FIRES and the HAYWARD EARTHQUAKE

One Day Workshop on

Fires following a M7 earthquake on the Hayward Fault

with special focus on Firefighting Water Supply Reliability

Wed. Oct 29, 2014, 9:30-4:30, UC Richmond Field Station

M7.0 Haywired scenario shaking intensity

Sponsored by

USGS
science for a changing world

Cal OES
GOVERNOR'S OFFICE OF EMERGENCY SERVICES

Pacific Earthquake Engineering Research Center, UC Berkeley

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Purpose

To learn….
To better understand the fire and water issues arising from a M7 Hayward Earthquake in the San Francisco Bay Area.

- **Review the effects of the recent M6 earthquake in Napa**
- **Present new estimates of the impacts of a M7 Hayward earthquake, with *special emphasis on resulting fire ignitions and fire spread***
- ***Get your feedback on these estimates***
- **Discuss problems of water supply given the effects of the M7 earthquake on water pipes and other infrastructure**
- **Have a roundtable discussion by senior fire officers on these findings**

In afternoon session we'll move to Gilman St. and the Bayshore in Berkeley for demonstrations of:

- **Berkeley FD 12" LDH,**
- **San Francisco FD 5" PWSS,**
- **Oakland FD 5" PWSS**
- **Vallejo FD 5" PWSS and Hydrosub**

Agenda

Workshop Program

9:00 Registration begins
9:30 Workshop Overview / Introductions
9:45 Napa Earthquake
10:00 Hayward M7 EQ– Overview and Impacts
10:15 Hayward M7 Ignitions and Fire spread
10:45 Q&A
11:00 Break
11:15 Water Supply
11:30 Roundtable discussion, senior Fire Chiefs
12:00 Lunch / General Discussion
12:45 Move to foot of Gilman Street, Berkeley
13:00 Exhibition of FD Water Systems

- **Berkeley FD 12" LDH Above Ground Water System**
- **San Francisco FD PWSS**
- **Oakland FD Hose Tenders**
- **Vallejo FD Hydrosub**

16:00 Closure

Caveat

Because some of the findings to be presented today are preliminary and subject to change, copies of some of the slides will not be available for sharing at this time.

The USGS will issue a final report in several months, which will contain updates of the findings presented today (and much else).

Information re the Napa earthquake can be shared – contact Chief Randolph (next speaker) or see PEER report (and video) at:

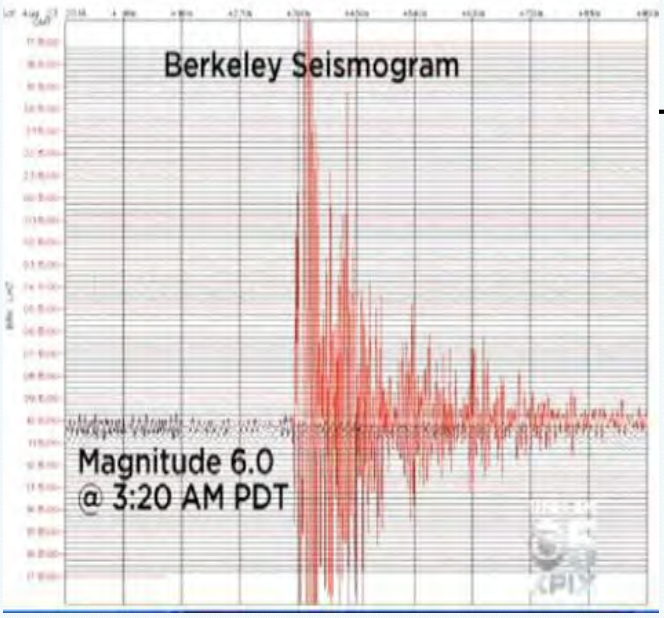
http://peer.berkeley.edu/publications/earthquake_recon_reports.html

M6 Napa Earthquake

24 August 2014

Chief Michael Randolph, Napa FD

mrandolph@cityofnapa.org



The South Napa Quake

August 24, 2014

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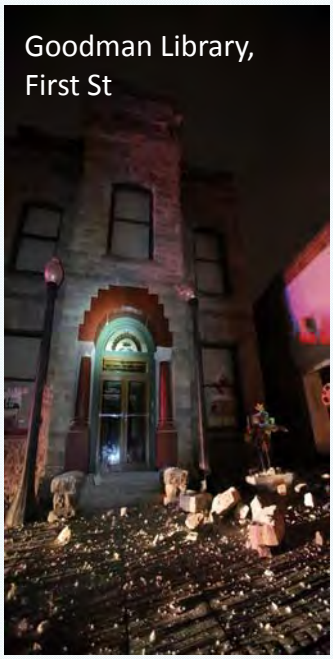
Immediately evident damage to roadways, water lines, buildings…

PHOTOGRAPH BY PETER DASILVA, EPA



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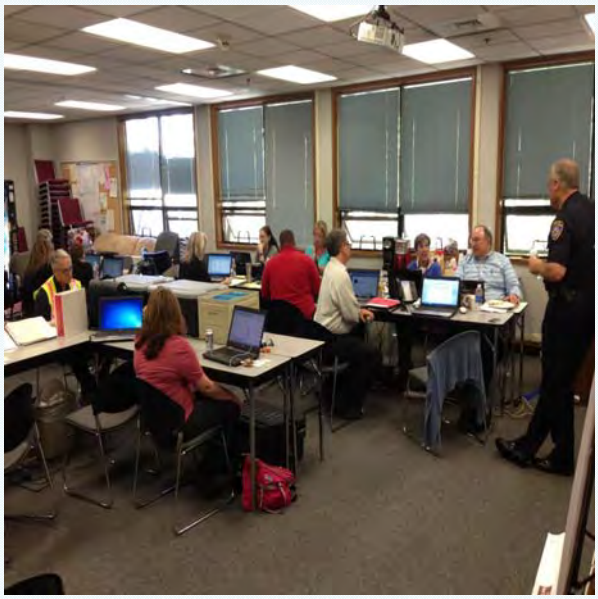
Some downtown hotels were evacuated due to damage

Justin Sullivan / Getty Images

Three structure fires were caused by broken gas lines – the worst at Napa Valley Mobile Home Park on Orchard Ave – broken water lines led to 6 destroyed homes

Napa Valley Register photos

The City and County opened Emergency Operations Centers (EOCs) around 6am using the ICS as indicated in the NIMS & SEMS system



City of Napa EOC at Police Department building

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When the sun came up, the extent of the damage was more apparent

Old Sonoma Road
Napa Valley register photo

Old Town, City of Napa *LA Times photo*

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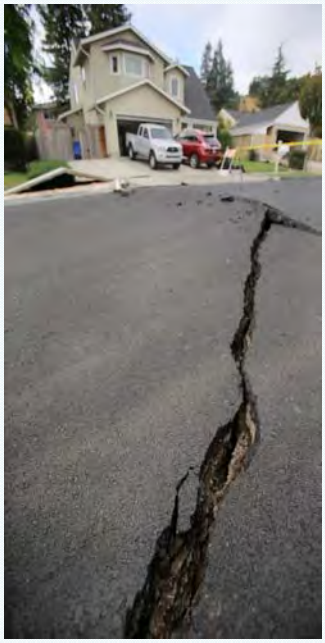

Browns Valley residential area

First United Methodist Church, Old Town, City of Napa

Hardest hit areas

West side of town in Browns Valley and Westwood

Older buildings Downtown and Old Town

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177 water system breaks Countywide discovered

Main transmission line and both City treatment plants undamaged

Up to 600 customers without water service for an extended time

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283 injuries reported Countywide

234 patients treated at Queen of the Valley Hospital, 12 at St. Helena Hospital

18 admitted, 4 in critical condition at QVH

1 fatality

ABC 7 News photo

Many injuries occurred hours after the quake during cleanup

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Bay Area News Group photo

153 buildings were red tagged at some time. More than 1,100 were yellow tagged.

FEMA photo

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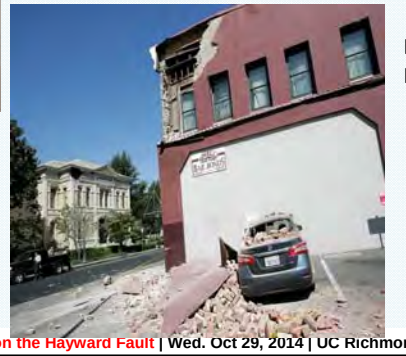
Noah Berger/AP

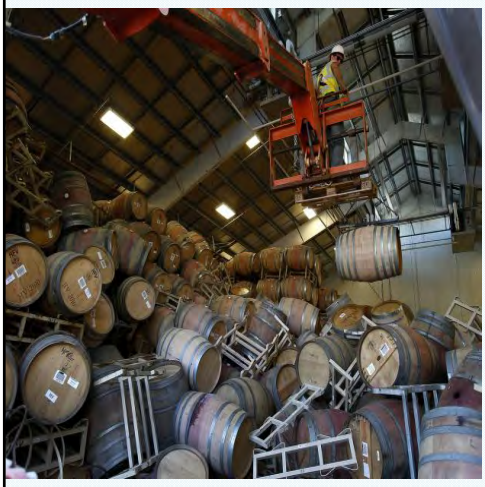


Napa Valley Register photos

Damage estimate:

- $362.4 million damage to private property & public infrastructure

Wine industry losses estimated at $80.3 million



Starmont Winery *SF Chronicle photo*

Val's Liquors *Justin Sullivan/Getty Images*

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Response

- **As EOC operations continued**
  - Closed specific streets/roads for safety of the public
  - Red Cross shelter opened
  - Called for and received mutual aid on infrastructure repairs
  - Began building inspections with local staff and state emergency services manpower
  - Established water supply stations for those without water service
  - Established sites for debris drop off
  - Held press conferences and issued status updates regularly
  - City Council waived inspection and permit fees for repairs
- **After EOC operations ended**
  - Continued to collect data for submission to FEMA
  - Opened Local Assistance Center and launched *napaquakeinfo.com*
  - Submitted requests for Public and Individual Assistance from FEMA

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Next Steps

- **Continue process of applying for federal and State Assistance**
  - Governor declared a disaster on Aug 24; asked President on Sept 2 for disaster declaration
  - President declared a disaster on Sept 11 and authorized "Public Assistance"
    - "Public Assistance" means reimbursement to government entities
  - Local government will continue making the case for the need for "Individual Assistance"
    - "Individual Assistance" can help homeowners and businesses directly
- **Continue operations of Local Assistance Center until need no longer exists**
  - A total of 1,482 have come to the LAC since opening Sept 8
  - Approx. 4,060 phone calls have been received at the call center
- **Provide any needed assistance to Community Foundation of Napa Valley to create process for disbursement of donations from Napa Valley Vintners and others**

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Bottom line:

- Communications will be overloaded, if not broken
- Fires will break out
- Fires will not be reported via 911 but only identified by non-911 means
- Water mains will break and hydrants will be dry
- Fires will spread

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Thank you

mrandolph@cityofnapa.org

Haywired: Hayward M7 EQ

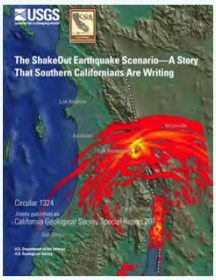
– Overview

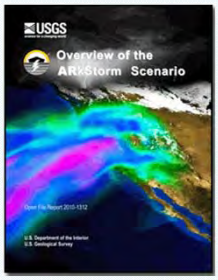
USGS Science Application for Risk Reduction (SAFRR)

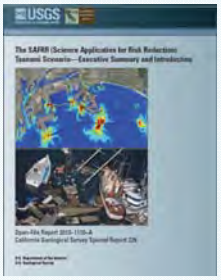
Dale Cox, USGS, Sacramento
Keith Porter, Univ. Colorado, Boulder

SAFRR Mission

Innovate and apply hazard science for the safety, security, and economic well-being of the nation

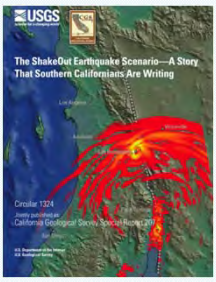


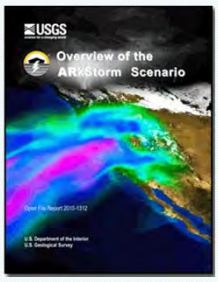


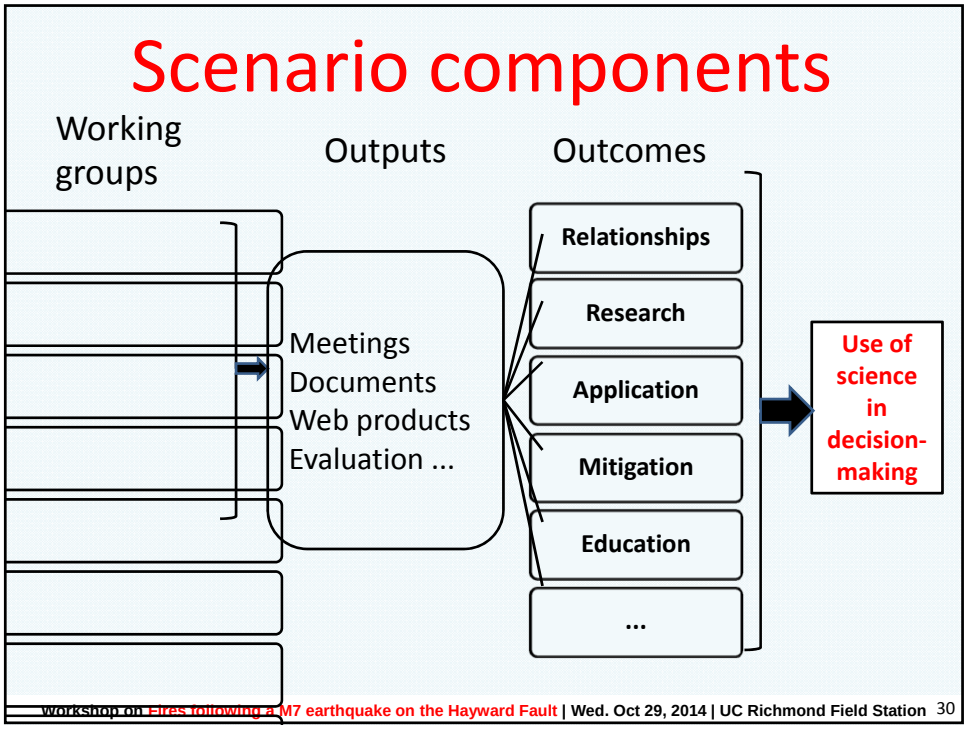


SAFRR scenario principles

- Best hazard science
- Consensus among leading experts
- A single, large but plausible event
- An event we need to be ready for
- Crafted with community partners







New with Haywired

- Aftershock sequence
- Internet economy
- Lifeline models, lifeline interaction
- Property damage model with building-code objectives

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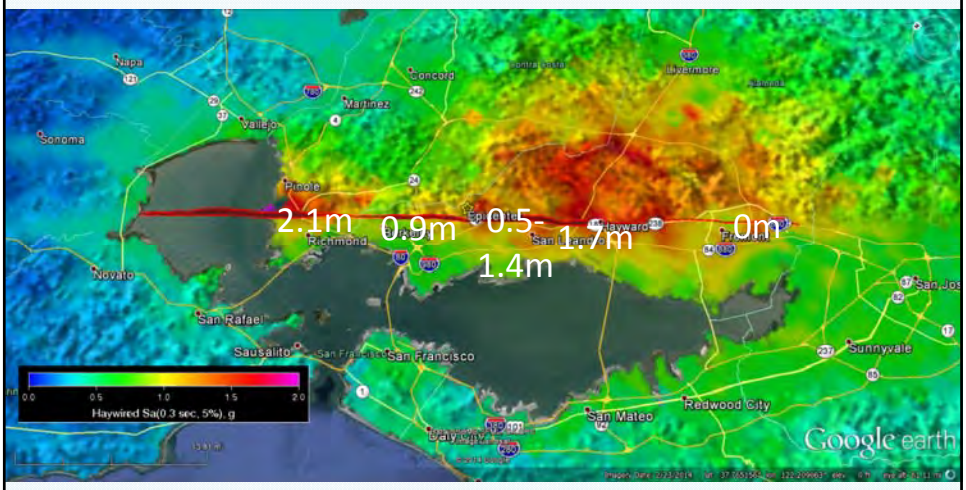
M7.05 Mainshock S_A(0.3 sec)
4:18 PM Wed 18 Apr 2018



Probability: 1 in 200 each year

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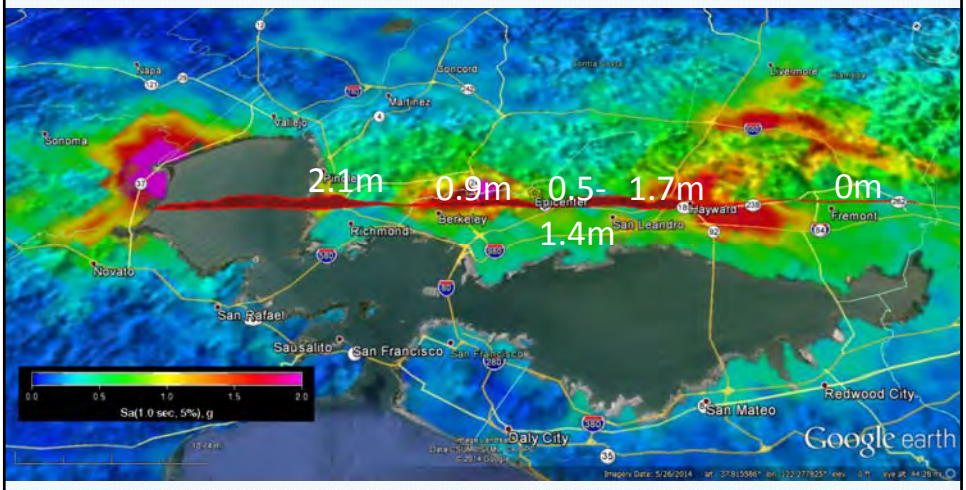
M7.05 Mainshock S_A(1.0 sec)
4:18 PM Wed 18 Apr 2018



Probability: 1 in 200 each year

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Aftershocks

Date	Day	Latitude	Longitude	Location	Depth (km)	Magnitude
2018-04-18	1	37.6008	-122.0172	Union City	0.65	5.23
2018-04-18	1	37.9630	-122.3473	San Pablo	0.65	5.04
2018-04-29	12	38.1916	-122.1483	Fairfield	11.05	5.58
2018-05-02	15	37.4829	-121.9146	Fremont	7.15	5.10
2018-05-19	32	37.7561	-122.1508	Oakland	8.45	5.42
2018-05-27	40	37.4491	-122.1624	Palo Alto	18.97	6.21
2018-05-27	40	37.4528	-122.1671	Menlo Park	7.26	5.52
2018-05-28	41	37.4099	-122.1184	Palo Alto	8.36	5.69
2018-05-28	41	37.4604	-122.1753	Atherton	7.91	5.11
2018-06-23	67	37.4391	-122.1511	Palo Alto	2.85	5.22
2018-06-30	74	37.4435	-122.1561	Palo Alto	8.69	5.26
2018-09-30	166	37.4283	-122.0655	Mountain View	15.45	6.40
2018-09-30	166	37.4386	-122.0770	Mountain View (Bay)	11.29	5.98
2018-09-30	166	37.3835	-122.0153	Sunnyvale	18.89	5.35
2018-09-30	166	37.3334	-121.9541	Santa Clara	7.00	5.09
2019-08-22	492	37.4145	-122.1235	Palo Alto	11.98	5.01

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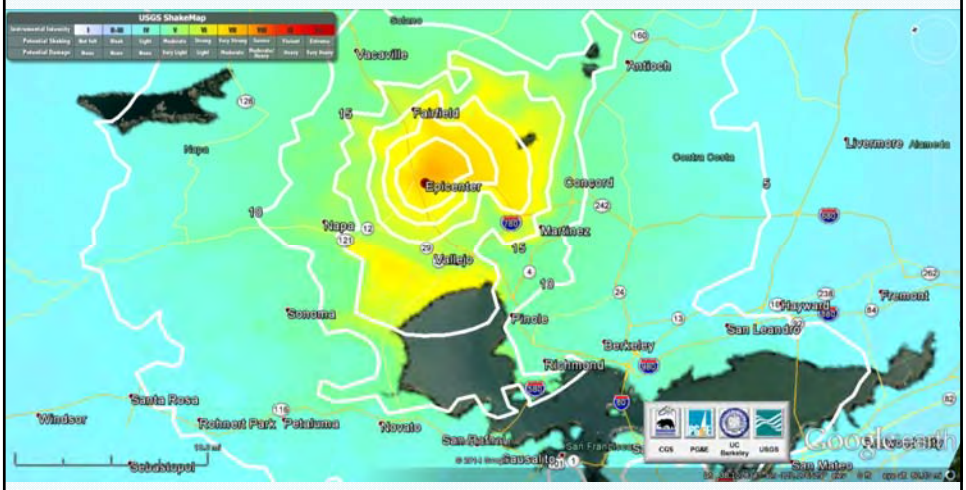
M 5.6 aftershock 29 Apr 2018



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M 6.2 aftershock 27 May 2018

