NGL: An Open Source Global Database for Next-Generation of Liquefaction Assessment

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Engineering Sustainable Infrastructure for the Future

NGL
NEXT GENERATION LIQUEFACTION

Acknowledgements

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UDOT Keeping Utah Moving

Project Co-PIs and collaborators

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Many other US and international collaborators…

UCLA undergraduate and graduate students

Outline

Liquefaction assessment: Needs and current situation

Steps in liquefaction risk assessment (three-step approach):

1. ***Susceptibility***
2. ***Triggering (Factor of safety and/or probability of liquefaction)***
3. ***Effects (consequences)***

Each is *empirical* or *semi-empirical*, and hence is reliant on available data.

Liquefaction Assessment: Current Needs

Small data sets

A few sites are especially consequential

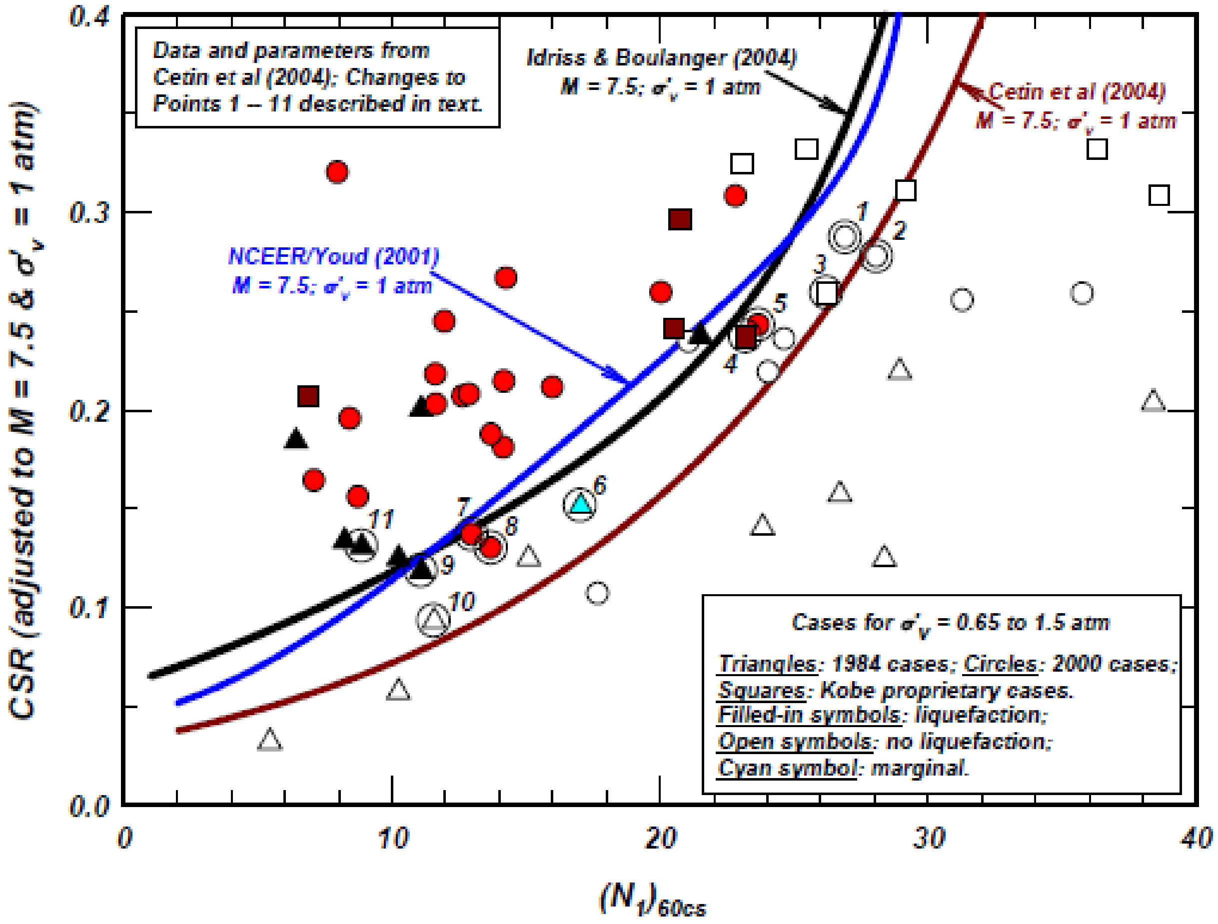
Existing data sets are necessarily incomplete, especially:

Depth > 10 m

M > 7.5 and **M** < 6.0

FC > 30%

CSR > 0.4



From Idriss and Boulanger (2010)

