Geotechnical Earthquake Engineering and Soil Dynamics V

Austin, Texas | June 10–13, 2018

UCLA Samueli School of Engineering

Next Generation Liquefaction (NGL) Case History Database

Paolo Zimmaro
Research *Scientist and Lecturer*

Co-authors:
Scott J. Brandenberg, Dong Youp Kwak, Yousef Bozorgnia, Steven L. Kramer, Jonathan P. Stewart

June 13, 2018

NGL NEXT GENERATION LIQUEFACTION

Engineer Change.

NGL Project Directors

Jonathan P. Stewart
UCLA

Steven L. Kramer
University of Washington

Yousef Bozorgnia
UCLA

Outline

Introduction

Databases vs collection of data

The NGL database structure

Current status of the database

Final thoughts and perspectives

NGL Project Activities

1. Develop a publicly available **database** of liquefaction/cyclic softening case histories.

2. Provide a coordinated framework for **supporting studies** to augment case history data for conditions that are poorly constrained by empirical data.

3. Provide an open, collaborative process for **model development** in which developer teams have access to common resources and share ideas during development.

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3. Provide an open, collaborative process for **model development** in which developer teams have access to common resources and share ideas during development.

NGL Database Contributors

- ***Database working group***: Scott Brandenberg (chair), Robb E.S. Moss (Cal Poly), K. Onder Cetin (METU), Kevin Franke (BYU), Paolo Zimmaro (UCLA), and Dong Youp Kwak (Hanyang University)
- ***Southwest Research Institute***: John Stamatakos, Miriam Juckett, Bis Dasgupta, Joey Mukherjee, Zackary Murphy, Steven Ybarra
- ***Nuclear Regulatory Commission***: Thomas Weaver
- ***Caltrans***: Tom Shantz
- ***Lateral Spread Project***: Steve Bartlett, Masoud Hosseinali


NGL Database Contributors

- ***BYU***: Heidi Dacayanan, Lila Lasson
- ***Virginia Tech***: Russell Green, Kristin Ulmer
- ***UC Berkeley***: Jonathan Bray, Christine Beyzaei
- ***Tonkin & Taylor***: Sjoerd Van Ballegooey, Mike Liu
- ***UCLA***: Chris Nicas, Omar Issa, Trini Inouye, Arielle Sanghvi, Tristan Buckreis, Naoto Inagaki, Wyatt Iwanaga, Michael Winders, Bryan Ong, Siddhant Jain
- ***Others***: Mike Greenfield, Teruo Nakai, Hideo Sekiguchi

What is a Database?

Definition Used by Engineers: “A Collection of Data”

- Examples include experimental data archived in DesignSafe (formerly NEEShub), or ground motion records made available through various NGA projects (**typically spreadsheets**).

- This is not a database according to the data science community, who reserve the word “database” for a **relational database** (e.g., MySQL, Microsoft Access).

Example Database

Event Name	Magnitude	Epicentral Latitude	Epicentral Longitude	Station Name	V_{S30} (m/s)	R_{jb} (km)	PGA (g)
Westwood Hills	6.3	34.0689	118.4452	Factor Building	380	2	0.84
Westwood Hills	6.3	34.0689	118.4452	Santa Monica Courthouse	215	14	0.28
Hollywood Valley	7.2	34.1027	118.3404	Factor Building	380	20	0.61
Hollywood Valley	7.2	34.1027	118.3404	Santa Monica Courthouse	215	30	0.32

Event

Station

Ground Motion

Example Database Schema

Event Table

Event_id	Event Name	Magnitude	Epicentral Latitude	Epicentral Longitude
1	Westwood Hills	6.3	34.0689	118.4452
2	Hollywood Valley	7.2	34.1027	118.3404

Primary Key

Foreign Key

Station Table

Station_id	Station Name	V_{S30} (m/s)
1	Factor Building	380
2	Santa Monica Courthouse	215

Motion Table

Motion_id	Event_id	Station_id	R_{jb} (km)	PGA (g)
1	1	1	2	0.84
2	1	2	14	0.28
3	2	1	20	0.61
4	2	2	30	0.32

Relationships set through shared fields (keys)

Primary key: unique identifier for each record

Foreign key: field in one table that identifies a record in another table

Benefits of relational databases:

Smart database (query, advanced tools)

Minimize duplicated fields

Avoid null fields

Traditional vs Next-Generation

From *spreadsheet*
(Traditional data analysis)

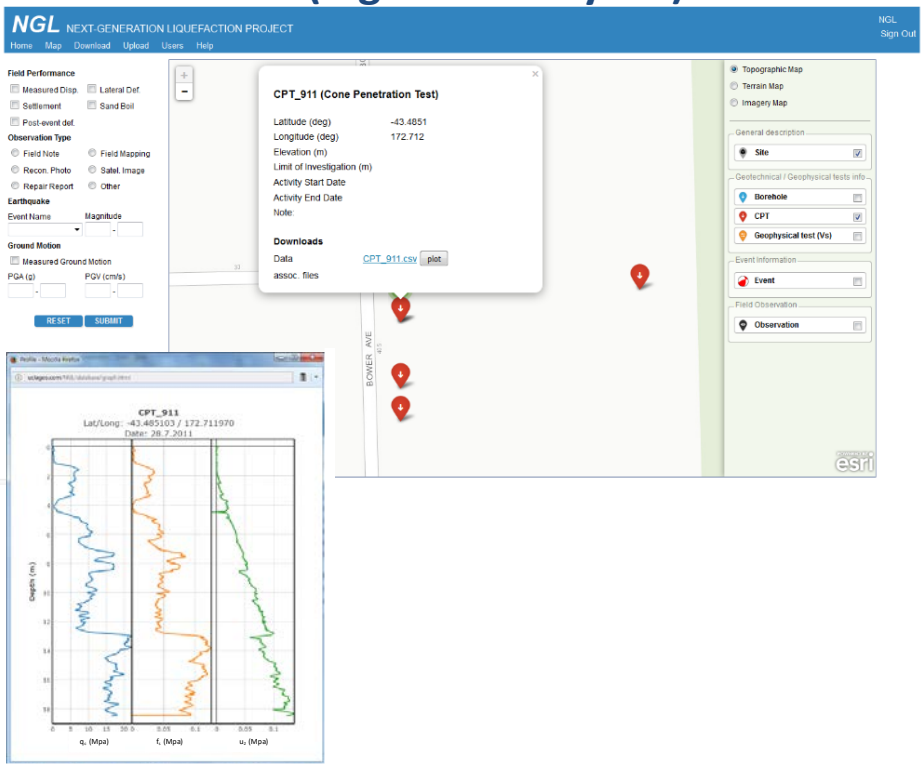
	A	B	C	D	E	F
1	Record Sequence Number	EQID	Earthquake Name	YEAR	MODY	HRMN
2	1	0001	Helena, Montana-01	1935	1031	1838
3	2	0002	Helena, Montana-02	1935	1031	1918
4	3	0003	Humbolt Bay	1937	0207	0442
5	4	0004	Imperial Valley-01	1938	0606	0242
6	5	0005	Northwest Calif-01	1938	0912	0610
7	6	0006	Imperial Valley-02	1940	0519	0437
8	7	0007	Northwest Calif-02	1941	0209	0945
9	8	0008	Northern Calif-01	1941	1003	1614
10	9	0009	Borrego	1942	1021	1622
11	10	0010	Imperial Valley-03	1951	0124	0717
12	11	0011	Northwest Calif-03	1951	1008	0411
13	12	0012	Kern County	1952	0721	1153
14	13	0012	Kern County	1952	0721	1153
15	14	0012	Kern County	1952	0721	1153

PSA_H2_d005 | Sa_H2_d005

	HZ	IA
1	T7.500S	T8.000S
8151	0.000247	0.000231
8152	0.003331	0.003473
8153	0.000661	0.000639
8154	0.000486	0.000700
8155	0.001060	0.001011
8156	0.001217	0.001057
8157	0.000836	0.000772
8158	0.008571	0.007123
8159	0.011123	0.009935
8160	0.002338	0.001956
8161	0.134076	0.112643
8162	0.298595	0.233477
8163	0.002516	0.002555
8164	0.004065	0.005418

PSA_H2_d005 | Sa_H2_

To relational database
(big-data analytics)



Next-Generation Liquefaction Database, Zimmaro et al. (2018a, SSA), Brandenberg et al. (2018b, GEESD)