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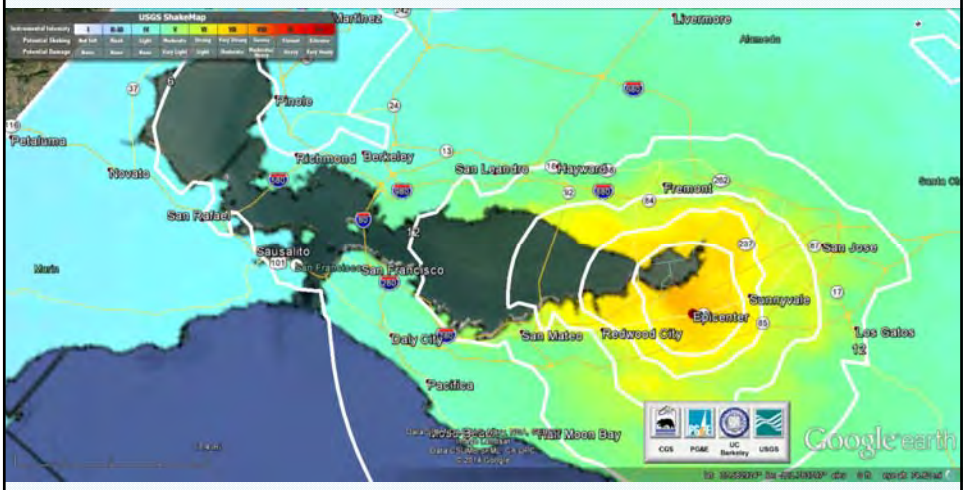
M5.7 aftershock 28 May 2018



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M 6.0 aftershock 30 Sep 2018

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M 6.4 aftershock 30 Sep 2014

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Thank you

Haywired: Hayward M7 Earthquake *Ignitions and Fire spread*

Charles Scawthorn
PEER

cscawthorn@berkeley.edu

Outline

- Overview of fire following earthquake
  - Past events
  - Analytical framework
- Hayward M7 ignitions and spread
  - Exposure
  - Ignitions
  - Water supply impacts
  - spread

Fire following earthquake – the problem

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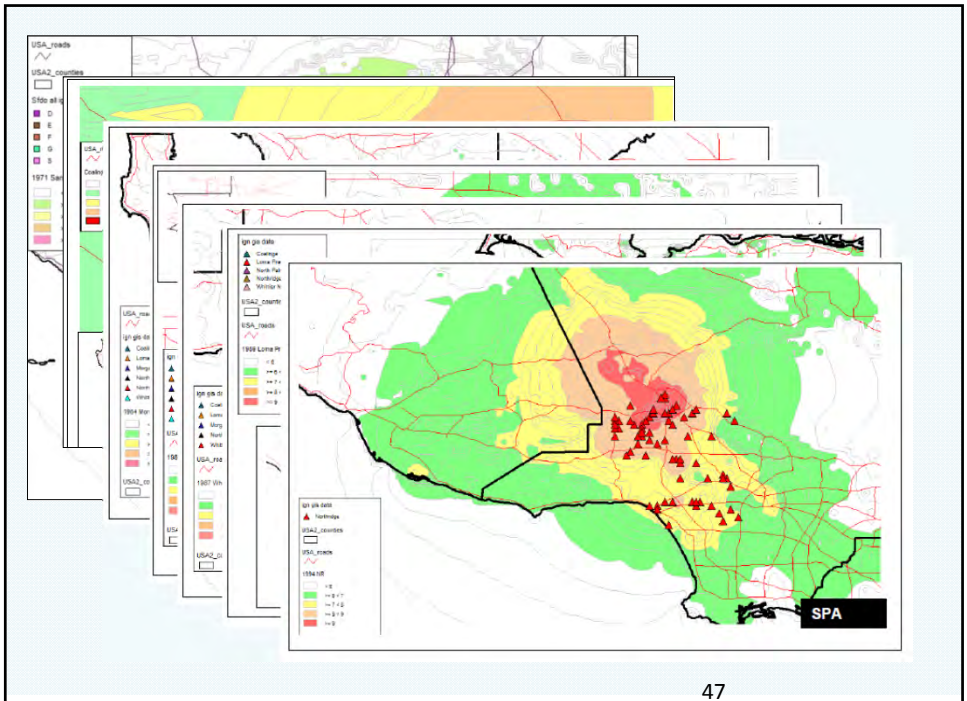

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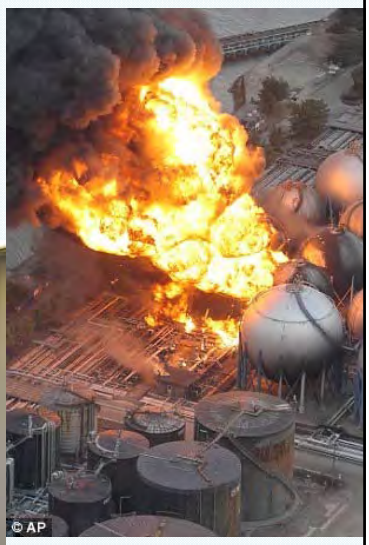
Fire following earthquake – 2011 Japan Tsunami



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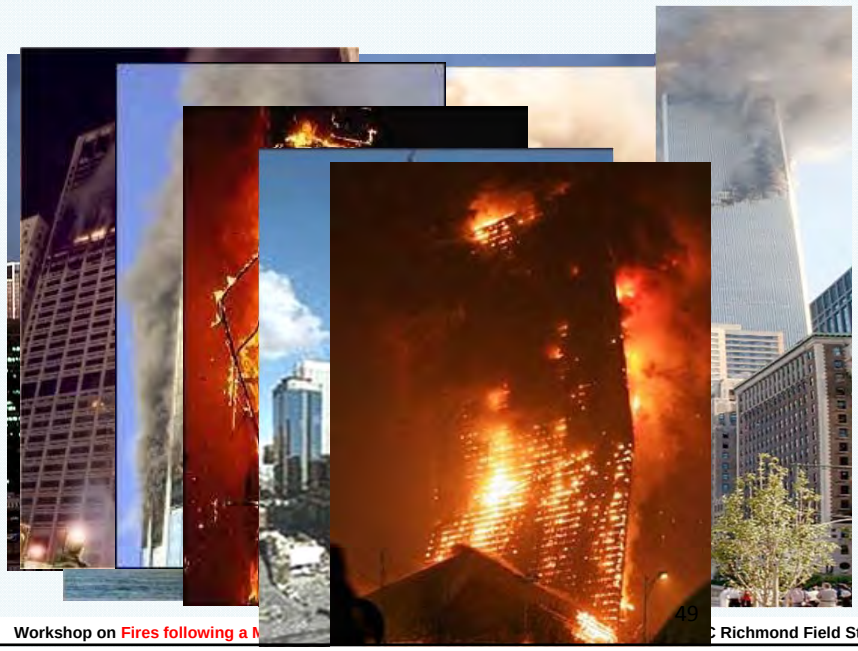
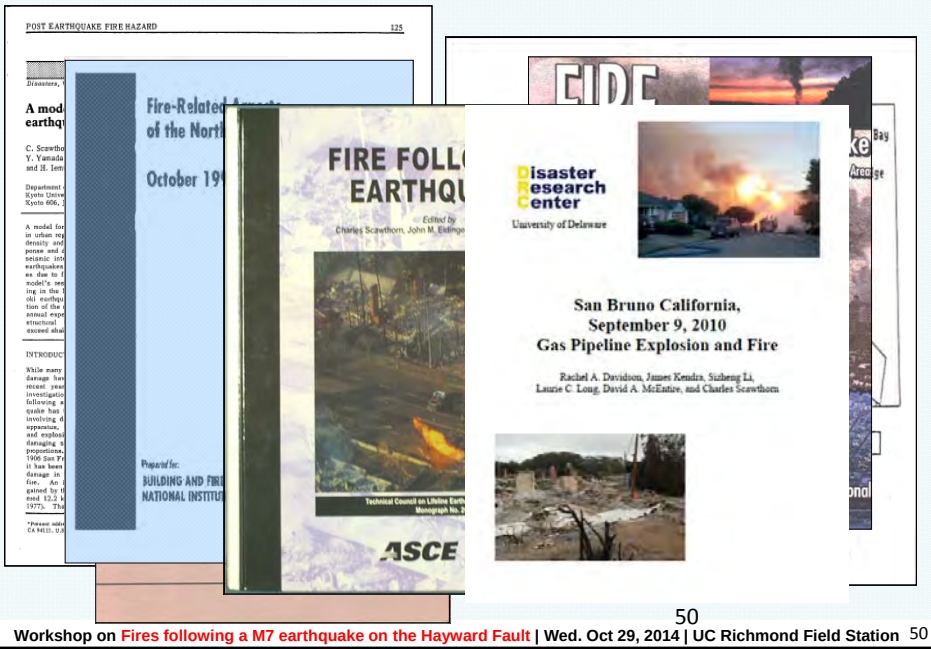
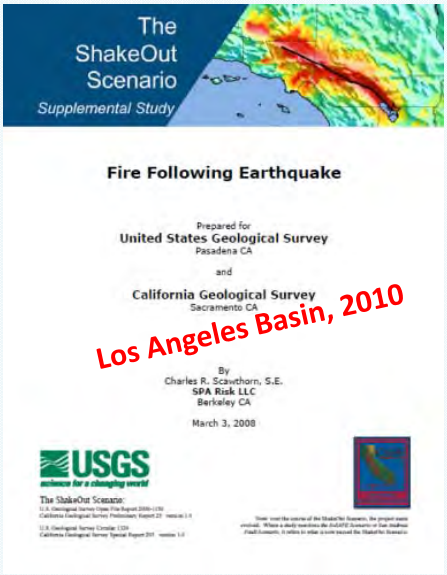
The Problem Today is Exacerbated