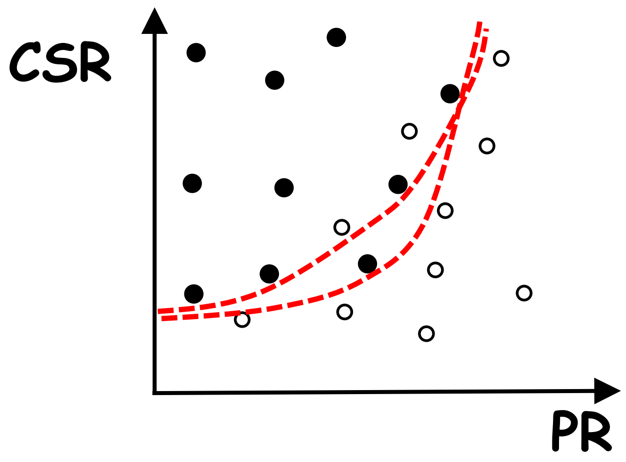
Liquefaction Assessment: Present Situation

Alternate liquefaction models provide different outcomes.

Why?

1. Inconsistent data sets
2. Different methods for data interpretation
3. Different models for extrapolation beyond data range
4. Potential errors in data analysis
5. Minimal between-developer interaction

- Liquefaction
- No Ground Failure



Graphic: S. Kramer

The NGL Project Vision

- Community field **case-history *relational* database**
- **Supporting studies** of critical effects poorly constrained by data
- **Model development**: team meetings, common resources, required parameter space

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Flatfiles vs Relational Databases

From *spreadsheet (flatfiles)*
(Traditional data analysis)

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

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

To relational database
(big-data analytics)

Primary Key
Foreign Key

Event table

Event_id (PK)	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

Station table

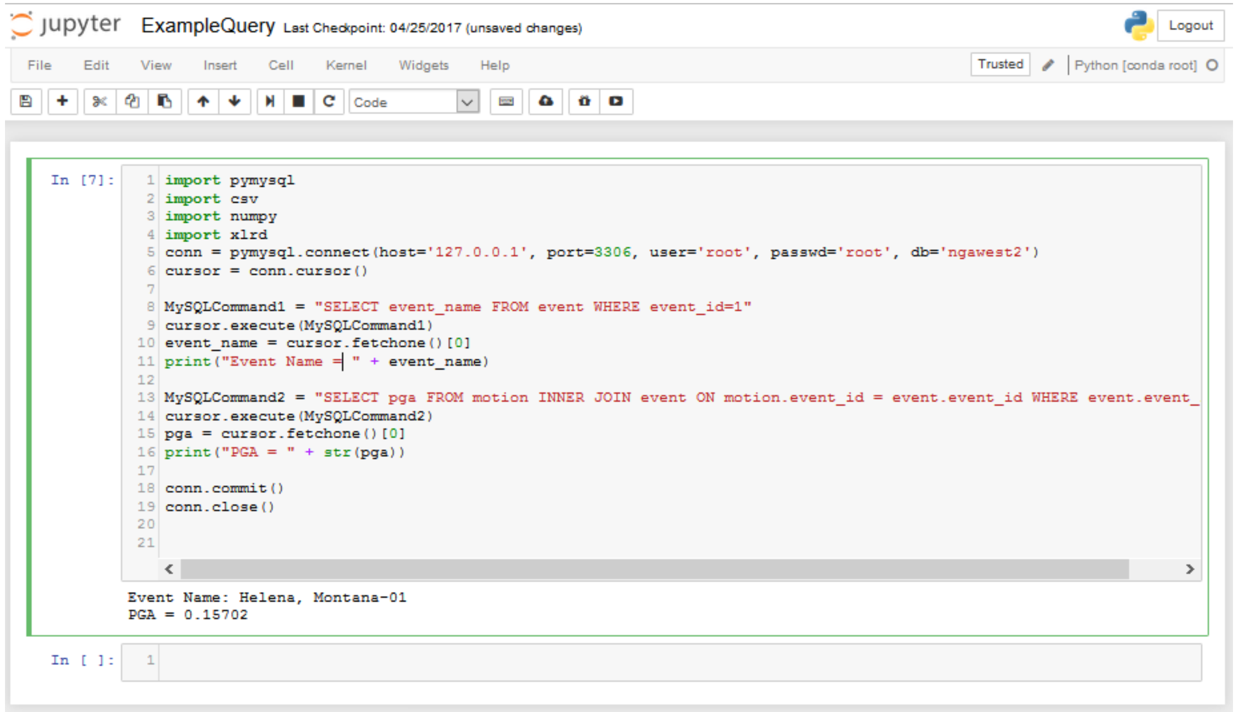
Station_id (PK)	Station Name	V_{S30} (m/s)
1	Factor Building	380
2	Santa Monica Courthouse	215