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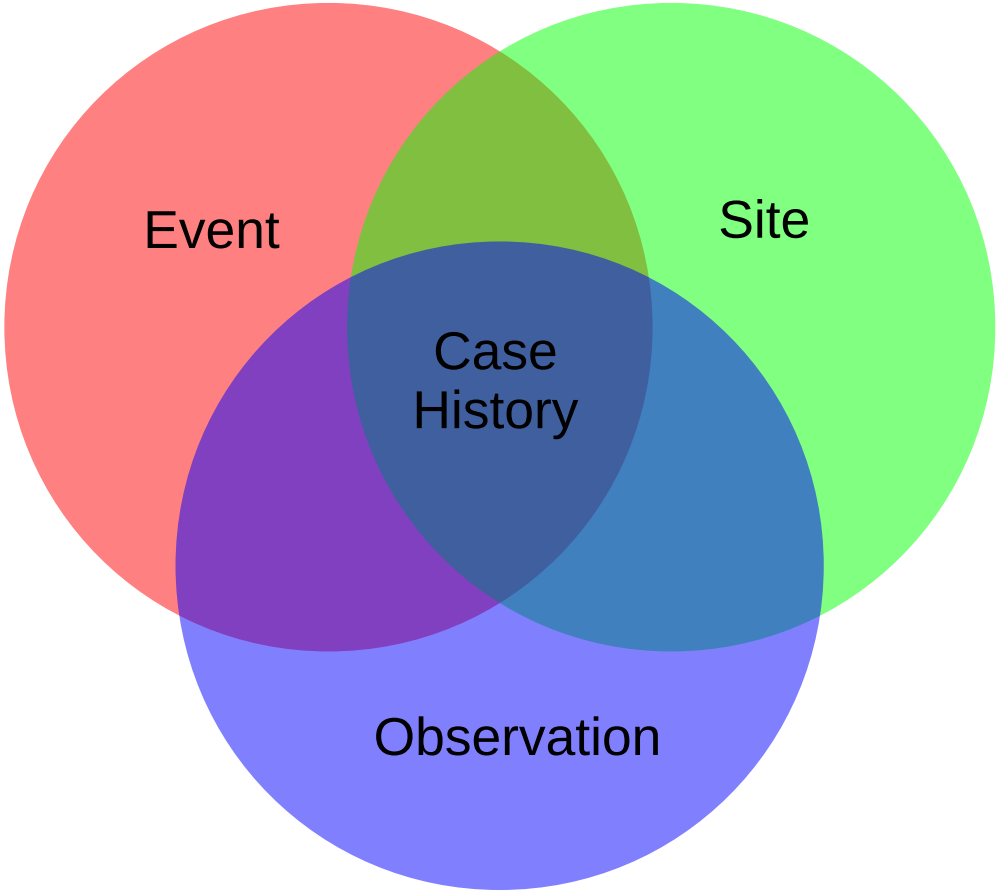
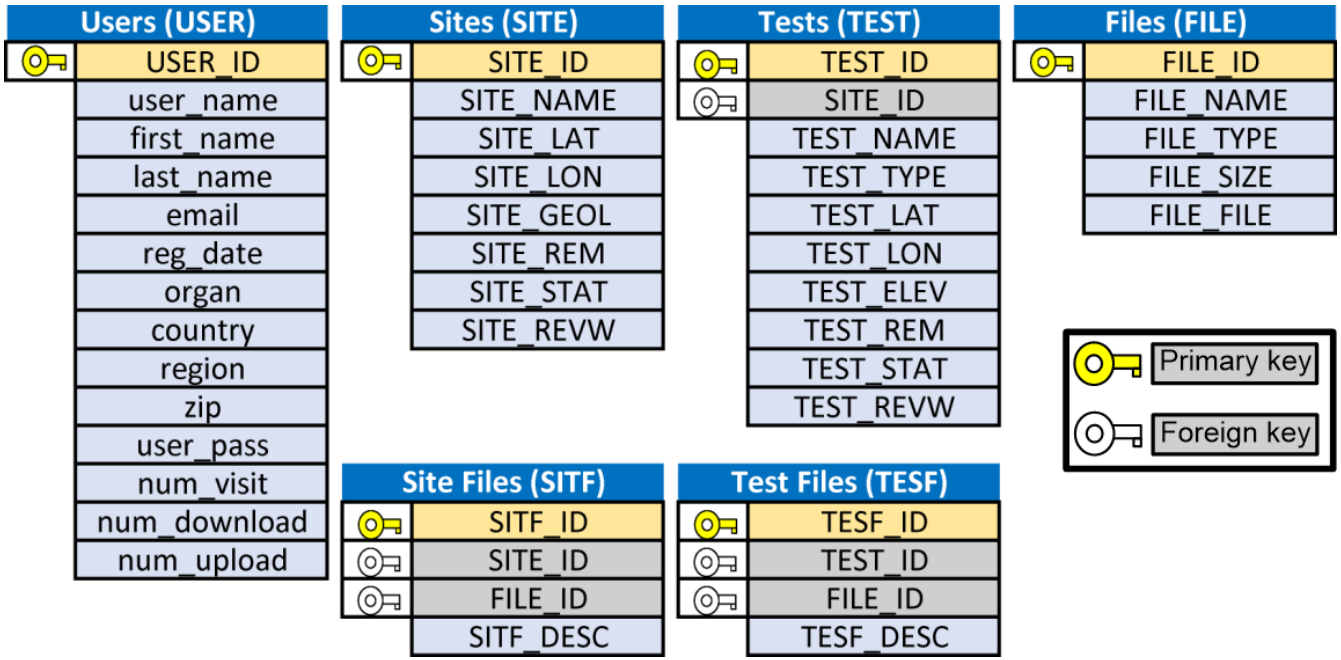
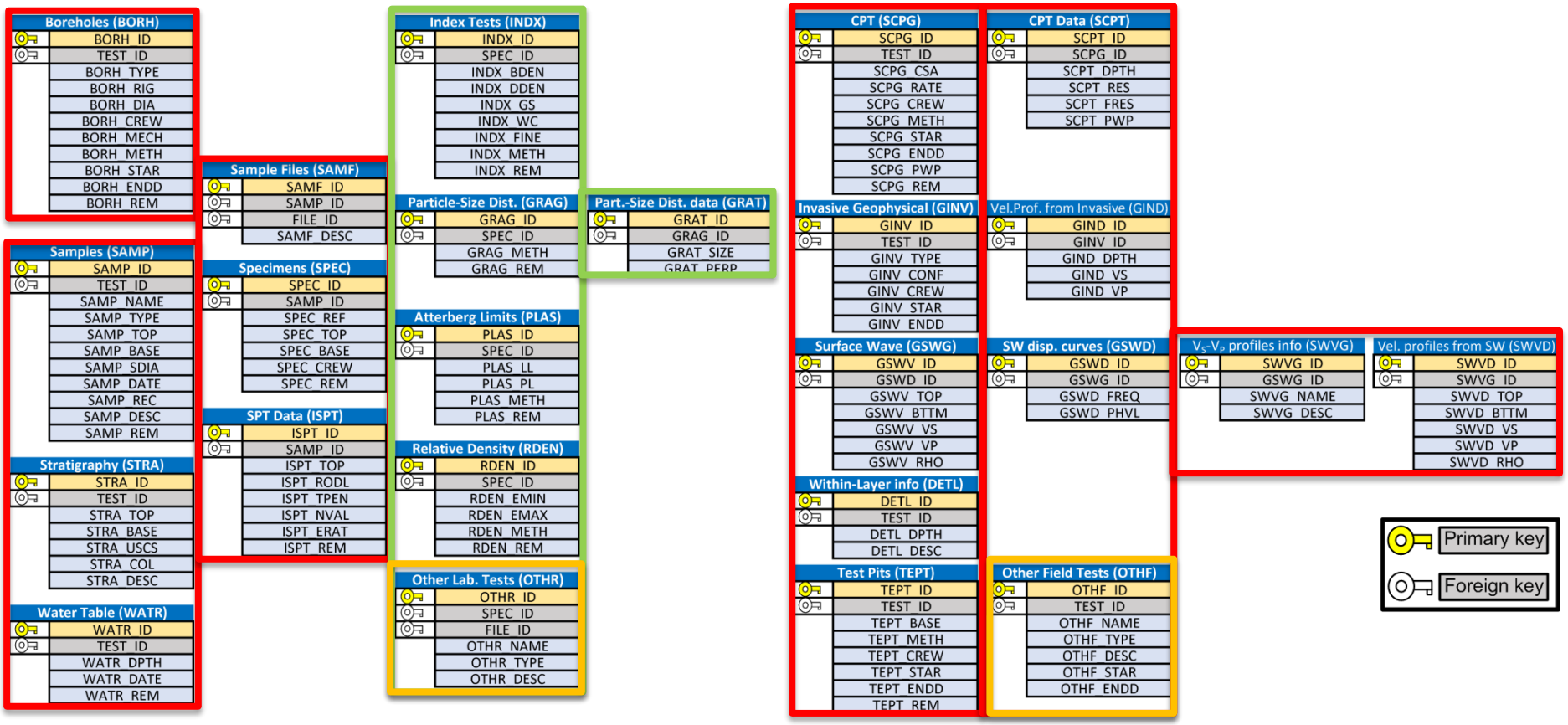
NGL Case History Definition