Analysis

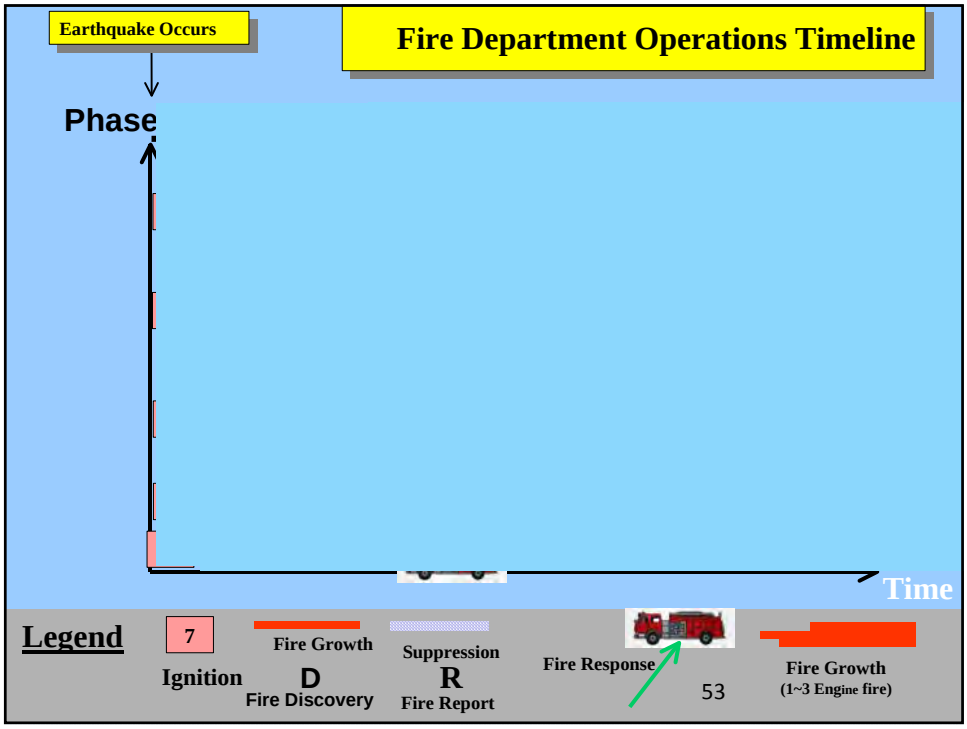


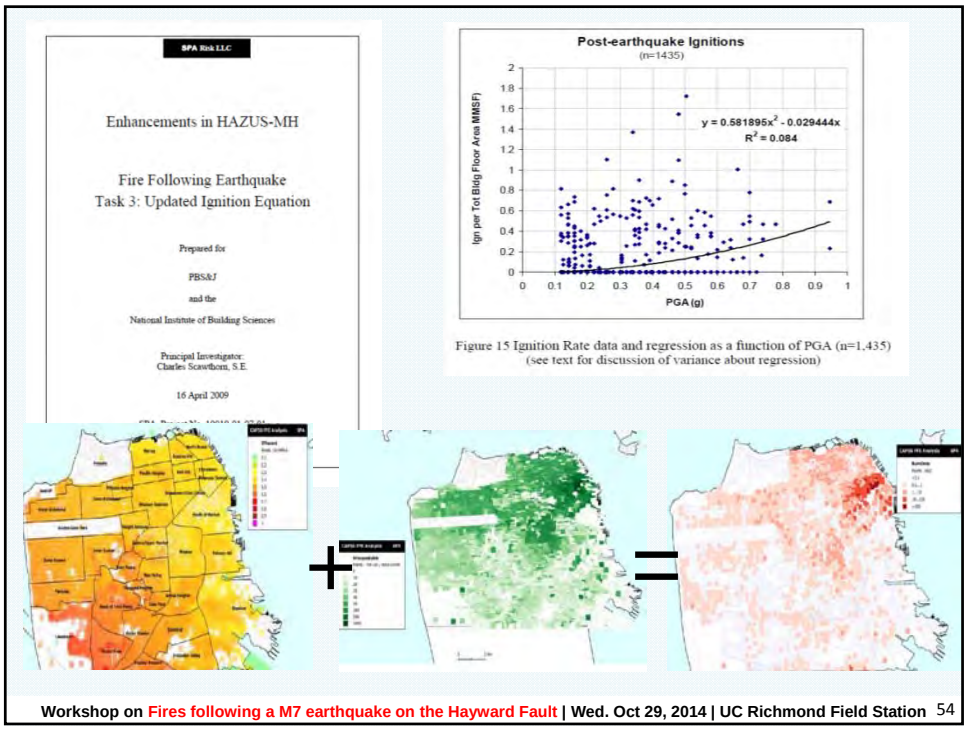


Available at Seismic Safety Commission, USGS, PEER websites and www.sparisk.com

The Analysis and Mitigation of Fire Following Earthquakes involves several major aspects

- Earthquake Damage
- Multiple Simultaneous Ignitions
- Fire Spread
- Water Supply and Response Problems
- Communication Breakdowns
- Competing Demands for Fire Service Resources (medical, SAR, hazmat…)


Earthquake Occurs
Fire Department Operations Timeline
Phase
Time
Legend
7
Ignition
Fire Growth
D
Fire Discovery
Suppression
R
Fire Report
Fire Response
53
Fire Growth
(1~3 Engine fire)


SPA Risk LLC
Enhancements in HAZUS-MH
Fire Following Earthquake
Task 3: Updated Ignition Equation
Prepared for
PBS&J
and the
National Institute of Building Sciences
Principal Investigator:
Charles Scawthorn, S.E.
16 April 2009
Post-earthquake Ignitions
(n=1435)
y = 0.581895x² - 0.029444x
R² = 0.084
Ign per Tot Bldg Floor Area MMSF)
PGA (g)
Figure 15 Ignition Rate data and regression as a function of PGA (n=1,435)
(see text for discussion of variance about regression)
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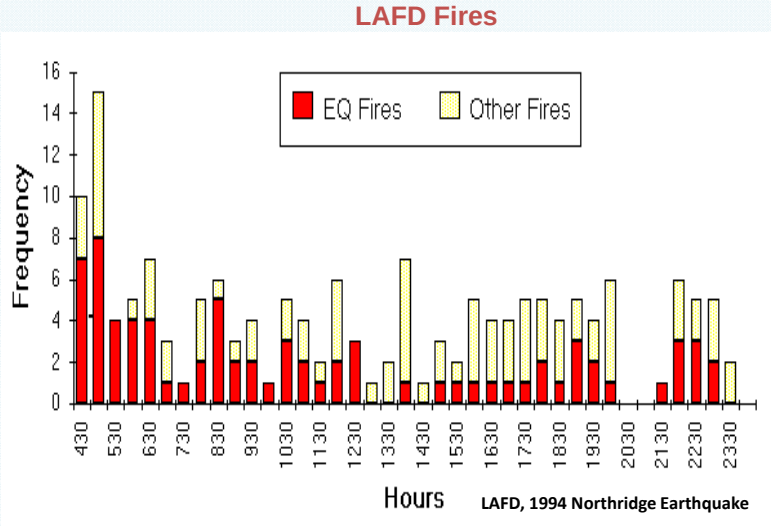
Post-Earthquake Ignitions, with Time



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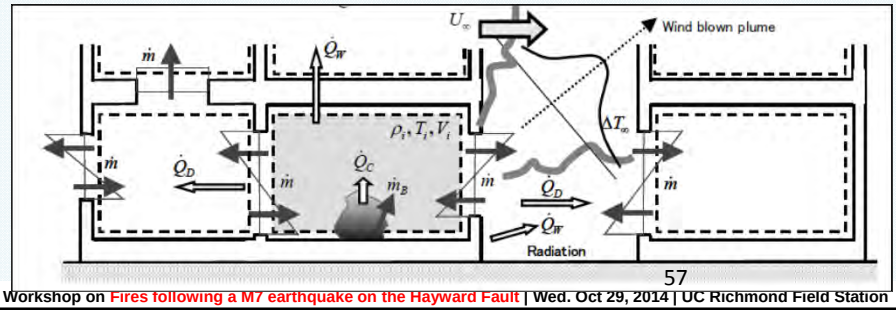
Recent Analytical Work – ***Physics Based Modeling***

Available online at www.sciencedirect.com
ScienceDirect
ELSEVIER
Fire Safety Journal 43 (2008) 477–494
FIRE SAFETY JOURNAL
www.elsevier.com/locate/firesaf

Development and validation of a physics-based urban fire spread model

Keisuke Himoto[a,*], Takeyoshi Tanaka[b]
[a]Pioneering Research Unit for Next Generation, Kyoto University, Gokasho, Uji, Kyoto 611-0011, Japan
[b]Disaster Prevention Research Institute, Kyoto University, Gokasho, Uji, Kyoto 611-0011, Japan

Received 1 May 2006; received in revised form 31 March 2007; accepted 18 April 2007
Available online 4 March 2008



Physics-based simulation model of post-earthquake fire spread

- **Estimates the extent of fire damage to an urban area**
- **Application in Los Angeles County**
- **Modes of spread considered:**
  - Evolution of room fire
  - Room-to-room spread within building by
    - Open doors
    - Burn through walls and ceilings
    - Leapfrogging
  - Building-to-building spread by
    - Radiation from room gas, window flame, roof flame
    - Flame impingement from window flame
    - Branding

Lee, S. (2009) "*Modeling Post-Earthquake Fire Spread*", PhD dissertation, R. Davidson, advisor Cornell University, 2009, in prep.

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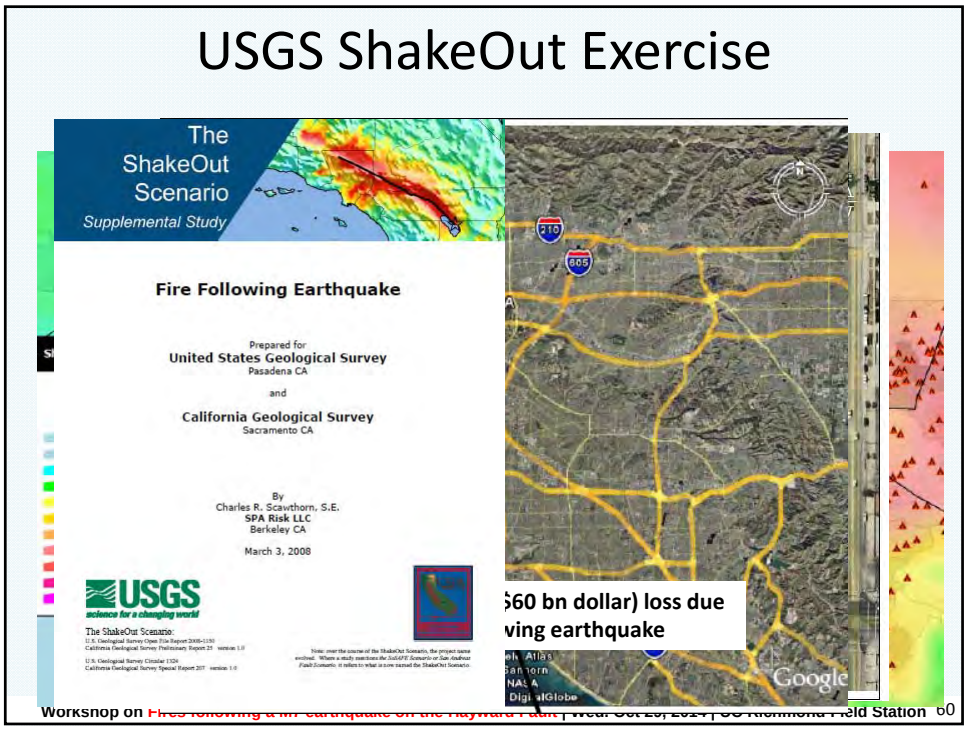