Ground Motion table

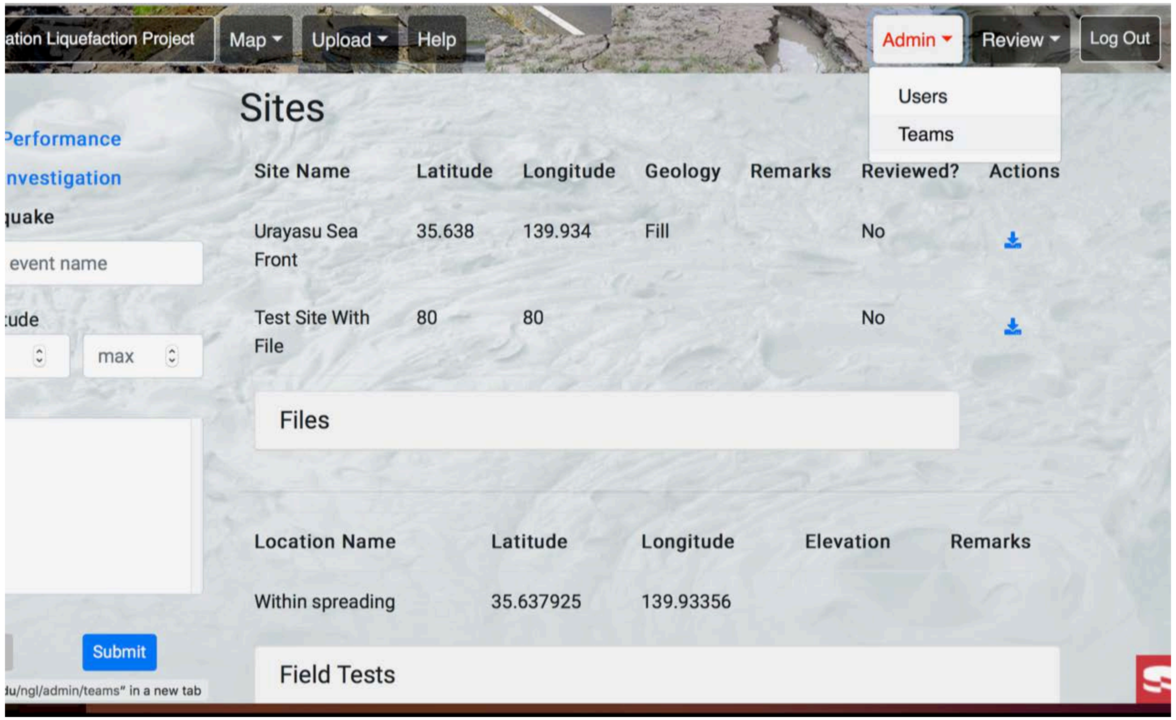
Motion_id (PK)	Event_id (FK)	Station_id (FK)	R_{jb} (km)	PGA (g)
1	1	1	2	0.84
2	1	2	14	0.28
3	2	1	20	0.61
4	2	2	30	0.32

From Brandenberg et al. (2018)

Benefits of a Relational Databases



Advanced tools (work on the cloud)



"Smart" database

The NGL Database

KPHP platform, GIS-based mapping tool, To be hosted at DesignSafe (UT NHERI site)

NGL NEXT-GENERATION LIQUEFACTION PROJECT

Home Map Download Upload Users Help Sign In

Next-Generation Liquefaction Database

Data Statistics	
Sites	63
Penetration/Geophysical tests	
Borehole (Boring, SPT)	36
CPT	246
Test pit	0
Geophysical test (Vs)	4
Lab tests	
Sieve	30
Atterberg limit	30
Consolidation	0
Triaxial (monotonic)	0
Triaxial (cyclic)	0
Others	0

Number of Sites

We acknowledge our sponsors.

PEER Caltrans SwRI U.S.NRC

On-line beta version

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

The NGL Database

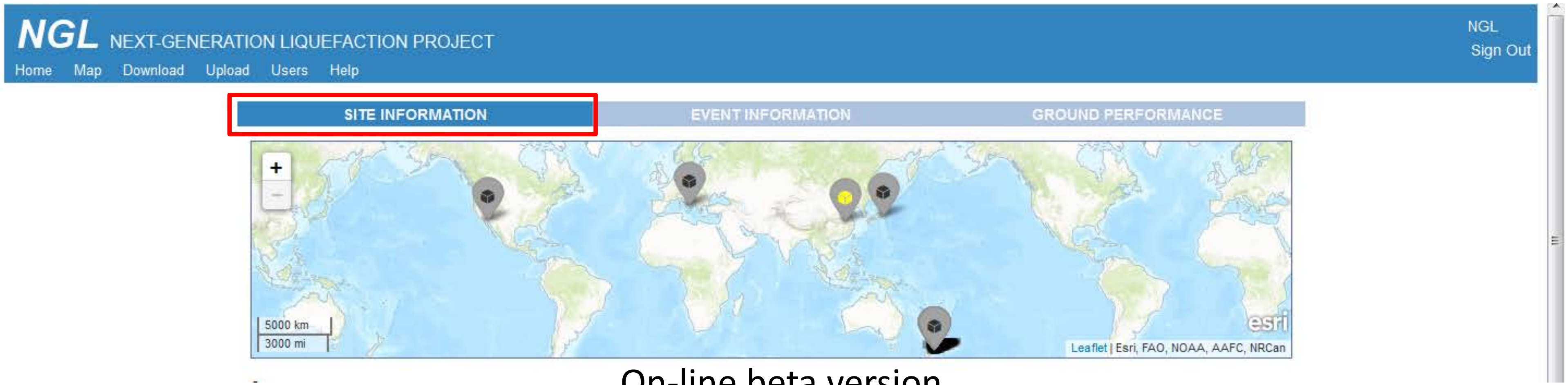
Graphical interface – User Experience Design