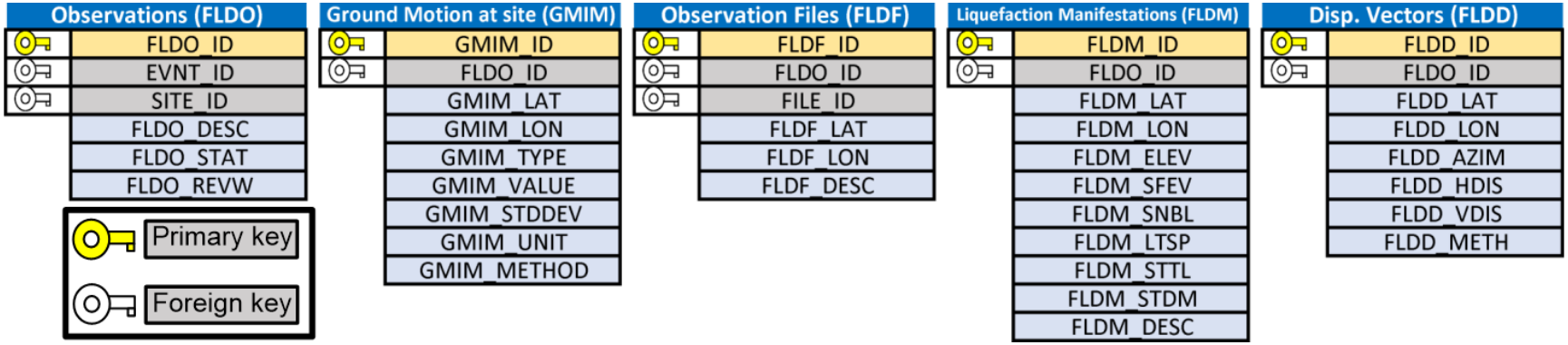
NGL Database Schema: General



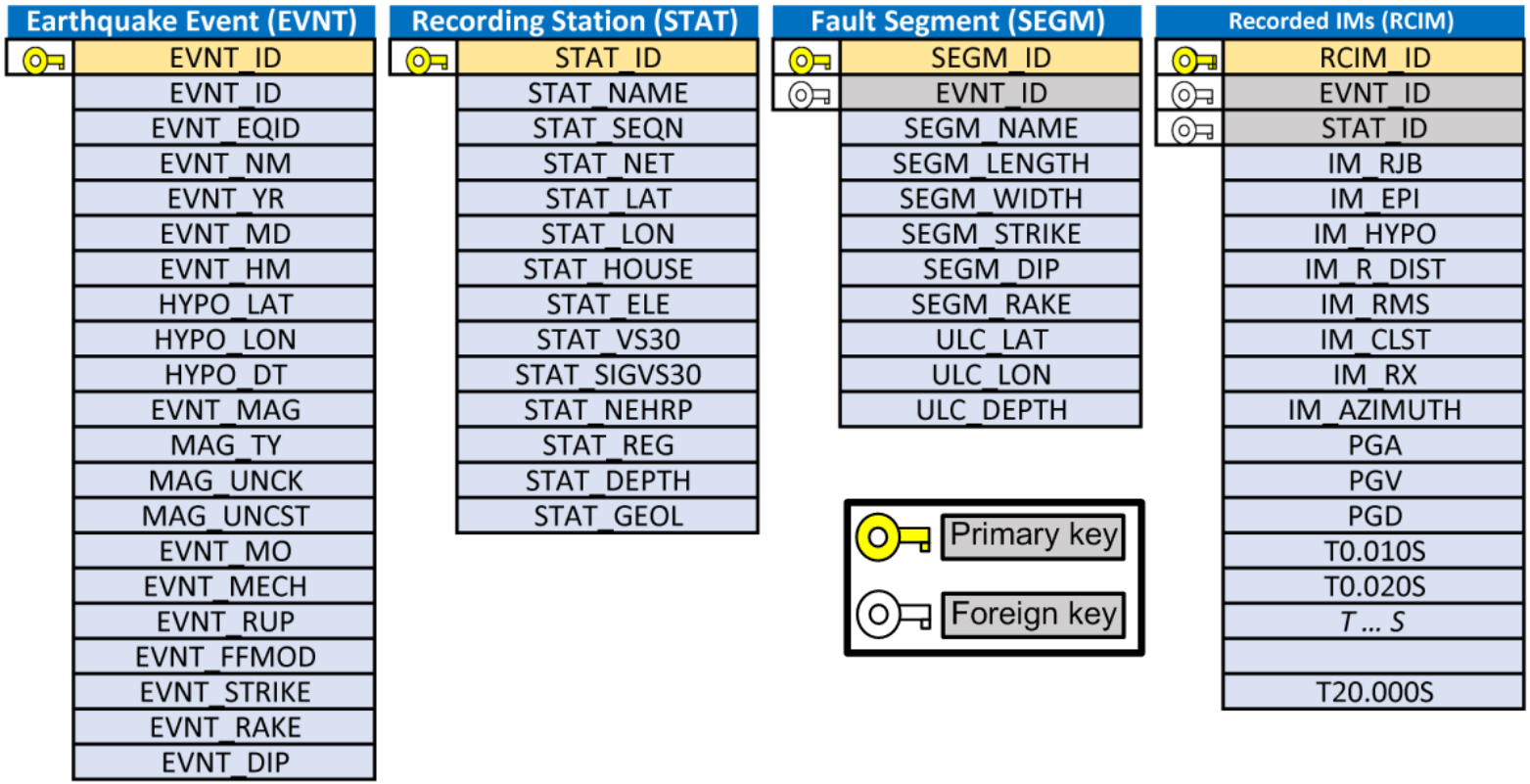
NGL Database Schema: Site



NGL Database Schema: Observation



NGL Database Schema: Event

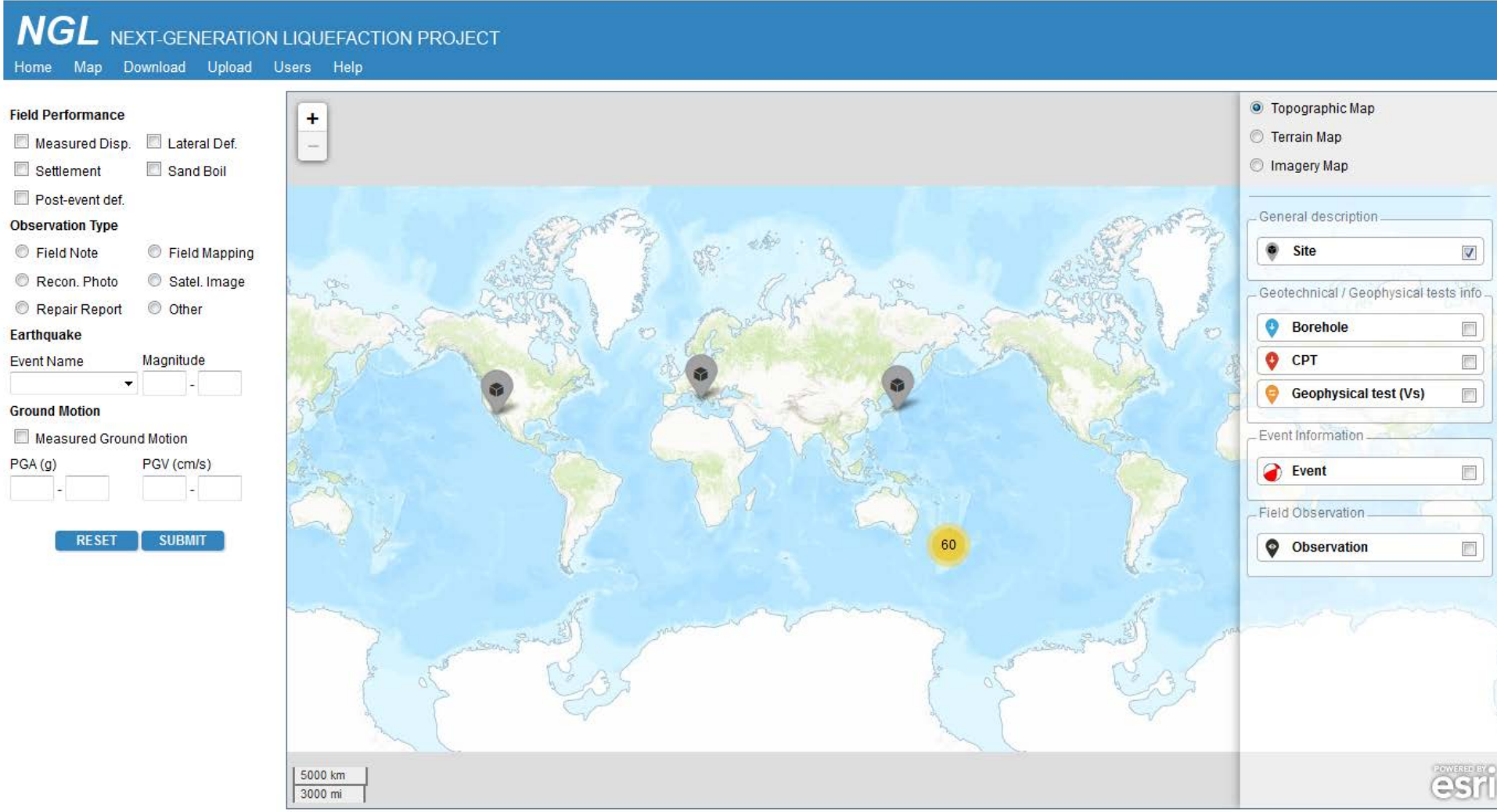


NGL includes NGA West-2 events
…soon NGA Sub

Community Vetting of Schema

- The schema is the outcome of a **broad community effort** involving review by the database working group and others.

- A 2-day workshop involving about 50 people was held in July 2017 in which the schema was presented and discussed in detail.