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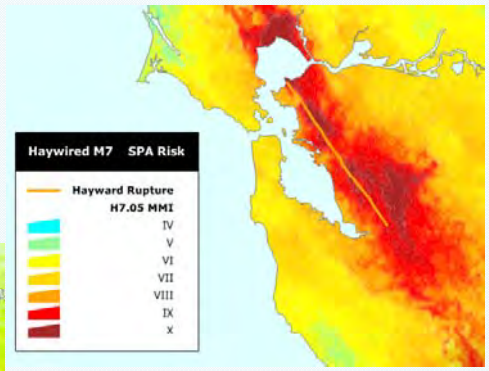
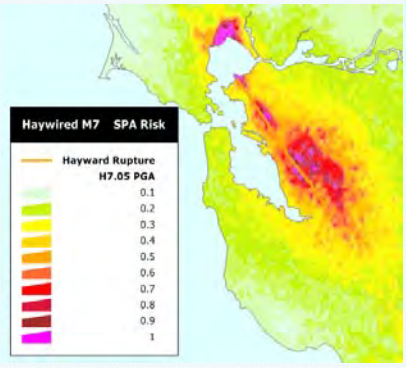
DRAFT -- DO NOT CITE OR DISSEMINATE -- FOR SCENARIO DEVELOPMENT ONLY

Haywired Mw 7.05 shaking intensity





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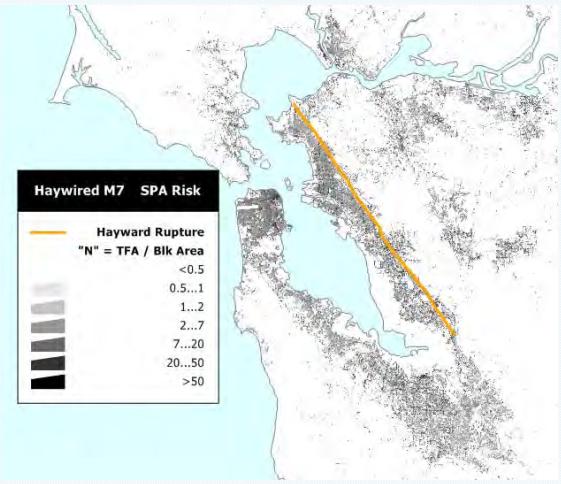
Exposure

Portions of 9 SFBA counties considered

- **6.97 million persons (2010 census)**
- **5.77 billion Total Bldg sq ft. floor area**
- **$1.15 trillion total bldg value (@ $200 psf)**

(structure only)



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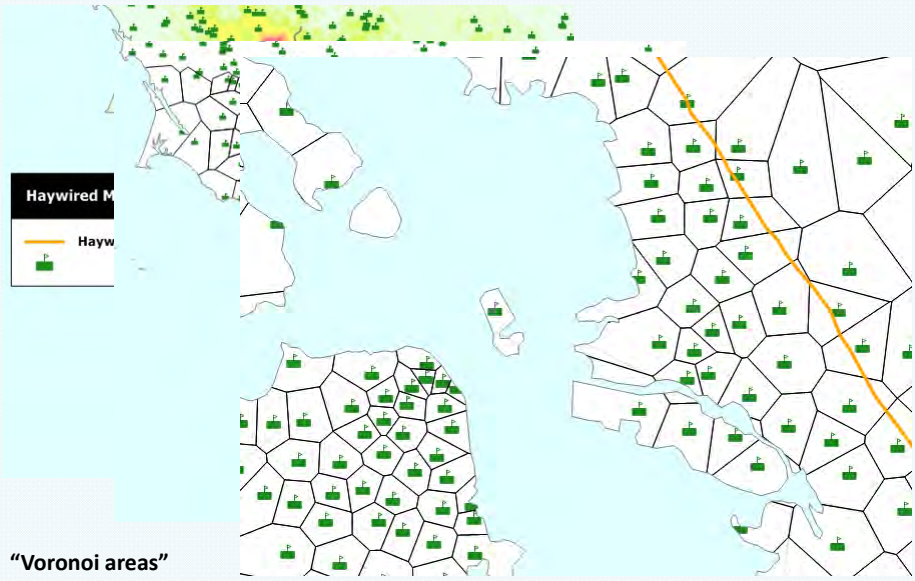
Fire Stations / Engines



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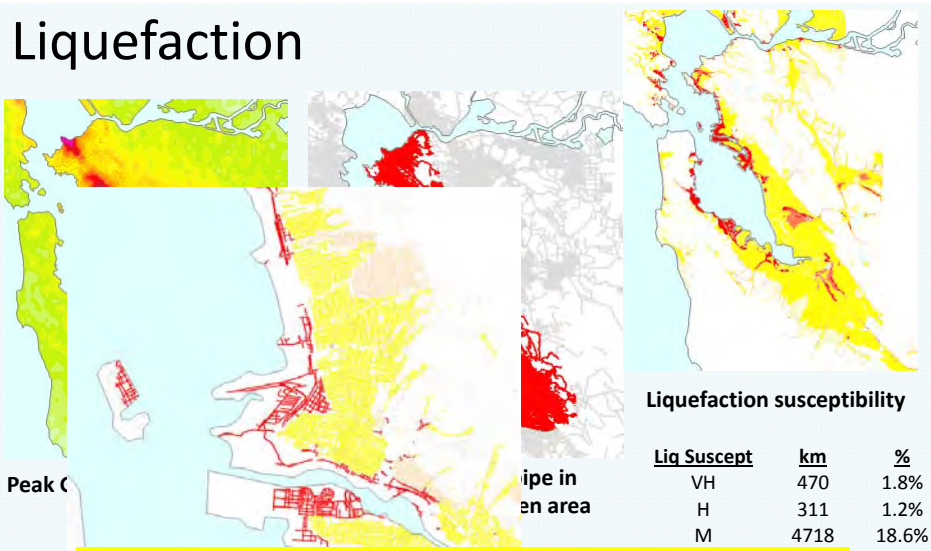
Liquefaction



Liquefaction susceptibility

Liq Suscept	km	%
VH	470	1.8%
H	311	1.2%
M	4718	18.6%
		100.0%

Thousands of breaks, to the extent that large areas may have to be wholesale replaced

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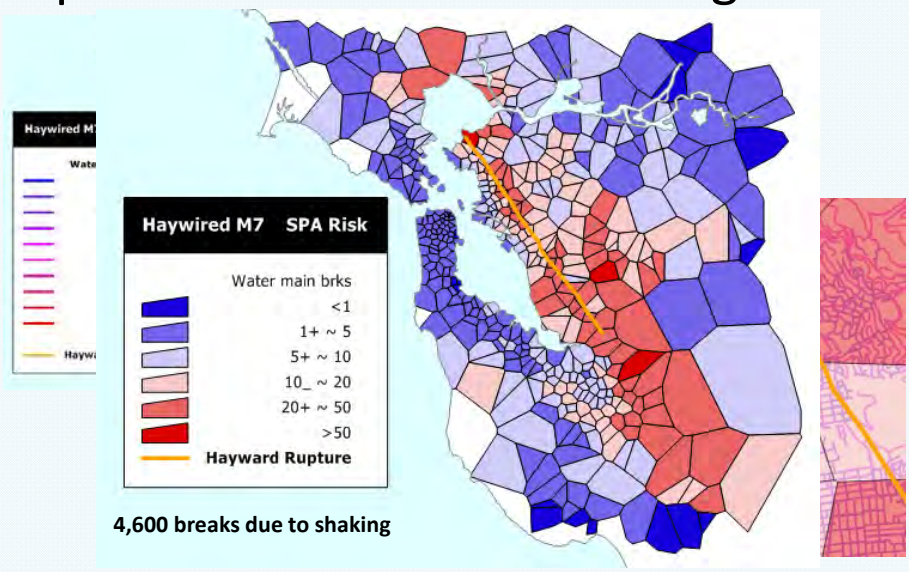
Pipeline Breaks due to Shaking



4,600 breaks due to shaking

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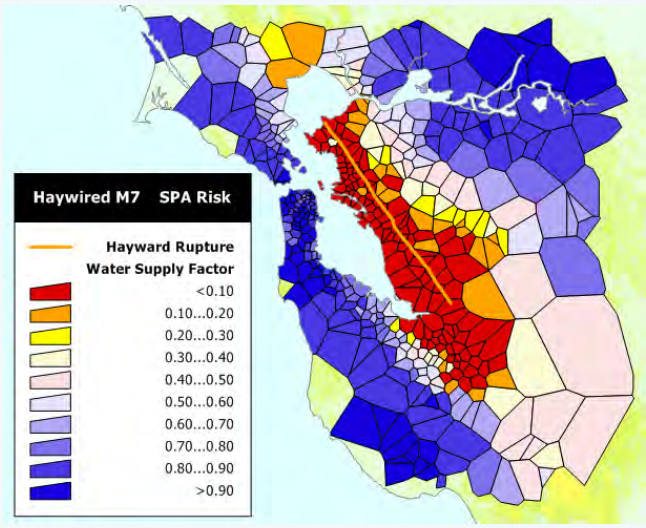
Total Breaks
Tot pipe length

→

Water Supply Factor (WSF)

0 = no water
…
1 = normal water



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EBMUD's estimate

Taming Natural

Risk Assessment

The earthquake hazard information described above, together with more detailed information on materials and design of these facilities, and pipeline materials and connections associated with EBMUD, were used to estimate the problems associated with District facilities in a 1994 study. At that time, EBMUD estimated, that, should a earthquake occur on the Hayward fault EBMUD customers could have expected:

- Water cut off immediately to 63 percent of customers, including hospitals and disaster centers;
- Loss of water for fire hydrants and increased fire risk;
- Over 5,500 pipelines serving homes and businesses to break;
- A likelihood of untreated drinking water due to damage to four of six treatment plants;

2010 Local Hazard Mitigation Plan Annex 10 October 25, 2011

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Alternative Water Supplies

34% SFBA pumpers *confirmed* as carrying Hard Suction
47% confirmed in East Bay

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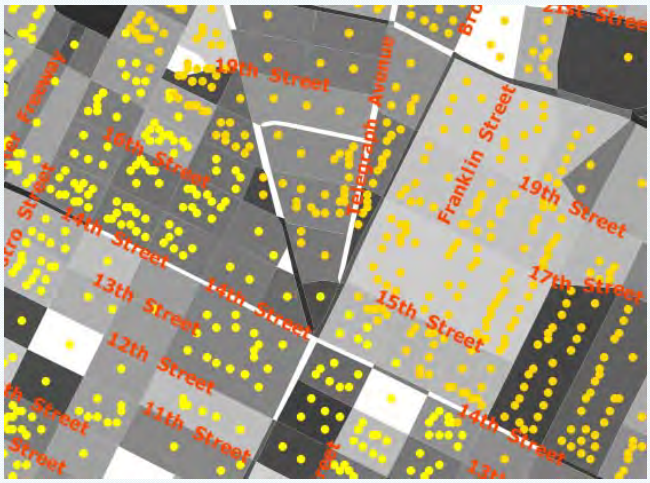
Firespread