The NGL Database

What constitutes a case history?

- Site information

Minimum requirements:
- Soil stratigraphy
- Ground water depth
- Details pertaining to soil type
- Penetration resistance or V_S



On-line beta version

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

The NGL Database

What constitutes a case history?

- Site information
- Event information

- From NGA!

On-line beta version

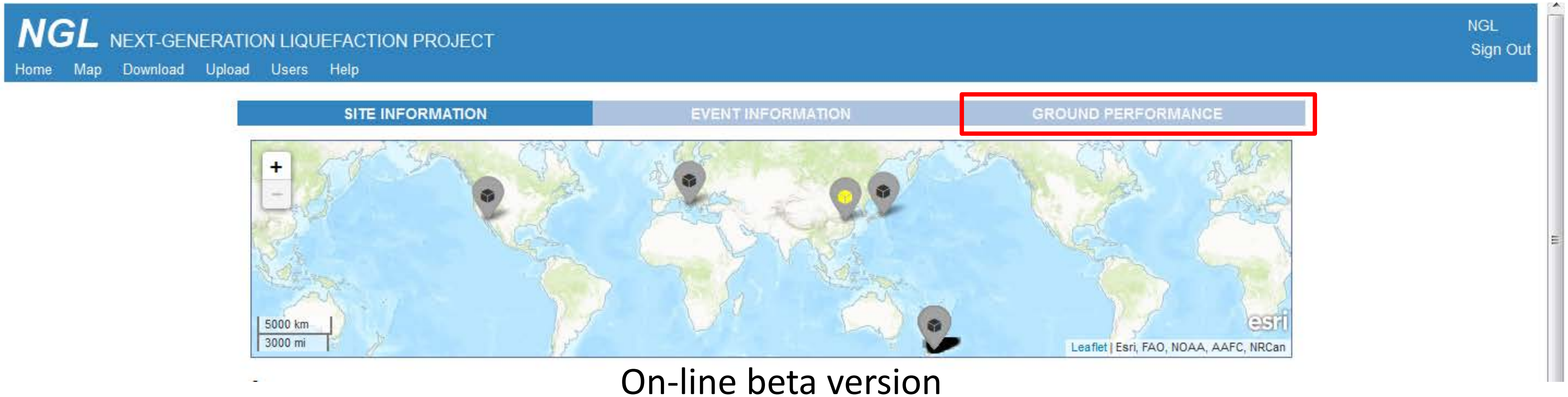
http://uclageo.com/NGL/database/index.php

The NGL Database

What constitutes a case history?

- Site information
- Event information
- Ground performance

Minimum requirements:
- Written, mapped, or imaged observations
- Date/time of reconnaissance
- Location (lat/long)