Developed as Structured Query Language (SQL) database management system

KPHP platform, GIS-based mapping tool

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Home Map Download Upload Users Help

Field Performance

☐ Measured Disp. ☐ Lateral Def.

☐ Settlement ☐ Sand Boil

☐ Post-event def.

Observation Type

○ Field Note ○ Field Mapping

○ Recon. Photo ○ Satel. Image

○ Repair Report ○ Other

Earthquake

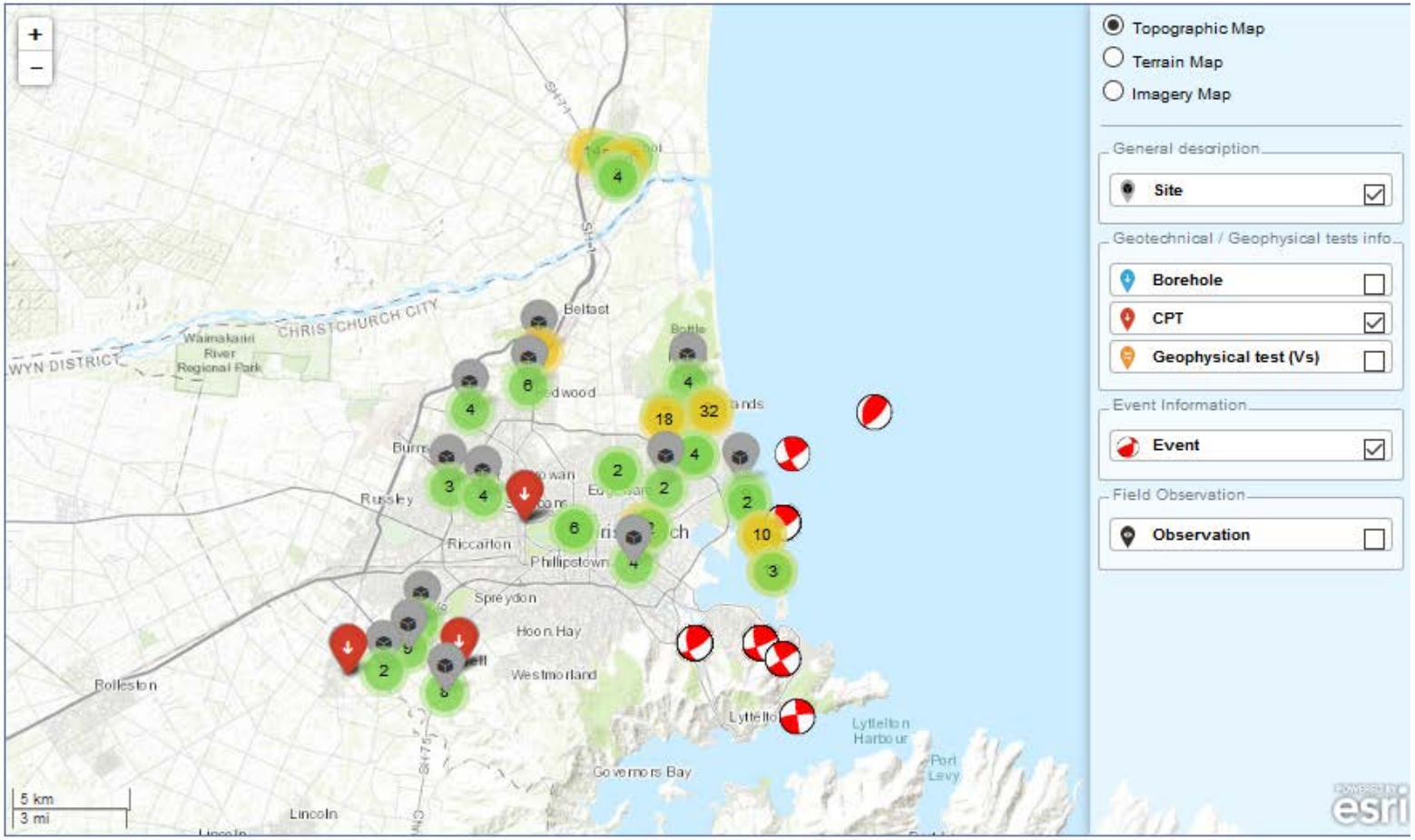
Event Name Magnitude

Ground Motion

☐ Measured Ground Motion

PGA (g) PGV (cm/s)

