United States Department of the Interior
U.S. Geological Survey

Report on the CONCERT/ASPRS Workshop

Earth Science Information and GIS Technology in Emergency Management

Conducted June 14, 1994

Carl E. Mortensen[1] , Elizabeth A. Wegenka[2] , James K. Buika[3]

Open-File Report 95-480

Menlo Park, California

1995

---

[1] U.S. Geological Survey, 345 Middlefield Rd, Menlo Park, CA 94025

[2] U.S. Geological Survey, 345 Middlefield Rd, Menlo Park, CA 94025; now with U.S. Forest Service, Salt Lake City, UT

[3] Federal Emergency Management Agency, Bldg 105, Presidio of San Francisco, CA 94129

Report on the CONCERT/ASPRS Workshop

Earth Science Information and GIS Technology in Emergency Management

Conducted June 14, 1994

Carl E. Mortensen, US Geological Survey, Menlo Park, CA
Elizabeth A. Wegenka, US Geological Survey, Menlo Park, CA[1]
James K. Buika, Federal Emergency Management Agency, Region IX
San Francisco, CA

INTRODUCTION

GIS shows promise of becoming an indispensable tool for emergency managers confronted with allocating resources and managing emergency response, recovery and mitigation operations. Following the recent Northridge earthquake, GIS and earth science information were used in responding to a catastrophic earthquake as never before. This experience emphasized both the utility of this technology and information, and the need to integrate them into emergency management operations in a more utilitarian way. Accordingly, the Coordinating Organization for Northern California Earthquake Research and Technology (CONCERT) and the American Society of Photogrammetry and Remote Sensing (ASPRS) sponsored a one-day workshop titled "Application of Earth Science Information and GIS Technology to Emergency Management". It was held at the U.S. Geological Survey (USGS) headquarters in Menlo Park, on June 14, 1994. The purpose of this workshop was to convene a multidisciplinary group to focus on the application and use of GIS technology to translate and transfer earth science information to emergency managers, with emphasis on problems and issues particular to the Bay Area. Objectives of the workshop were (1) to develop a network of GIS and earth science information resources and points of contact for people working on the associated problems, (2) to identify critical digital data layers needed before the next large Bay Area earthquake, (3) to identify critical information gaps and strategies for developing needed information and (4) to propose a model structure for blending GIS technology and earth science information with emergency management operations.

A broad representation of agencies and institutions concerned with the major workshop themes was apparent. 94 attendees representing 26 agencies and institutions participated, demonstrating a substantial interest in creating systems and linkages, both technological and organizational, that will allow the effective application of earth science information to emergency management in the greater San Francisco Bay region. A roster of attendees, their affiliations and points of contact, are tabulated in Appendix A to this report.

The workshop agenda was as follows:

AGENDA

0815 - 0845	* Opening Remarks	Carl Mortensen (USGS)
0845 - 0905	* The Bay Region Database (BARD)	Liz Wegenka (USGS)

[1] Now with US Forest Service, Salt Lake City, Utah

0905 - 0925	* What's available in the Bay Area now	Jeanne Perkins (ABAG)
0925 - 0945	* How to put it all together	Ron Eguchi (EQE)
0945 - 1015	* Discussion	
1015 - 1030	Break	
1030 - 1050	* Strong Ground Motion	Bill Joyner (USGS)
1050 - 1110	* Mapping Geologic Hazards of the Bay Area	Carl Wentworth (USGS)
1110 - 1130	* Damage Estimation	Stephanie King (Stanford)
1130 - 1200	* Real Time Seismology	Lind Gee (UC Berkeley)
1200 - 1300	Lunch	
1300 - 1330	* Discussion	
1330 - 1350	* Response & Recovery	Rich Eisner (OES)
1350 - 1410	* Recovery & Mitigation	Jim Buika (FEMA)/Ed Bortugno (OES
1410 - 1430	* GIS Applications	Dave Kehrlein (OES)
1430 - 1445	* National GIS Resources	Paul Bryant (FEMA)
1445 - 1530	* Discussion/Wrap-up	
1500 - 1600	Optional tour of GIS Lab/ESIC	

All of the talks ended with a lively discussion period, reflecting the high level of interest and relevance of the workshop topics.

SUMMARIES OF PRESENTATIONS

The Bay Region Database (BARD) **Liz Wegenka (USGS)**

Elizabeth Wegenka of the USGS, National Mapping Division (NMD), lead the technical presentations with a description of the Bay Area Region Database (BARD), maintained in the USGS, NMD GIS laboratory. She noted that BARD presently consists of Digital Line Graphs (DLG's) at 1:100,000 scale. Also included are layers of land use with cultural features, gravity points, and epicenters of earthquakes greater than M=2.0 through the period ending August 7, 1992. Future plans include the addition of results from the SF Bay and Delta Ecosystem study. 1:24,000 DLG's will also be added as they become available in digital form. Elizabeth also described plans to make BARD files available via the Internet.

What's available in the Bay Area now **Jeanne Perkins (ABAG)**

The Association of Bay Area Governments (ABAG) has maintained and distributed digital, spatial databases of the SF Bay region for almost 20 years. Among other products, ABAG has produced damage estimation summaries for scenario earthquakes, including estimated damage for different structure categories. Application of these techniques to actual damages from the Loma Prieta earthquake revealed inconsistencies between the intensity models and damage distribution, indicating a need to calibrate and revise the models, and/or more accurately catalogue and characterize existing building stock and infrastructure (Perkins, 1992). ABAG databases also include information on hazardous material spills following Loma Prieta.