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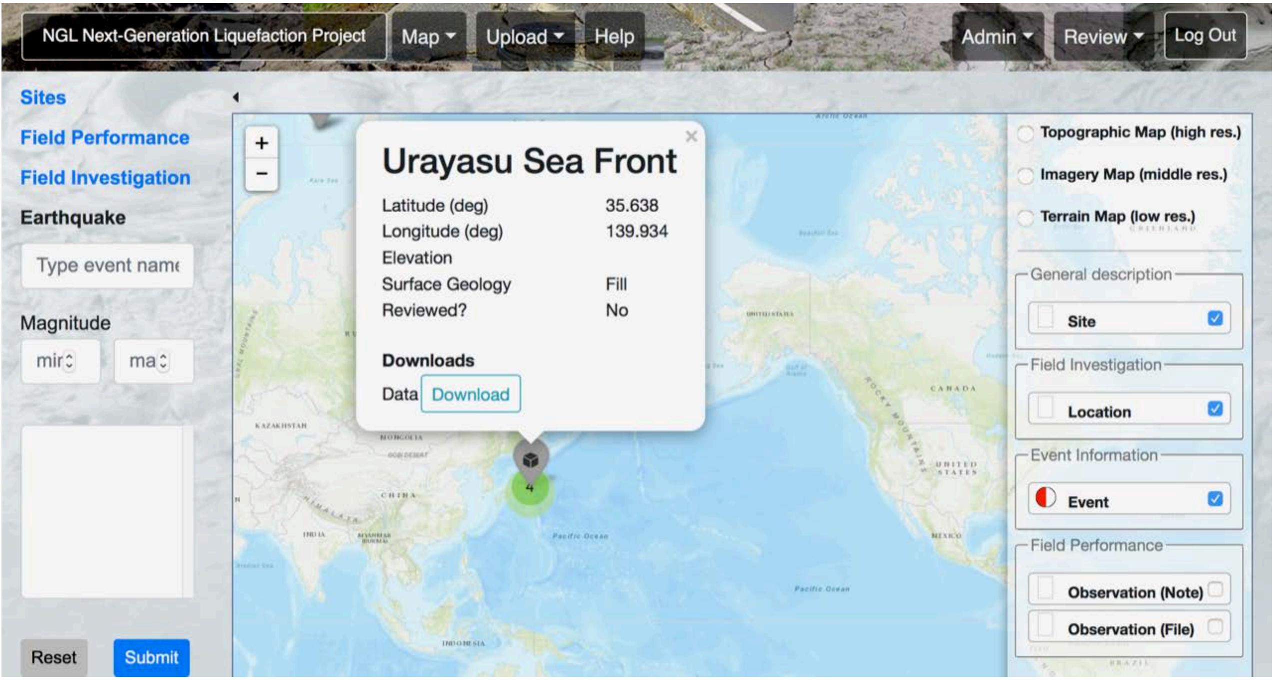
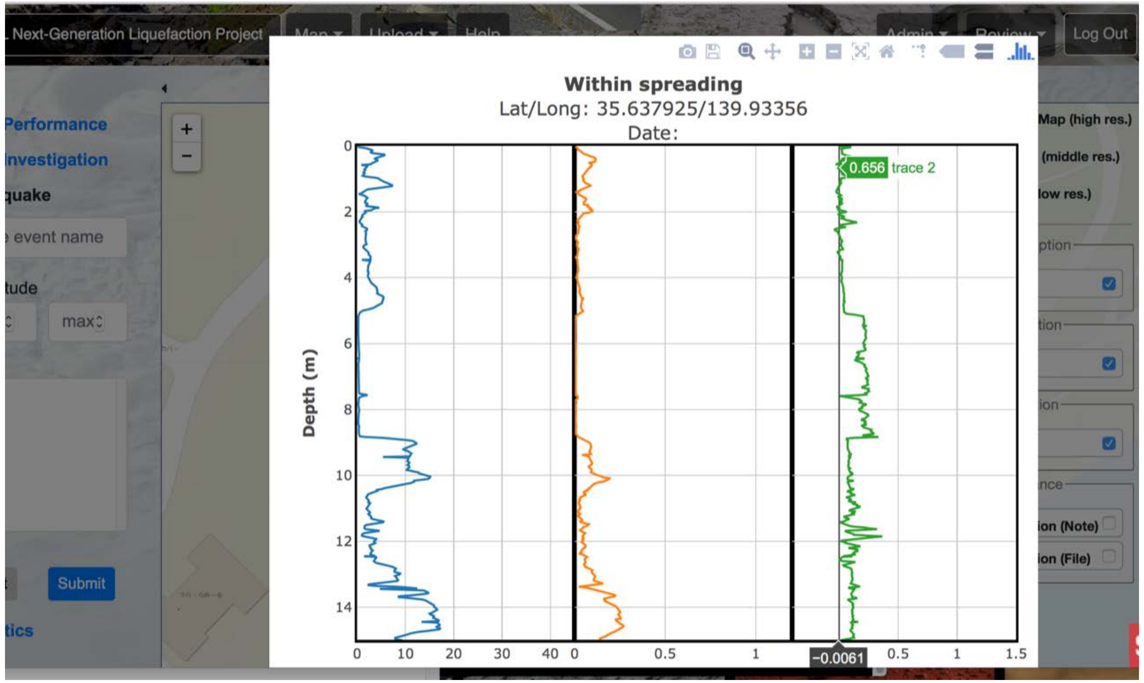
Site Information





