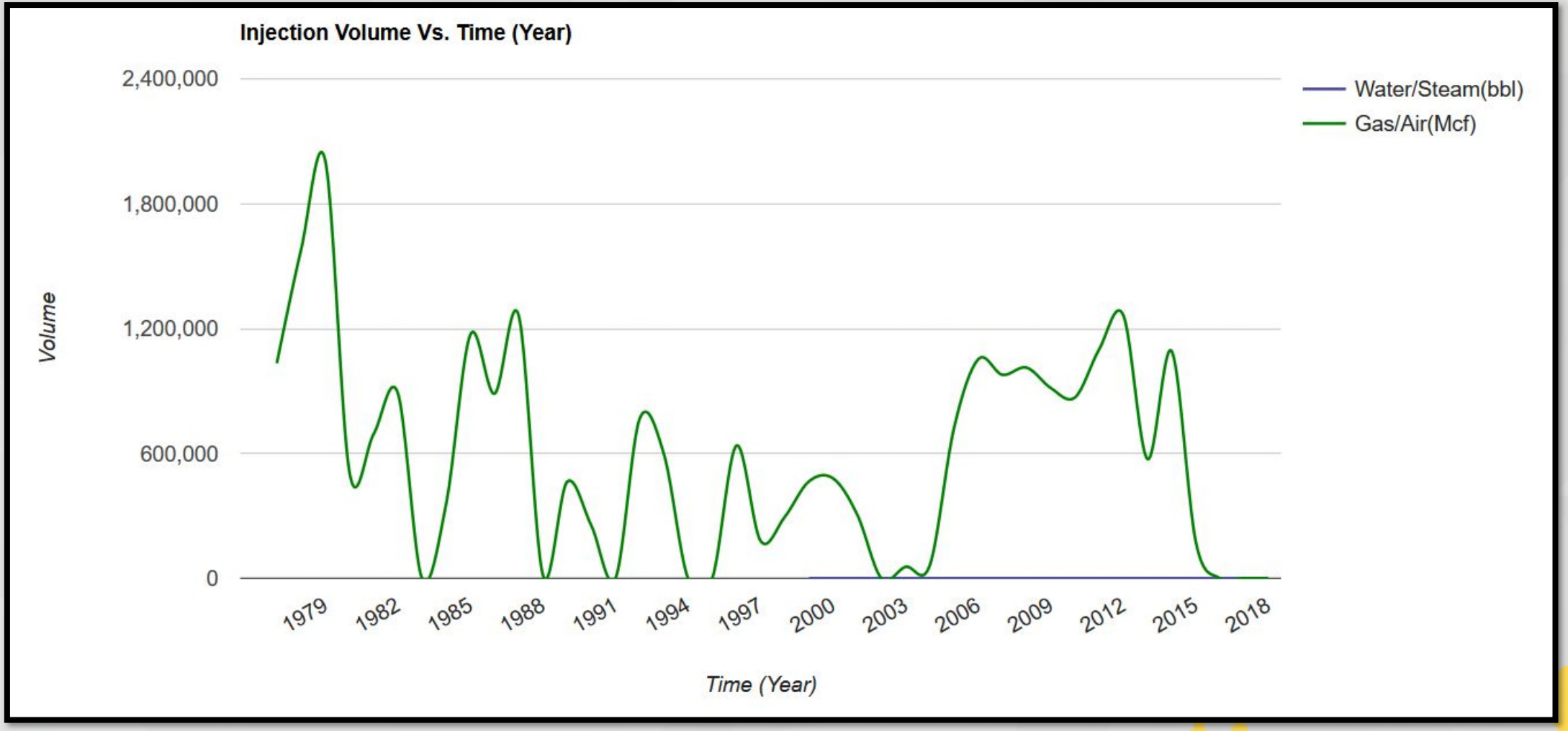
‹ Previous 1 2 3 4 Next ›

Showing 1 to 25 of 79 entries

File Name	Type	Size	Modified on
03700041_SS 29_MAC_01-24-2019.pdf	PDF	6.00 MB	5/6/2019
03700041_DATA_03-19-2008.pdf	PDF	80.00 MB	4/12/2019
03700041_SS 29__WBD_01-31-2019.pdf	PDF	79.00 KB	2/25/2019
03700041_SS 29_PTEST_01-27-2019.xlsx	Excel	51.00 KB	2/7/2019
03700041_SS 29_CBL_12-27-2018.pdf	PDF	5.00 MB	1/29/2019
03700041_SS 29_CsgInsp_5in_12-26-2018.PDF	PDF	514.00 KB	1/29/2019
03700041_SS 29_IBC_01-07-2019.pdf	PDF	18.00 MB	1/29/2019
03700041_SS 29_MAC_12-27-2018.PDF	PDF	11.00 MB	1/29/2019
03700041_SS 29_CsgInsp_5.5in_12-26-2018.PDF	PDF	8.00 MB	1/29/2019
03700041_SS 29_CsgInsp_5in_12-26-2018.xlsx	Excel	37.00 KB	1/28/2019
03700041_SS 29_CsgInsp_5.5in_12-26-2018.xlsx	Excel	94.00 KB	1/28/2019
03700041_SS 29_IBC_01-07-2019.xls	Excel	169.00 KB	1/28/2019
03700041_SS 29_PTEST_12-28-2018.xlsx	Excel	54.00 KB	1/11/2019
03700041_SS 29_CBL_12-13-2018.pdf	PDF	3.00 MB	12/14/2018
03700041_SS 29_CBL_10-10-2018.pdf	PDF	5.00 MB	10/12/2018

California

Limited charts are available



Michigan

Department of Environment, Great Lakes, and Energy

EGLE MICHIGAN DEPARTMENT OF ENVIRONMENT, GREAT LAKES, AND ENERGY

Search

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LAND

- Remediation
- Redevelopment
- Oil & Gas
- Compliance & Enforcement
- Mining
- Mineral Wells
- Dunes
- Soil Erosion and Construction Storm Water

EGLE / LAND / OIL & GAS

DATABASE DOWNLOADS - WHERE TO FIND DIGITAL DATA

Contact: Oil, Gas, and Minerals Division 517-582-3446

INTERNET MAPPING/DATA ACCESS APPLICATIONS

- **GeoWebFace** - 120 oil & gas and geological layers **Application** **Website** **User Guide**
- **Data Portal** (work in progress) **Application** **User Guide** **About Data Portal**