RESET SUBMIT



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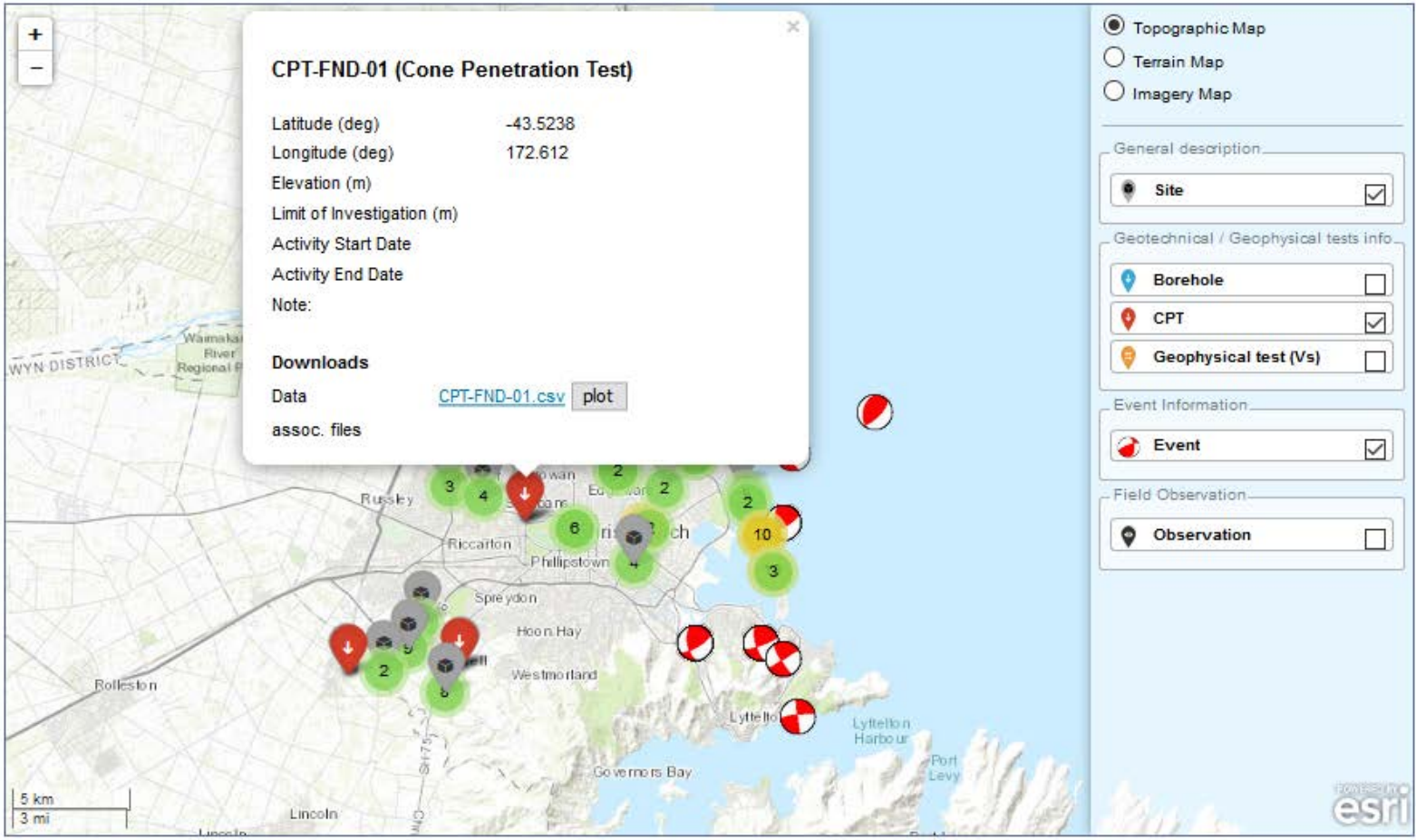

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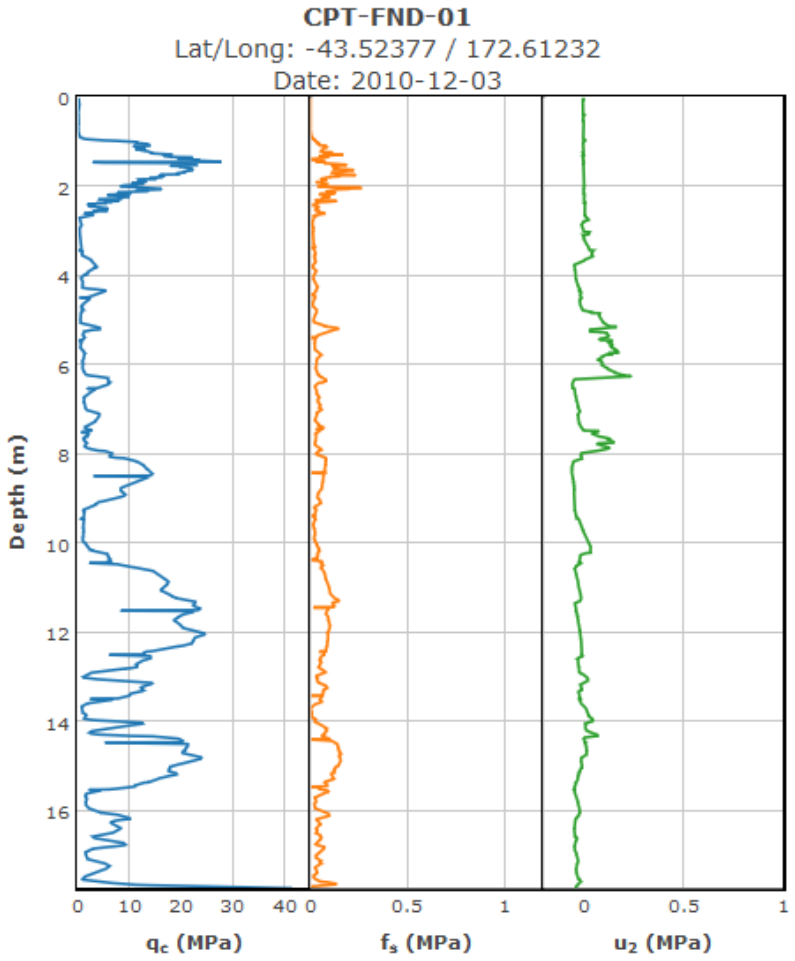