The NGL Database

Event Information: Integration with NGA (Next-Generation Attenuation) products

NGA data

	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_

Data collection stored in a series of flatfiles

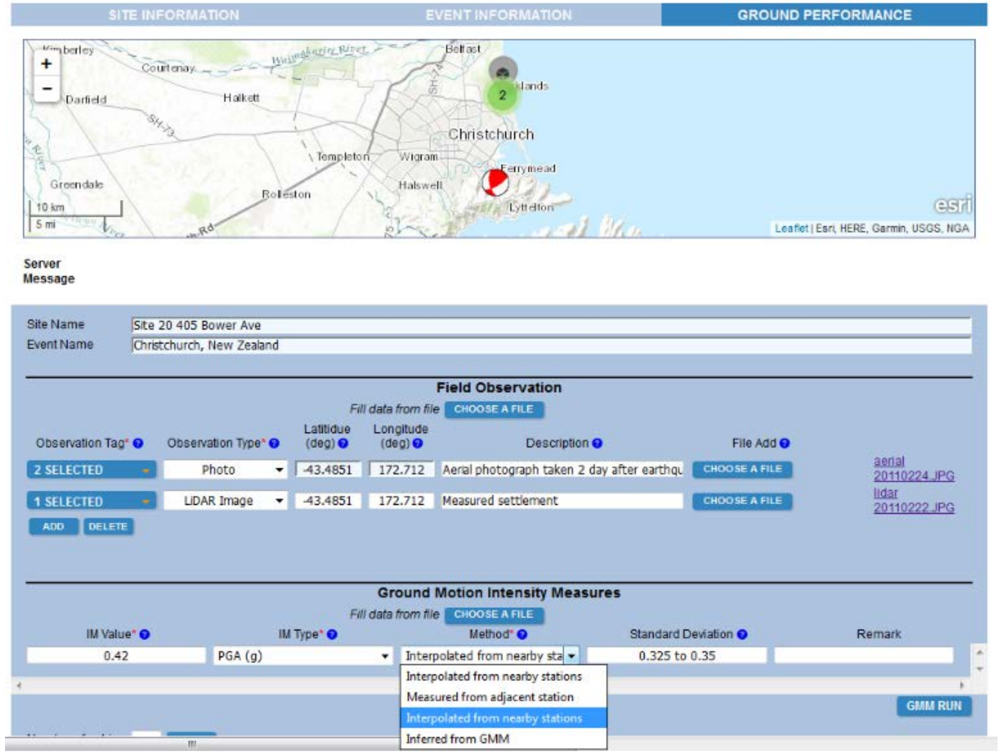
PEER Ground Motion Database
Pacific Earthquake Engineering Research Center

Integration with NGL

- **NGA Data implemented as part of the NGL Relational Database**
- **Only fields relevant to NGL are included:**
  - **Recording stations**
  - **Event information**
  - **Fault-segments information (more than one for multi-fault ruptures)**
  - **5% damped response spectra only**

The NGL Database

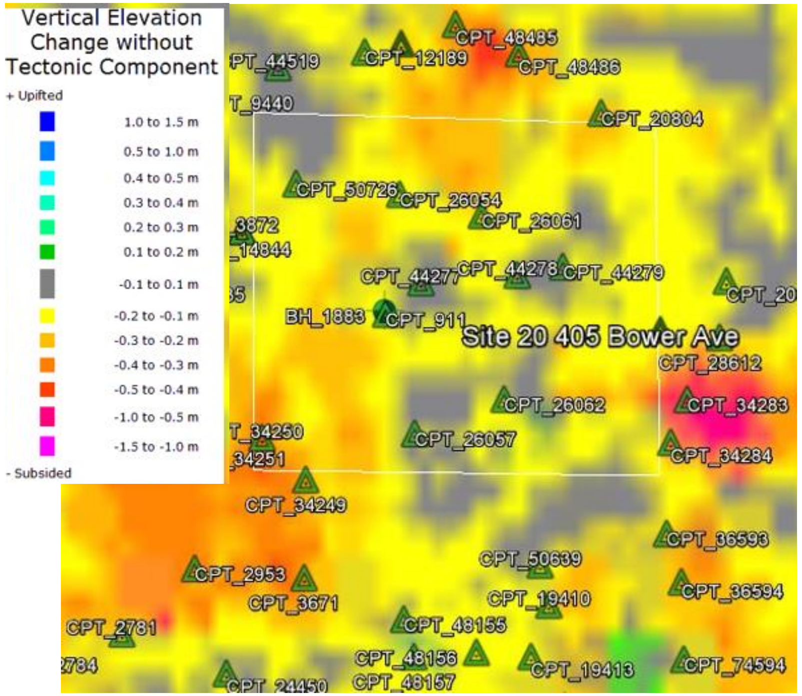
Ground Performance: High-Resolution Satellite Images