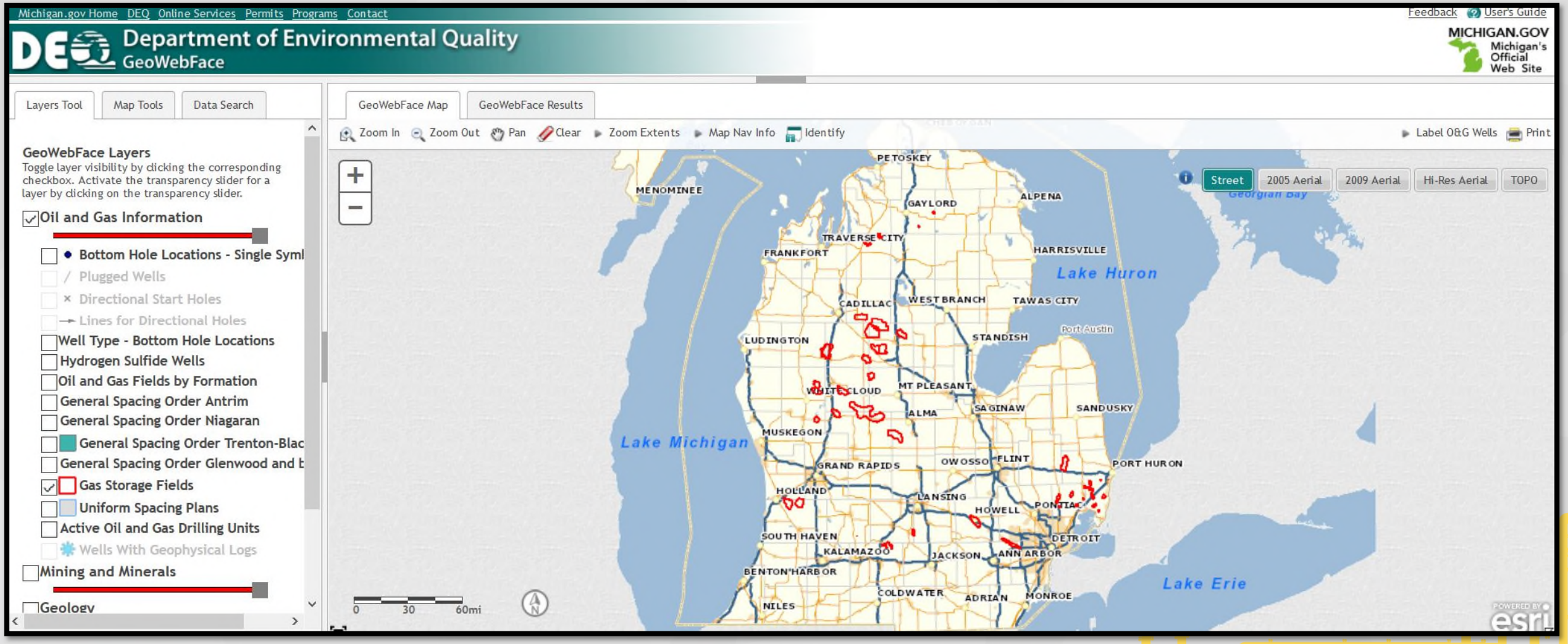
OIL & GAS WELL DOCUMENTS

- Individual Well Files
- Raster Logs (Geophysical logs in .tiff, .pdf, and .las formats)
- Drillers Logs