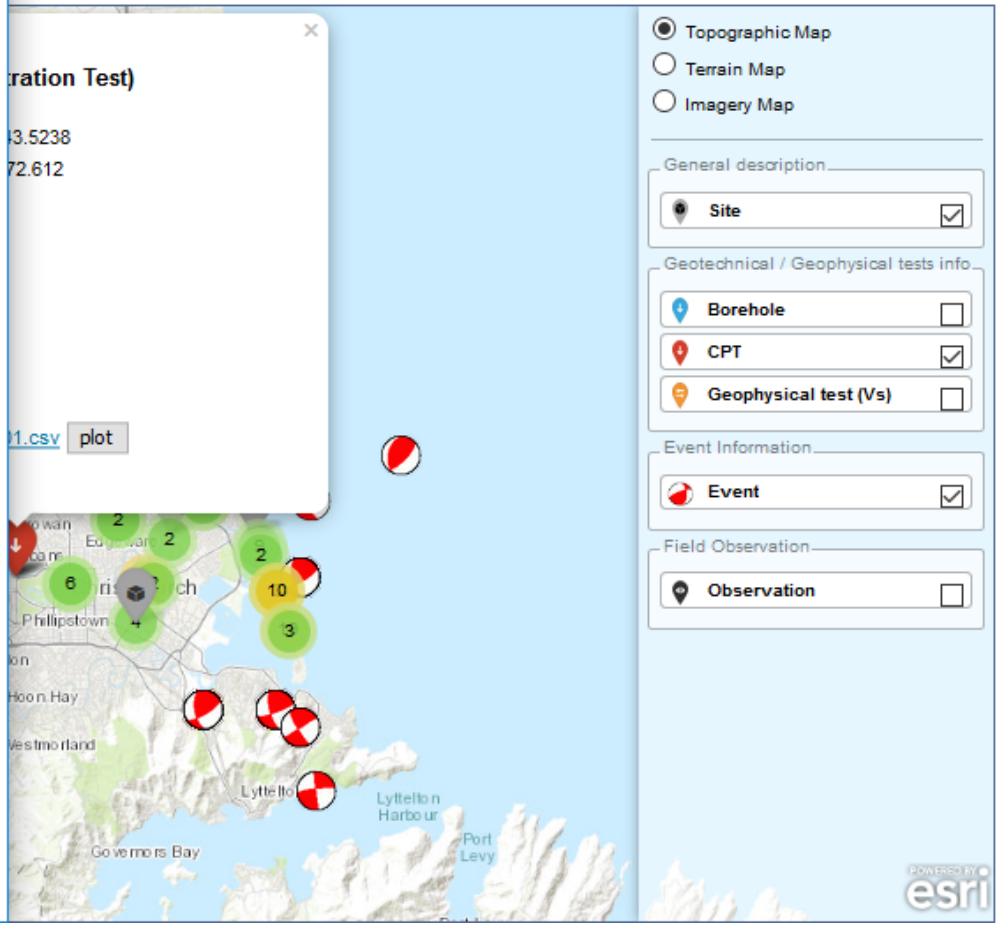

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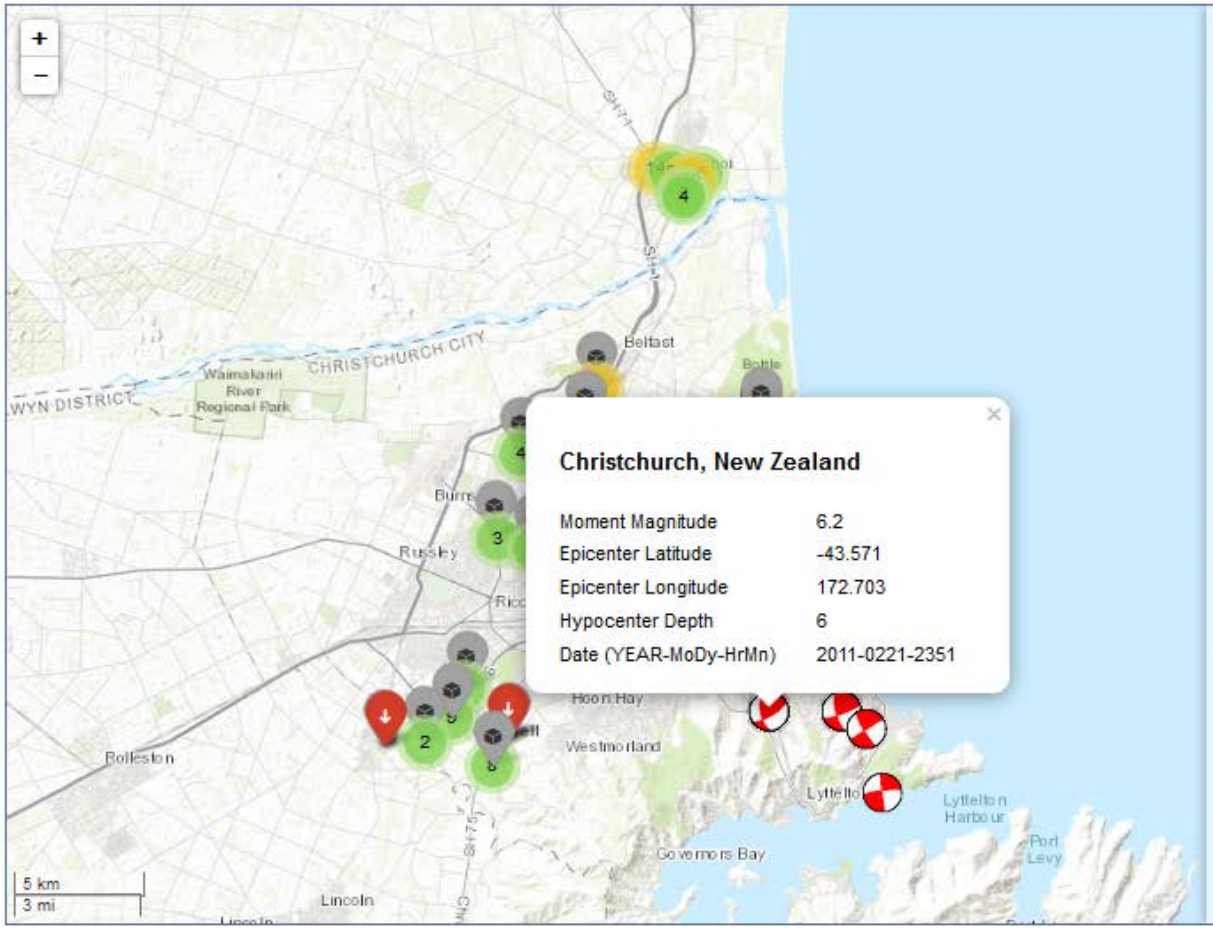

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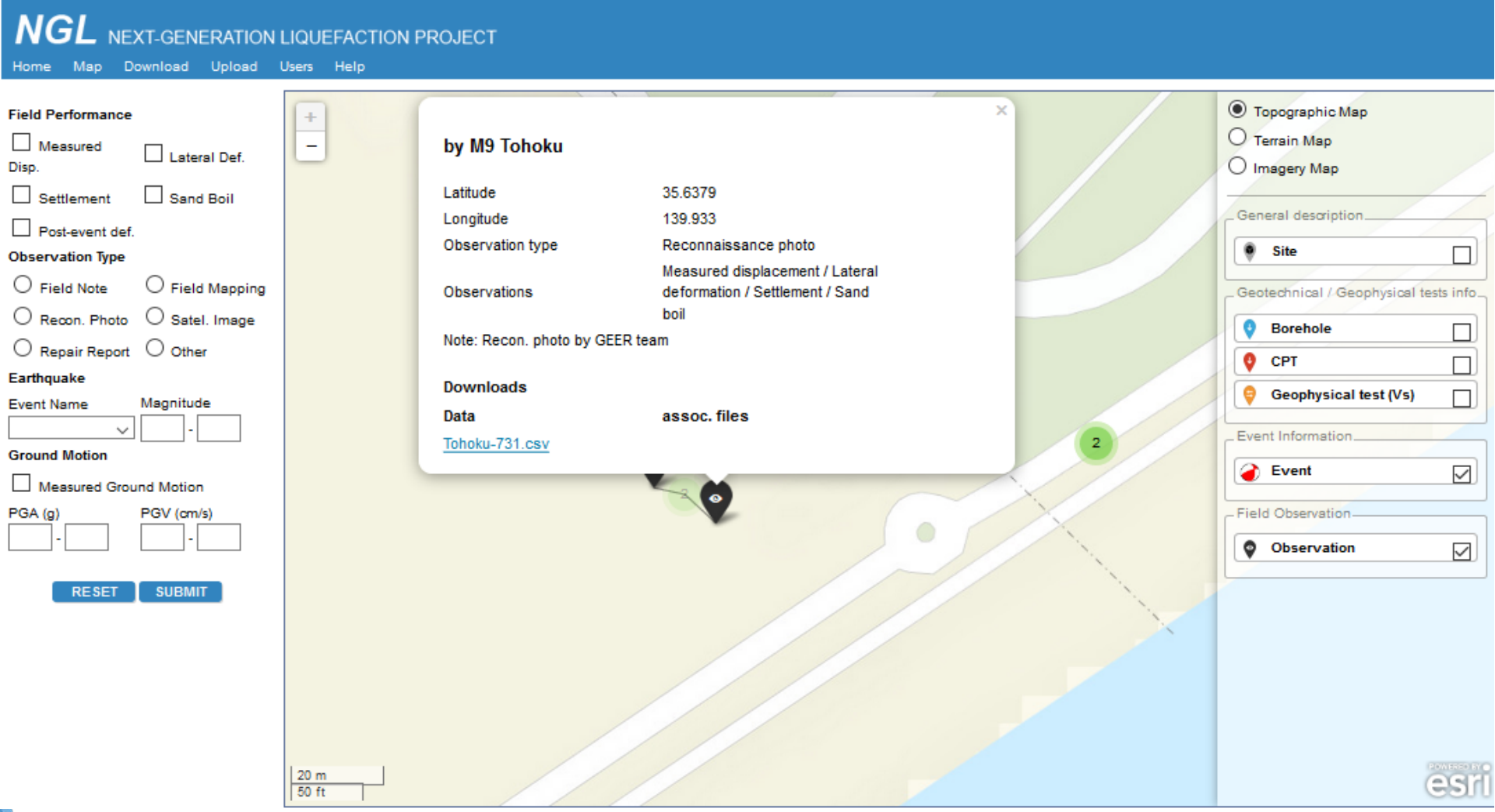
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Event Name
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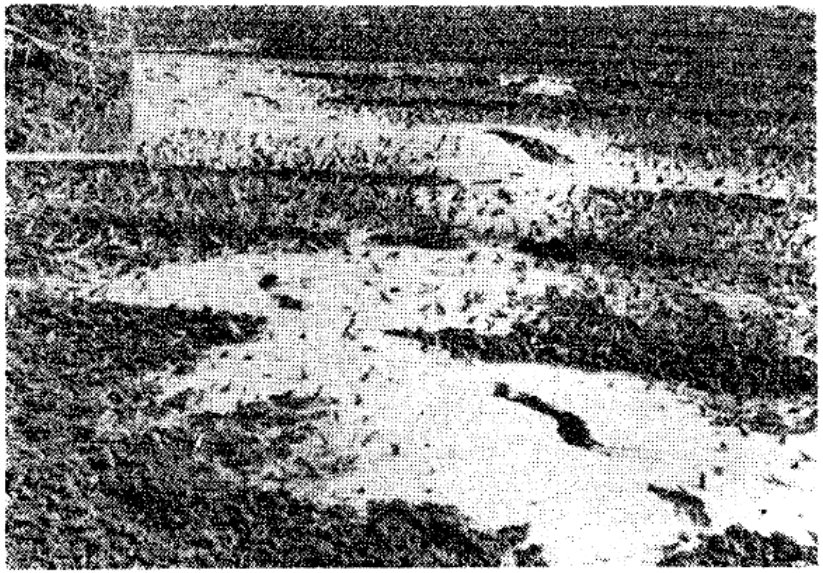
PGA (g)
PGV (cm/s)
RESET
SUBMIT
by M9 Tohoku
Latitude 35.6379
Longitude 139.933
Observation type Reconnaissance photo
Observations Measured displacement / Lateral deformation / Settlement / Sand boil
Note: Recon. photo by GEER team
Downloads
Data assoc. files
Tohoku-731.csv
2
20 m
50 ft
Topographic Map
Terrain Map
Imagery Map
General description
Site
Geotechnical / Geophysical tests info
Borehole
CPT
Geophysical test (Vs)
Event Information
Event
Field Observation
Observation
esri