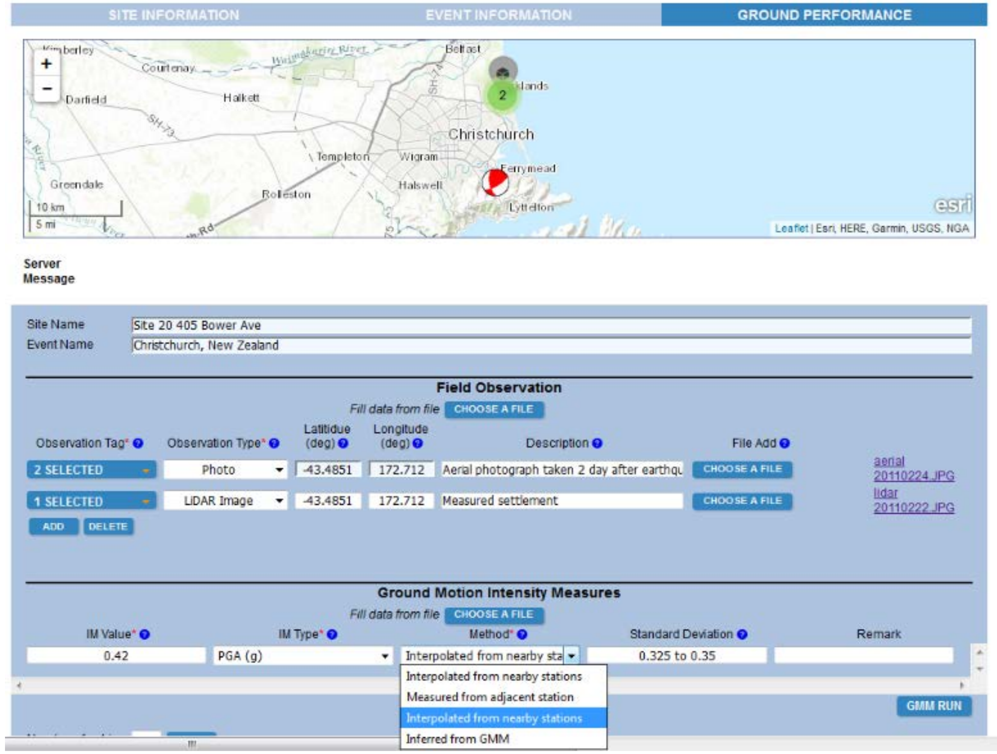


Bower Avenue Site after the 2011 Christchurch Earthquake (New Zealand)

The NGL Database

Ground Performance: LiDAR Maps

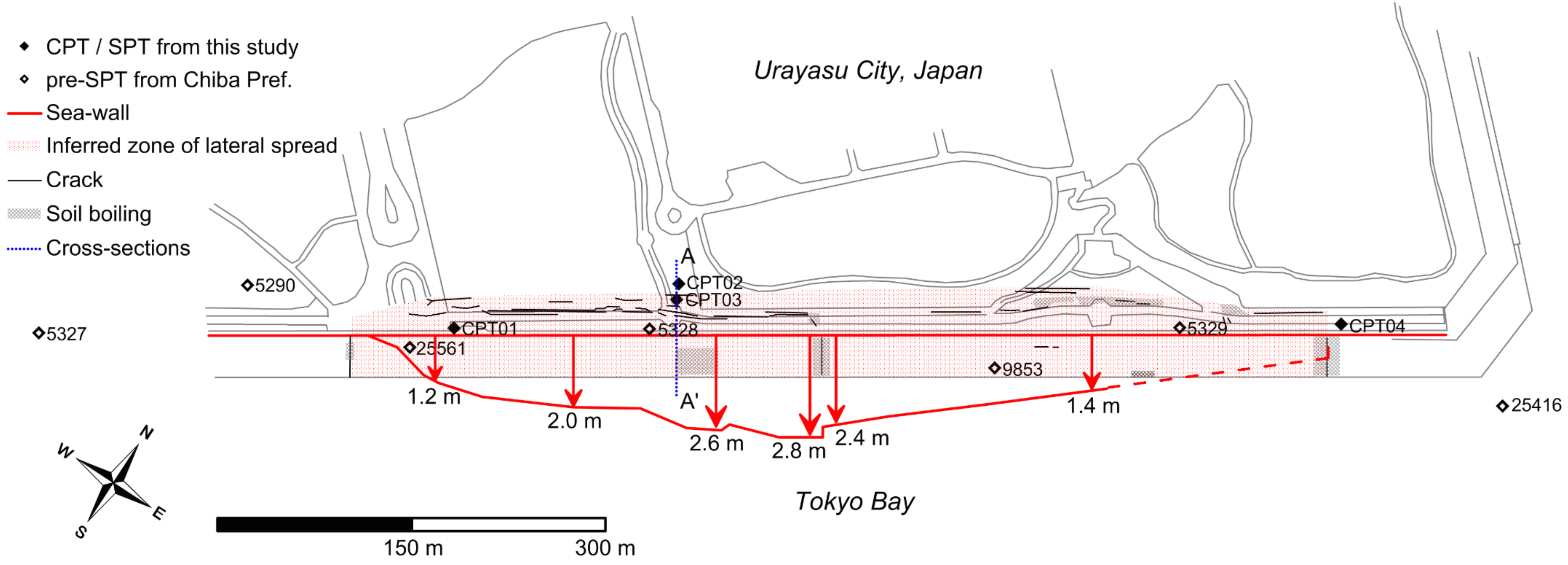




Bower Avenue Site after the 2011 Christchurch Earthquake (New Zealand)