Data
- Parcel data:
- TFA
- Occupancy
- Values

- Bldg Spacing
- Street widths

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Firespread – Flats (dense)

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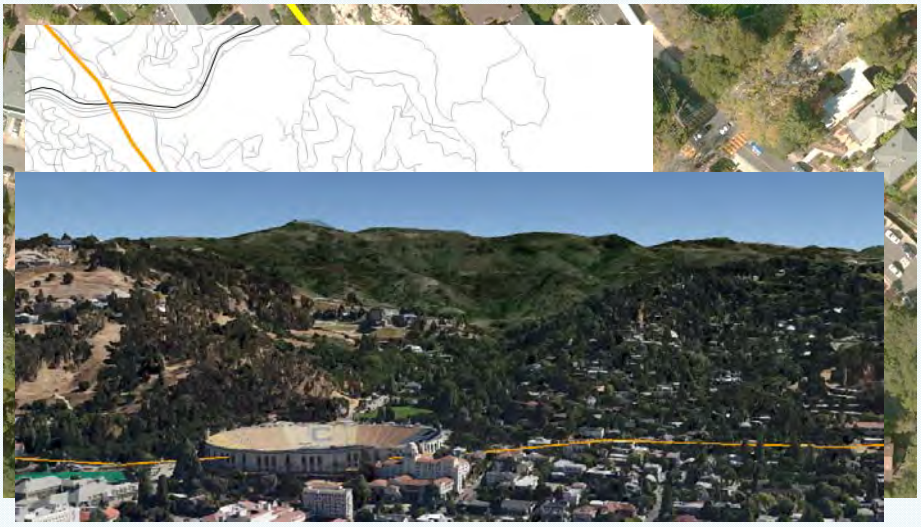
Firespread – Hills

(narrow windings streets, topography, vegetation…)



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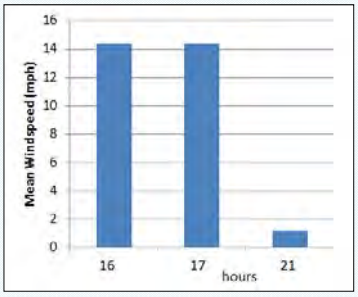
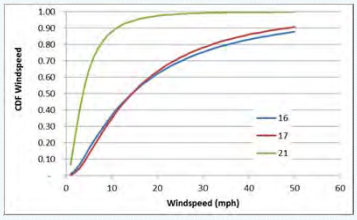
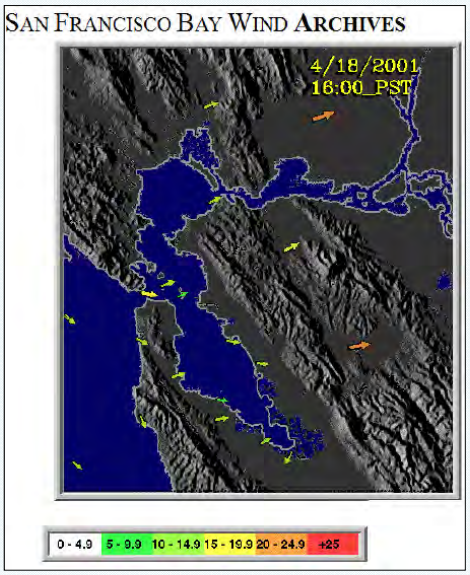
Windspeed







Credit: http://www.met.sjsu.edu/cgi-bin/wind/windbin.cgi

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Mutual Aid

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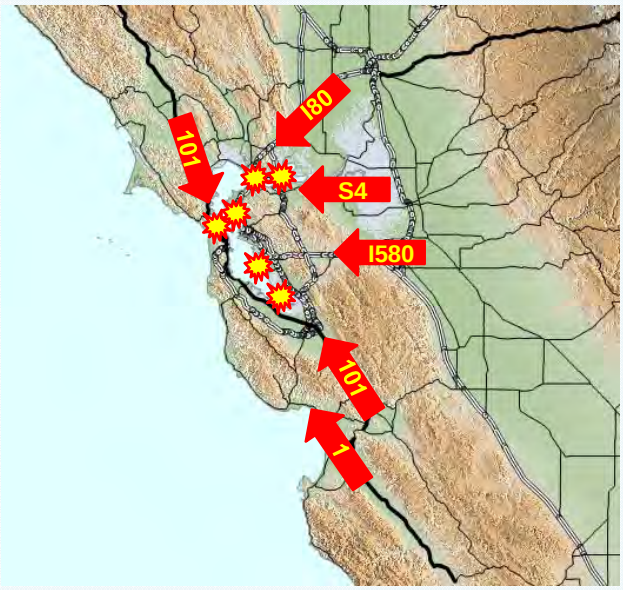
Strike Team access



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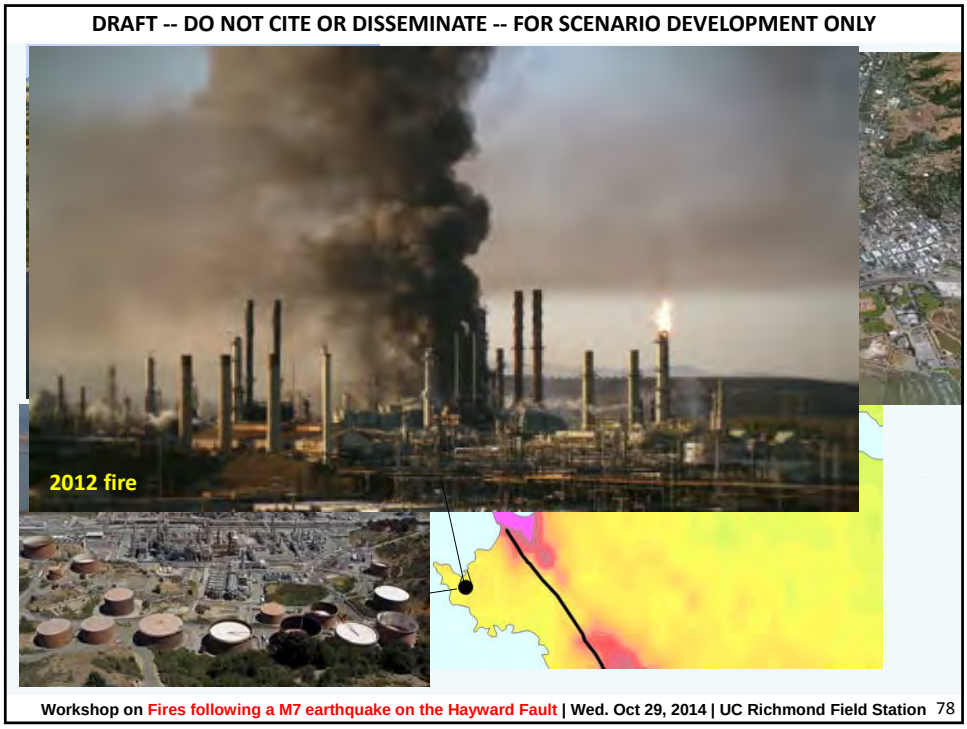
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2012 fire
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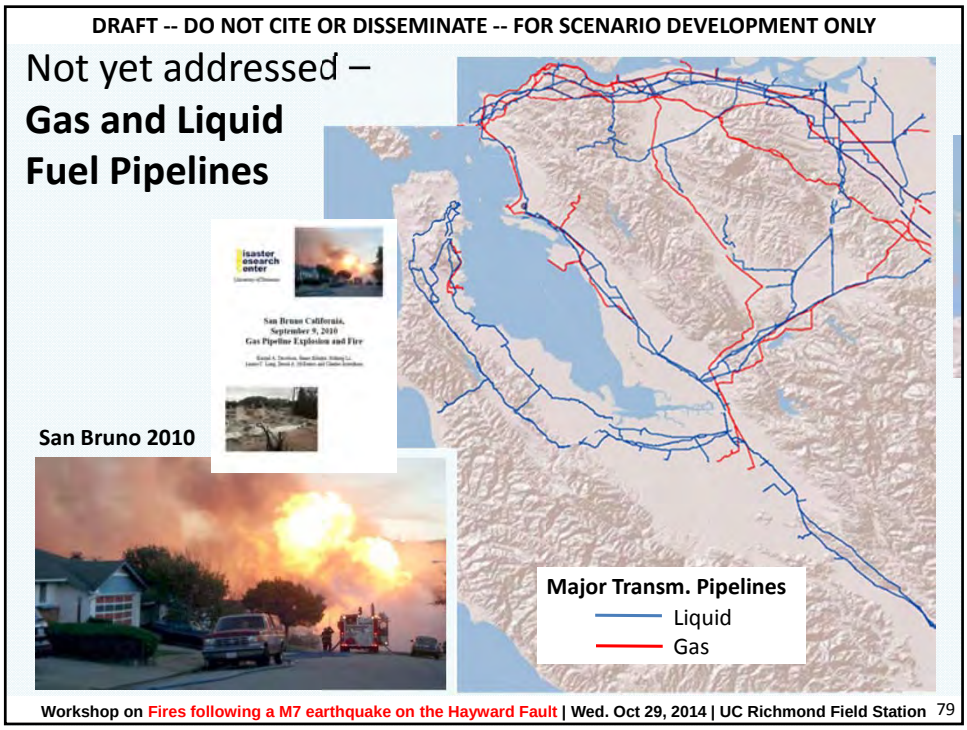
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Not yet addressed –
Gas and Liquid
Fuel Pipelines
San Bruno 2010
Major Transm. Pipelines
Liquid
Gas
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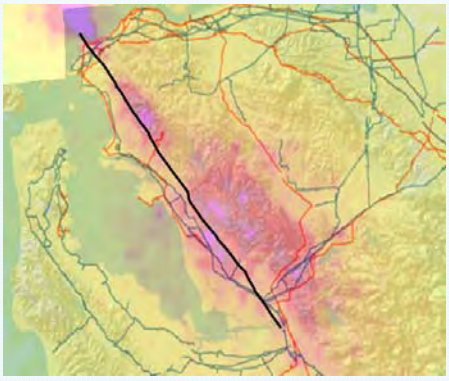
Gas and Liquid Fuel Pipelines



PGA and fault crossing hazard

Liquefaction hazard

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Not yet addressed –
Fire Dept.
Functionality

assumption:
100%

"18% high risk not functioning"

Proceedings of the 8th U.S. National Conference on Earthquake Engineering
April 18-22, 2006, San Francisco, California, USA
Paper No. 1662

SAN FRANCISCO BAY AREA FIRE STATIONS – SEISMIC RISK ASSESSMENT

Marguerite Bello[1], Craig A. Cole[2], Keith L. Knudsen[3], Fred M. Turner[4], Donald Parker[5], Jacqueline D.J. Bott[6], and other members of the EERI-NC Local Government Committee

ABSTRACT

The Local Government Committee of the Northern California Chapter of the Earthquake Engineering Research Institute (EERI-NC) conduct an earthquake risk assessment for 492 fire stations in the San Francisco Bay Area. This assessment included calculation of ground shaking and identification of other seismic hazards and also an assessment of the vulnerability of the fire stations based on information such as building age, structural type, if and when station was retrofitted and type of garage doors. Results indicated that average peak ground acceleration are 0.5 g. and 52% of the stations are in areas mapped as moderate to very high liquefaction susceptibility with 102 stations being located within State designated Seismic Hazard Zone of Required Investigation for liquefaction or landsliding. More than 60 volunteers conducted walk-through field surveys of about 100 stations. In terms of life safety considerations, based on construction type, age and assessment of vulnerability, 42% of fire stations are in moderate to high-risk categories. In terms of functionality of the fire stations, based on a subset (293 stations) for which information was available, 67% were of moderate to high risk of not functioning after an earthquake. Based on these results, it is recommended that those fire stations at higher risk be evaluated and retrofitted such that life safety and vulnerability are improved before the next large earthquake occurs.