Benefits of the NGL Database

Old case-histories

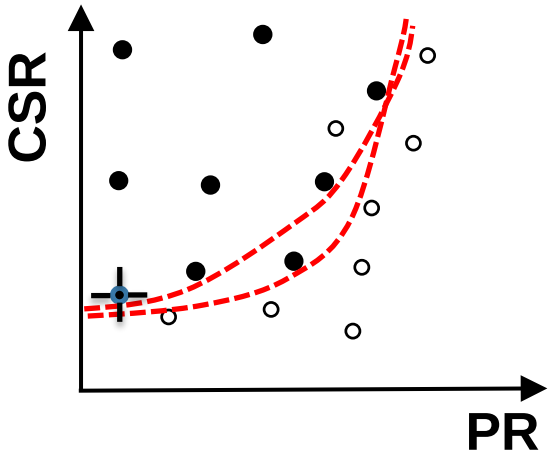
face clay silt layer. Following the 1977 earthquake, signs of liquefaction such as ejection of fine sand through the fissures or cracks were observed here and there in this area. Photo. 2 shows typical sand ejection



Bucarest (1977, Vrancea earthquake)
From Ishihara and Perlea (1984)

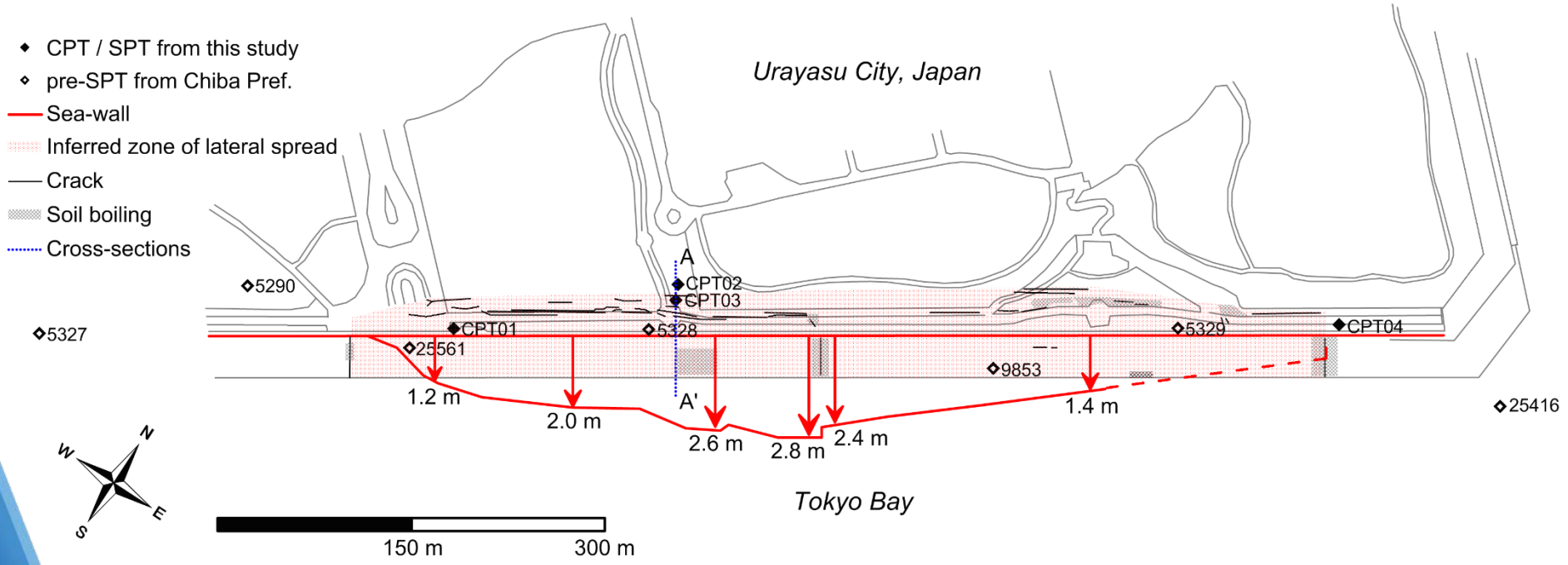
Earthquake	M_w
1977 Vrancea, Romania	7.20±0.11
Site	Liquefied?
Site 2	No

- Liquefaction
- No Ground Failure



Benefits of the NGL Database

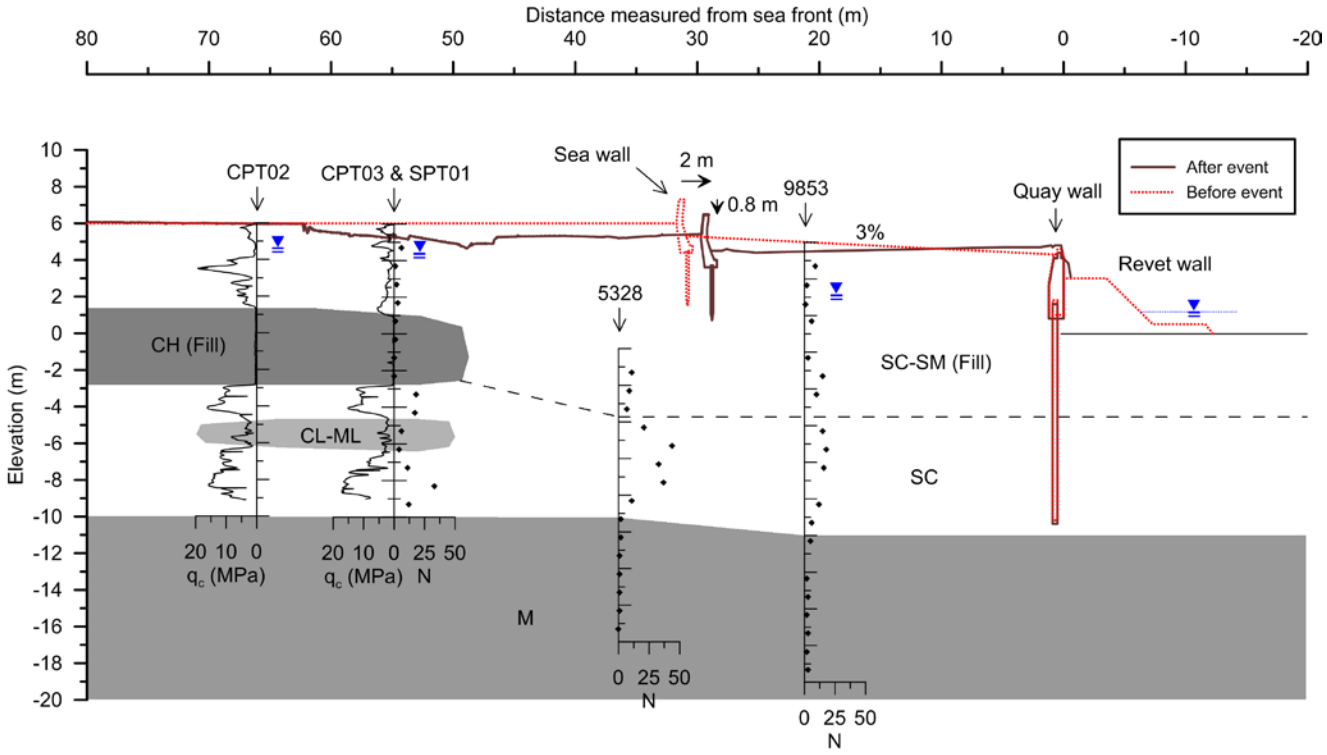
Recent case-histories



Urayasu, Japan (2011 – Tohoku-Oki)
From Stewart et al. (2016)