The NGL Database

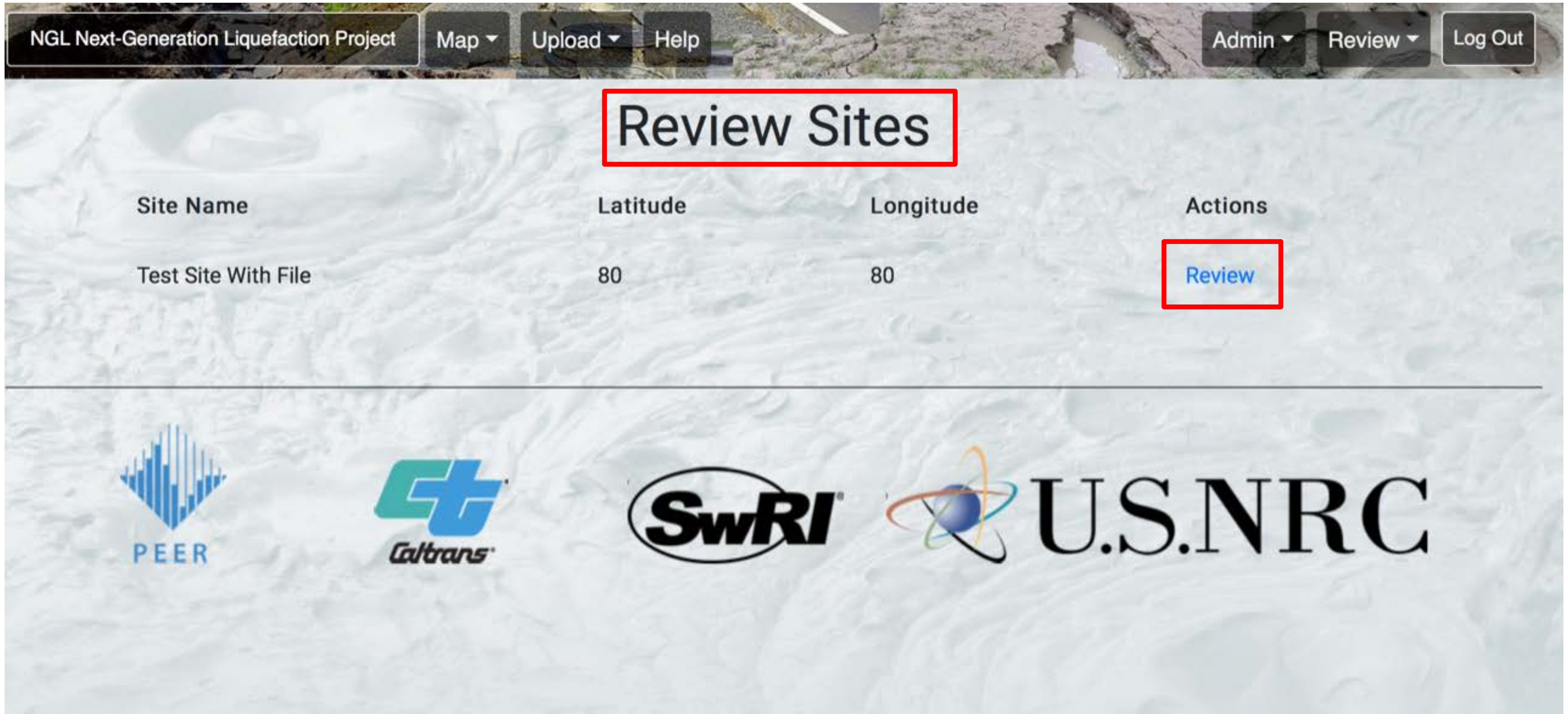
Ground Performance: Site Maps



Urayasu City Site after the 2011 Tohoku Earthquake (Japan)

The NGL Database

Current Tasks: Database Population and Data Vetting



Review/Vetting: NGL Datbase Working Group (Brandenberg (chair), Moss, Franke, Cetin)

Final Remarks

- ***Urgent need for high-quality, transparent, case-history database***
- ***The NGL relational database (being populated): open-source relational database***
- ***Relational databases are more powerful than flatfiles (transformational shift from past practices!)***
- ***The NGL database will include NGA data***
- ***Future task: Completion of database population, supporting studies, model development***

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Thank You!

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.

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.

Project homepage:

https://uclageo.com/NGL/

Database (beta):

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