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Thank You

cscawthorn@berkeley.edu

Q&A / Discussion

Agenda

Workshop Program

9:00 Registration begins
9:30 Workshop Overview / Introductions
9:45 Napa Earthquake
10:00 Hayward M7 EQ– Overview and Impacts
10:15 Hayward M7 Ignitions and Fire spread
10:45 Q&A
11:00 Break
11:15 Water Supply
11:30 Roundtable discussion, senior Fire Chiefs
12:00 Lunch / General Discussion
12:45 Move to foot of Gilman Street, Berkeley
13:00 Exhibition of FD Water Systems

- **Berkeley FD 12" LDH Above Ground Water System**
- **San Francisco FD PWSS**
- **Oakland FD Hose Tenders**
- **Vallejo FD Hydrosub**

16:00 Closure

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Water Supply

Charles Scawthorn
PEER

Capt. Michael Sullivan
Berkeley FD

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capacity of the 38 first line and 15 relief and reserve engines totaled 35,100 gpm. In summary, the department was rated by the National Board of Fire Underwriters (NBFU 1905) as efficient, well organized and, in general, adequate. For the factors noted above, however, the NBFU concluded that

…In fact, San Francisco has violated all underwriting traditions and precedent by not burning up. That it has not done so is largely due to the vigilance of the fire department, which cannot be relied upon indefinitely to stave off the inevitable.

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San Francisco Bay Area - built to burn
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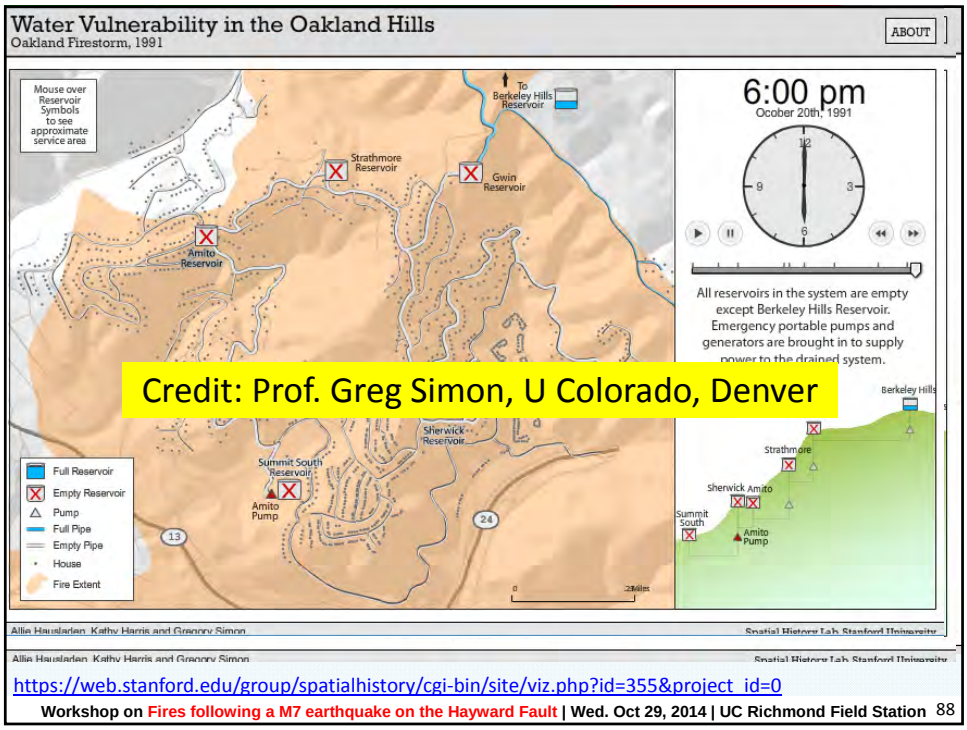
Water Vulnerability in the Oakland Hills
Oakland Firestorm, 1991
ABOUT
Mouse over Reservoir Symbols to see approximate service area
To Berkeley Hills Reservoir
Strathmore Reservoir
Gwin Reservoir
Amito Reservoir
Sherwick Reservoir
Summit South Reservoir
Amito Pump
Full Reservoir
Empty Reservoir
Pump
Full Pipe
Empty Pipe
House
Fire Extent
13
24
6:00 pm
Ocober 20th, 1991
All reservoirs in the system are empty except Berkeley Hills Reservoir. Emergency portable pumps and generators are brought in to supply power to the drained system.
Credit: Prof. Greg Simon, U Colorado, Denver
Allie Hauslarden, Kathy Harris and Gregory Simon
Spatial History Lab, Stanford University
https://web.stanford.edu/group/spatialhistory/cgi-bin/site/viz.php?id=355&project_id=0
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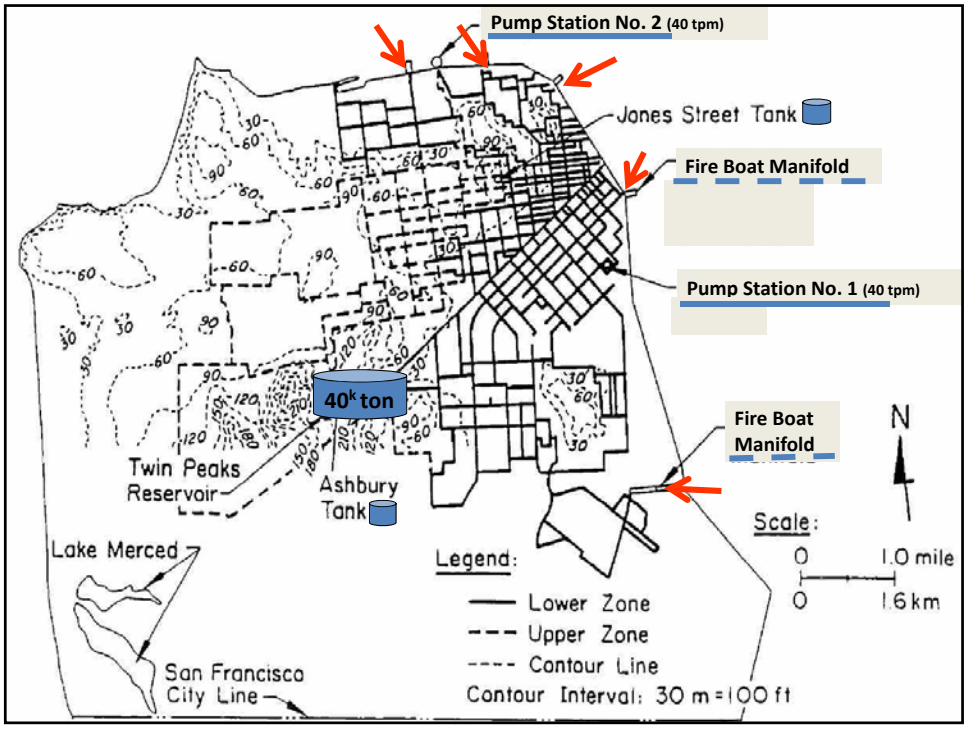
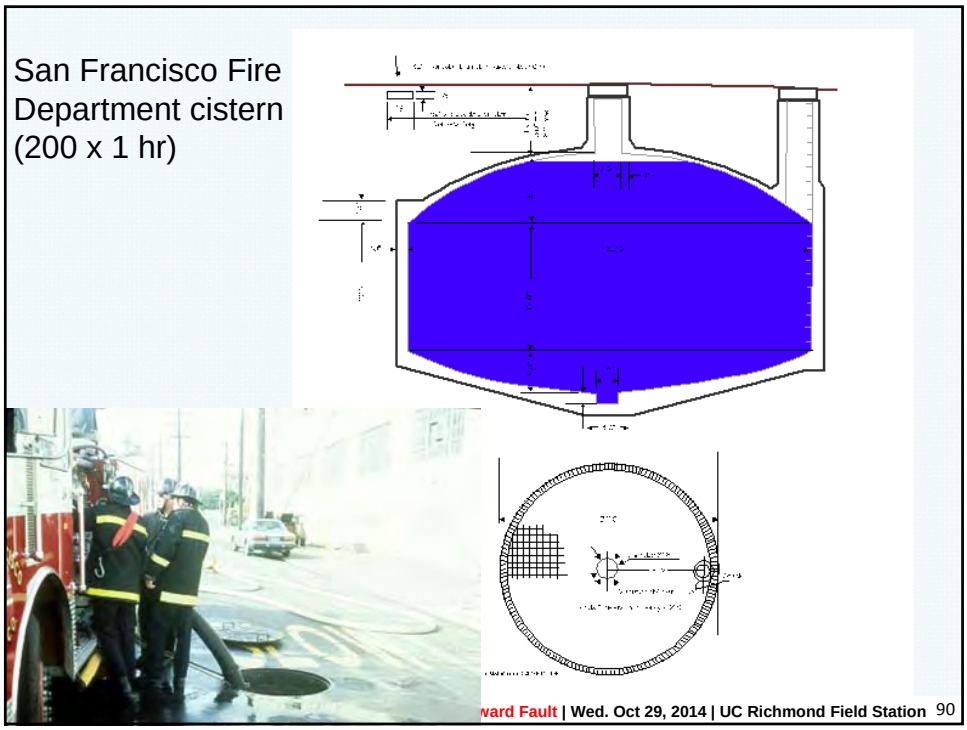

Pump Station No. 2 (40 tpm)
Jones Street Tank
Fire Boat Manifold
Pump Station No. 1 (40 tpm)
40k ton
Fire Boat Manifold
N
Twin Peaks Reservoir
Ashbury Tank
Scale:
0 1.0 mile
0 1.6 km
Lake Merced
Legend:
Lower Zone
Upper Zone
Contour Line
Contour Interval: 30 m = 100 ft
San Francisco City Line


San Francisco Fire Department cistern (200 x 1 hr)
ward Fault | Wed. Oct 29, 2014 | UC Richmond Field Station 90

San Francisco FD Hose Tenders (4)

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San Francisco FD Fireboats (2)

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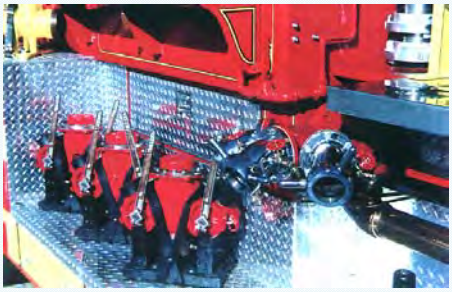
Oakland FD hose tenders (4)

Oakland FD PWSS hose tender, showing Gleeson pressure reducing valves (red), portable hydrants (yellow, upper left and right), and hose ramps (yellow, lower left, slung under the rig).