Benefits of the NGL Database

Recent case-histories

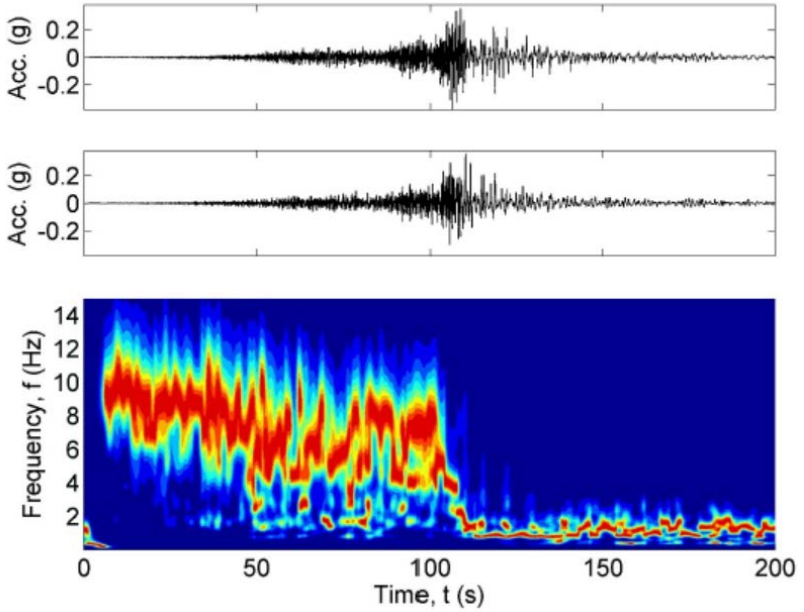


Urayasu, Japan (2011 – Tohoku-Oki)
From Stewart et al. (2016)

Benefits of the NGL Database

Recent case-histories

Motion-based data



Ibaraki, Japan (2011 – Tohoku-Oki)
From Kramer et al. (2016) and
M. Greenfield pers. comm.

Current Status

- 63 sites (~200 case histories) in current version of NGL website.
- During development, we have created 25 additional case histories using a CSV template that can easily be uploaded to the new website.
- Legacy case-histories will be added
- **Beta version of new website** is being evaluated now, and we anticipate official release within a few weeks.

Review Process

- The **database working group** will review all of the uploaded data.
- Users will indicate when a dataset is ready for review, and the data will be immediately available.
- After review, the data will be marked as reviewed.
- Purpose of review is to verify that all required fields are present and the inputs match source materials.

Vision for Community Access

- Due to **large amount of data**, downloading data and processing them on a laptop is inefficient and undesirable (though still possible).

- We plan to **mirror the database to DesignSafe** (www.designsafe-ci.org), where users will be able to interact with the data using SQL queries in Jupyter notebook Python scripts.

- Python can be used to extract and process data, and has a wide array of data processing libraries available.

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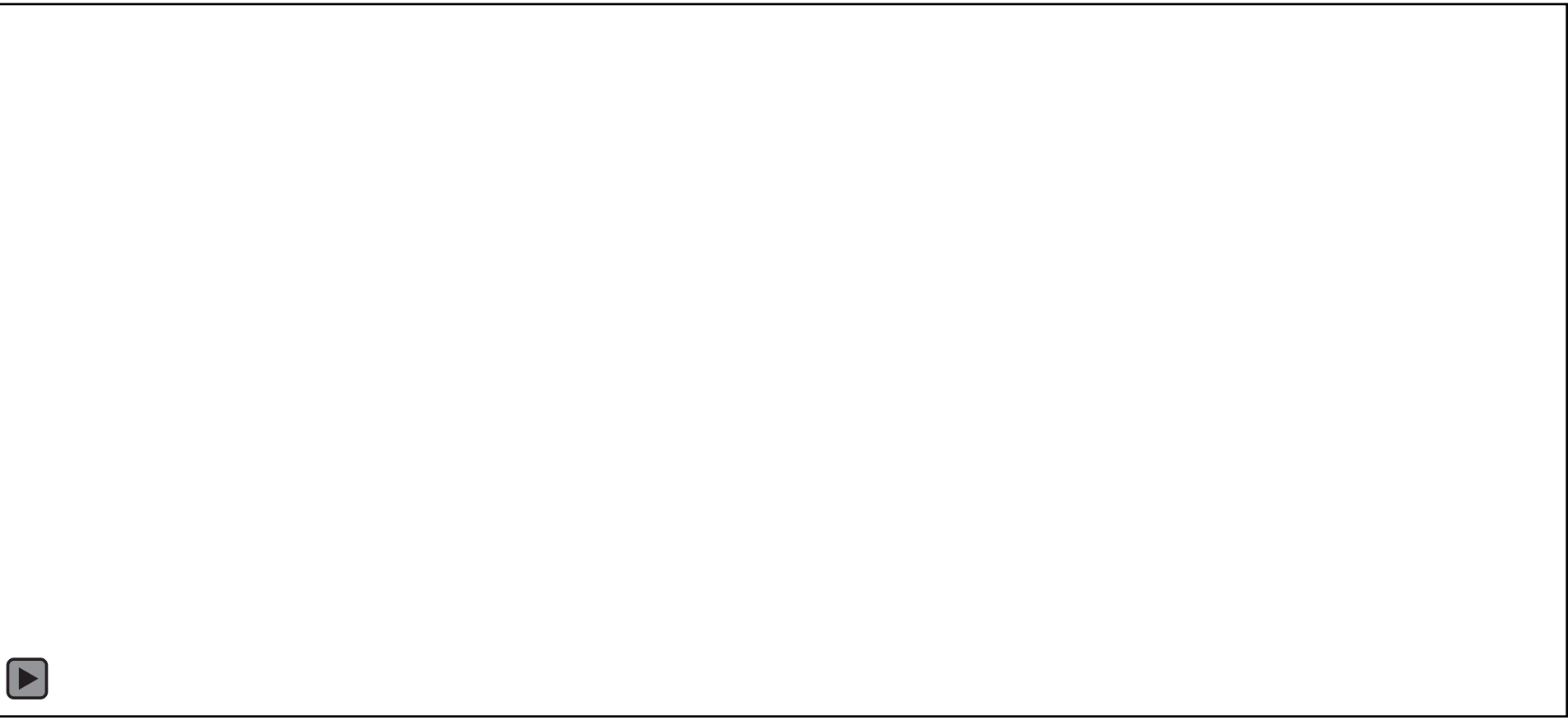

Final Remarks

- Need for high-quality, transparent, liquefaction case-history **database**
- The NGL relational database (being populated): capabilities for big data analytics
- Relational databases are more powerful than flatfiles (transformational shift from past practices!)
- NGL-NGA interaction
- Future task: Completion of database population, NGL database mirroring (DesignSafe)

Save the Date

Second workshop to be held at UCLA:

September 24 and 25, 2018

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Thank you!

Questions?

Relevant References

Brandenberg S.J., Kwak D.Y., Zimmaro P., Bozorgnia Y., Kramer S.L., Stewart J.P. (2018). Next-Generation Liquefaction (NGL) Case History Database Structure. Fifth decennial Geotechnical Earthquake Engineering and Soil Dynamics Conference, Earthquake Engineering and Soil Dynamics Committee of the Geo-Institute. Austin, TX (USA), June 10-13.

Zimmaro P., Kwak D.Y., Brandenberg S.J., Stewart J.P. (2018). NGL: An Open Source Global Database for Next-Generation of Liquefaction Assessment. SSA-LACSC scientific conference - Seismology of the Americas. Miami, FL (USA), May 14-17.

Stewart J.P., Kramer S.L., Kwak D.Y., Greenfield M.W., Kayen R.E., Tokimatsu K., Bray J.D., Beyzaei C.Z., Cubrinovski M., Sekiguchi T., Nakai S., Bozorgnia Y. (2016). PEER-NGL project: Open source global database and model development for the next-generation of liquefaction assessment procedures. Soil Dyn. Earthquake Eng., 91, 317–328.

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Project homepage:

https://uclageo.com/NGL/

Database (beta):

http://uclageo.com/NGL/database/index.php