For more information - **About Oil and Gas Well Documents.**

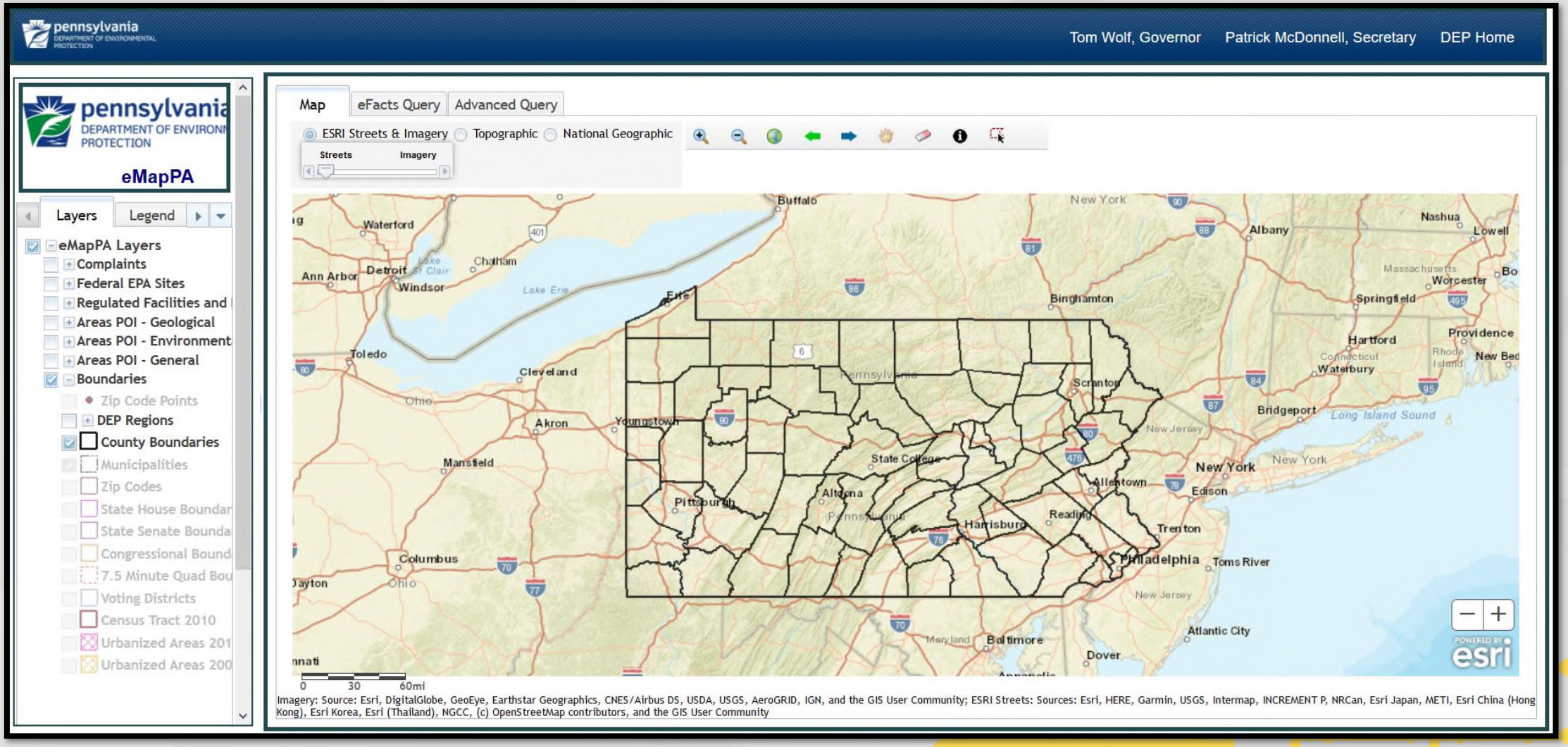
Michigan

Some mapping available



Pennsylvania

Department of Environmental Protection



URL: https://www.michigan.gov/egle/0,9429,7-135-3311_4231-188295--,00.html

Pennsylvania

Additional information hosted by Penn State

https://www.pasda.psu.edu/

PASDA

PENNSYLVANIA SPATIAL DATA ACCESS
The Pennsylvania Geospatial Data Clearinghouse

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Data Summary

Oil & Gas Locations

2019 - *Pennsylvania Department of Environmental Protection*

Metadata | **Download** | **Preview** | **KMZ** (GoogleEarth) | **Spreadsheet** | **GeoJSON** | Add to ArcMap IMAGE | FEATURE

API
REST: https://maps.pasda.psu.edu/ArcGIS/rest/services/pasda/DEP/MapServer
WMS: https://maps.pasda.psu.edu/arcgis/services/pasda/DEP/MapServer/WMSServer?SERVICE=WMS&request=getcapabilities

ADDITIONAL RESOURCES
Online Viewer Application: https://maps.psiee.psu.edu/paatlas/
Data Archive: Download historic versions of this dataset

ABSTRACT
An Oil and Gas Location is a DEP primary facility type related to the Oil & Gas Program. The sub-facility types related to Oil and Gas that are included in this layer are:_____ Land Application -- An area where drilling cuttings or waste are disposed by land application Well-- A well associated with oil and/or gas production Pit -- An approved pit that is used for storage of oil and gas well fluids . Some sub facility types are not included in this layer due to security policies.

Extracting Data – The Library

Extracting Data – The Library

Task: Find the pages that reference failure

Extracting Data – The Library

Potential Problems

- Not optimized for solving our problem

Extracting Data – The Library

Potential Problems

- Not optimized for solving our problem
- Small number of occurrences

Extracting Data – The Library

Potential Problems

- Not optimized for solving our problem
- Small number of occurrences
- …still need to sample everything

Extracting Data – The Library

Potential Problems

- Not optimized for solving our problem
- Small number of occurrences
- …still need to sample everything
- Classification inconsistencies

Future Data Collection

- Failure statistics ↔ Reliability Metrics
- Data collection and storage
- Common classification

Discussion to follow…

Takeaways

- Data are available
- Large undertaking to extract useful statistics
- *Moving forward*, need for standardized data collection

Discussion – Data Collection

1. Would your company be willing to collaborate with industry partners in sharing well barrier element reliability information to a secure, managed data warehouse?

2. What type of data is useful? What is already being captured? What should be captured? How can it be standardized?