Oakland FD PWSS

Equipment carried includes:

- 1 mile of 5" hose w/ 4½" couplings
- 5) Portable hydrants (4½" x 3½" side outlets)
- 6) Gleeson valves
- 1) 4½" line gate
- 4) 3" to 4½" clapper siamese
- 12 sets LDH hose bridges
- Large capacity (6-inlet) deck pipe
- Assorted increasers, reducers & gender changers
- Assorted short hose "pigtails"

Rear View

Vallejo FD Hose Tender and Hydrosub

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Berkeley 12" PWSS

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http://www.hytransfiresystem.com/

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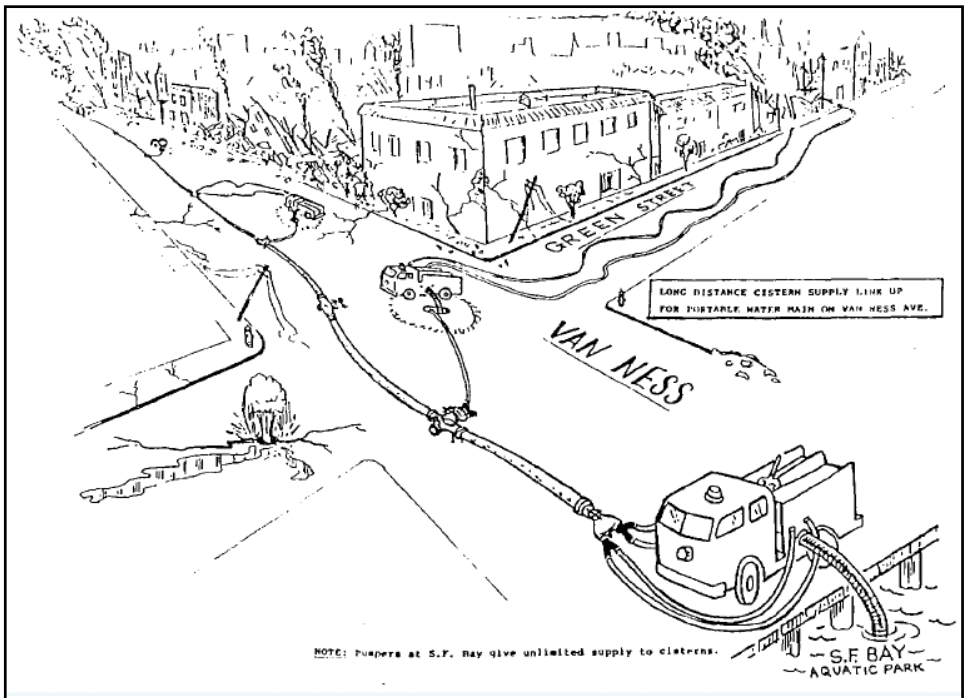

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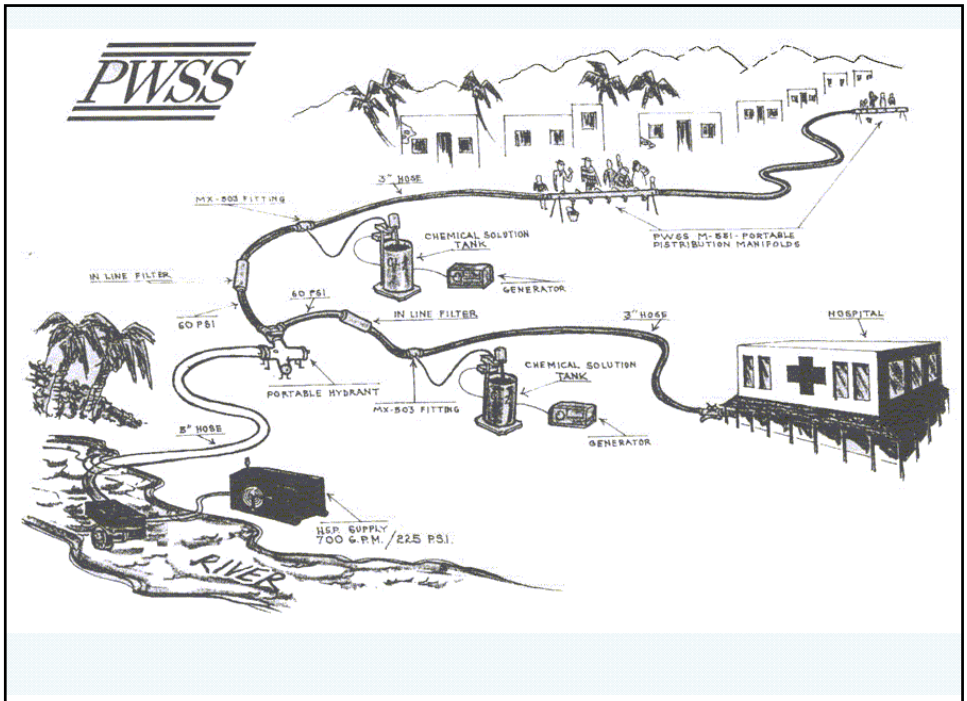
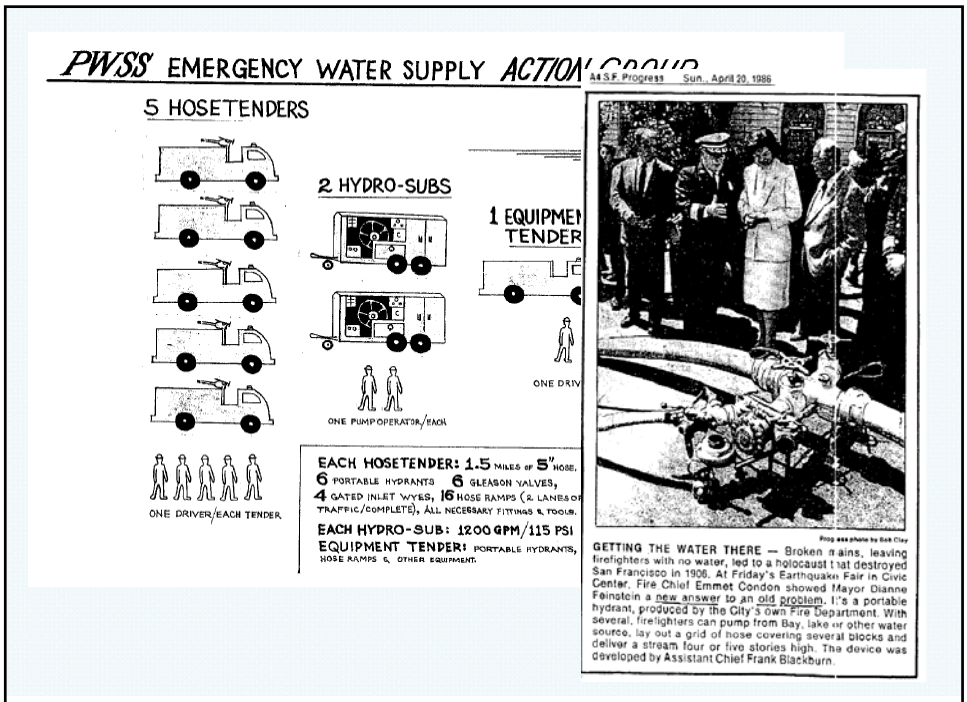


Workshop on Fires following a M7 earthquake on the Hayward Fault | Wed. Oct 29, 2014 | UC Richmond Field Station 99

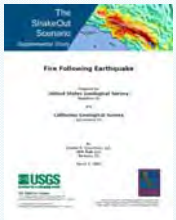


Workshop on Fires following a M7 earthquake on the Hayward Fault | Wed. Oct 29, 2014 | UC Richmond Field Station 100

Thank you

cscawthorn@berkeley.edu

Scawthorn, C. (2011) Water Supply In Regards to Fire Following Earthquakes. pp. 173. Pacific Earthquake Engineering Research Center, College of Engineering, University of California, sponsored by the California Seismic Safety Commission, Berkeley. Water Supply in regard to Fire Following Earthquake - Sca***wthorn FINAL PEER Report 2011***. ***A four page summary of the report is available*** here



Scawthorn, C. (2011). Fire following earthquake aspects of the Southern San Andreas Fault Mw 7.8 earthquake scenario. *Earthquake Spectra* 27 (2), 419-441. http://www.sparisk.com/pubs/Scawthorn-2011-ShakeOut-FFE.pdf

www.sparisk.com

Q&A / Comments

Panel Discussion

General Discussion

Lunch

Photo of Workshop

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Demonstration

Workshop on Fires following a M7 earthquake on the Hayward Fault | Wed. Oct 29, 2014 | UC Richmond Field Station 105

Photos from Demonstration

Workshop on Fires following a M7 earthquake on the Hayward Fault | Wed. Oct 29, 2014 | UC Richmond Field Station 106

Photos from Demonstration

Workshop on Fires following a M7 earthquake on the Hayward Fault | Wed. Oct 29, 2014 | UC Richmond Field Station 107

Photos from Demonstration

Workshop on Fires following a M7 earthquake on the Hayward Fault | Wed. Oct 29, 2014 | UC Richmond Field Station 108

Photos from Demonstration

Workshop on Fires following a M7 earthquake on the Hayward Fault | Wed. Oct 29, 2014 | UC Richmond Field Station 109

Photos from Demonstration

Workshop on Fires following a M7 earthquake on the Hayward Fault | Wed. Oct 29, 2014 | UC Richmond Field Station 111

Photos from Demonstration

Workshop on Fires following a M7 earthquake on the Hayward Fault | Wed. Oct 29, 2014 | UC Richmond Field Station 112

Photos from Demonstration

Workshop on Fires following a M7 earthquake on the Hayward Fault | Wed. Oct 29, 2014 | UC Richmond Field Station 113

End

for further information

cscawthorn@berkeley.edu

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