Currently ABAG is inventorying housing stock, by address, throughout the Bay Area, including mobile homes, units in unreinforced masonry (URM) buildings (estimated to number some 25,000 dwelling units), and units in buildings over three stories. The latter work is prompted by the large number of three-story housing units that collapsed during the Northridge earthquake. This information will be used to improve damage estimation scenarios.

Among particular technical problems, Jeanne noted that the commonly used TIGER files contain positional errors of up to 300 meters. She noted that these errors should be taken into account when interpreting various maps and spatial databases that rely on TIGER information. This can be generalized to an admonition that any spatial data set must be geographically registered and validated against ground truth. Jeanne provided a handout that listed the various data layers made available by ABAG, including information and data for some 100 cities and the nine Bay Area counties. Maps should be available over the Internet in 1995.

How to put it all together **Ron Eguchi (EQE)**

Ron Eguchi of EQE, International, described EQE's Early Post Earthquake Damage Assessment Tool (EPEDAT), which was developed principally with OES and USGS funding. Parts of the EPEDAT system for damage estimation were successfully employed following the Northridge earthquake to "fast-track" Individual Assistance Grants by zip code, and to conduct community outreach. EPEDAT uses the CalTech USGS Broadcast of Earthquakes (CUBE) system to calculate initial post-earthquake damage patterns, fatalities, injuries and number of displaced individuals from modeled intensities, building and lifeline databases, and empirical estimation schemes.

Parts of the EPEDAT system were employed successfully following the Northridge earthquake, and it is being developed and extended for application to the Bay Area. It is estimated that the Bay-Area-capable system will be delivered by the end of 1994 In addition to the estimates of damaged buildings by type, the system will be able to provide estimates regarding hazardous materials, damage to regional lifelines and a gross regional dollar-loss estimate. Following the Northridge earthquake, EPEDAT estimated gross dollar loss at $12.5 to 22.4 billion. Ron emphasized the importance of conveying the information to decision makers following a catastrophic event in an understandable and informative manner, including the likely inaccuracies of initial estimates.

Ron noted the need to rapidly update initial damage estimates using air and ground reconnaissance and satellite imagery data. Actual strong ground motion recordings, when available, greatly improve the initial estimates and are critical for calibrating shaking models. One problem not considered prior to the Northridge earthquake was the blind thrust earthquake source. This problem complicates the development of an initial assessment because manual intervention is necessary to initiate the model calculations.

EPEDAT databases include: digitized faults of California, surface soils and geology of California (the State geologic map), various population databases from the Bureau of Census, building exposure data developed from County Assessors' records, major utility corridor information including water and waste-water, electrical power, and gas, and other relevant data layers.

Critical issues for completion of the Bay Area EPEDAT are: availability of real time earthquake source information; a comprehensive building inventory database for the region; lifeline information; and close coordination between USGS and State OES officials to ensure standard and consistent application throughout California.

Strong Ground Motion **Dr. William Joyner (USGS)**

Bill Joyner of USGS, Menlo Park, described how peak horizontal acceleration and response spectra may be used to characterize ground motion rather than intensity. The response spectra contain information about how ground motion affects particular structures, and thus provides a more direct method for predicting the response of structures. He described how ground motion depends upon magnitude, distance, and site conditions (as characterized by the average shear velocity in the upper 100 feet of the earth's crust). Graphs of peak acceleration versus distance from the source fault for various earthquake magnitudes (known as the "Boore-Joyner" curves) were presented. Combining this information with local shear velocity as measured in boreholes in different geologic units can result in maps that predict ground motion for a given size earthquake. The USGS is currently working on constructing maps of San Mateo County depicting predicted peak ground acceleration and response values at 0.3 and 1.0 second periods. In another project, the USGS is developing techniques for more realistic map portrayals of ground motion that take better account of directivity than current methods.

Mapping Geologic Hazards of the Bay Area **Dr. Carl Wentworth (USGS)**

Carl Wentworth of the USGS described the overall context for the use of geologic information in the development of analytical tools for hazard assessment. He noted that the classification and characterization of geologic units, along with the careful definition of their spatial distribution, form the fundamental basis for such assessments. He noted also that geologic investigations were necessary to determine the potential for surface fault rupture along fault traces. The assessments of hazards from strong ground shaking, landslides, liquefaction, ground rupture, and other earthquake effects all depend critically on such fundamental geologic investigations and summaries. Compiled in the form of appropriate GIS data bases, the results of these investigations are available for further integration into the analytical assessments of various hazards. Carl described the state of progress on the various geologic investigations and compilations throughout the San Francisco Bay region.

Damage Estimation **Dr. Stephanie King (Stanford)**

Stephanie King of Stanford University described the damage estimation methodology developed at the John Blume Earthquake Engineering Research Center. This methodology is comprehensive in terms of the hazards addressed, and can lead to actual building specific estimation with sufficient input information. She first described structural inventory development, specifying damage definitions categorized by two factors: Damage Factor (dollar loss/replacement value) and Damage Ratio (number of damaged buildings/total number of buildings). Required inventory information includes attributes describing location, use, and structural properties. Ground motion-damage

relationships were discussed in terms of damage-loss curves and fragility curves, leading to damage probability matrices and expected damage factor curves. Classification and inference schemes were described which included 17 classes of structures based on structure type and social function, and heuristic rules for inferring missing data. A compilation methodology was applied for the combining of various databases utilizing expert system integration.

A prototype project in the Salt Lake City, Utah, region based on a scenario earthquake of M=7.5 on the Wasatch fault was presented in which a database of some 200,000 buildings and 280 highway bridges was assessed utilizing ARC/INFO. Census tracts were used for analysis to improved the likelihood of uniformity and thus the accuracy of inferred data. Maps showing various geologic hazards and damage estimates were produced, including liquefaction, landslide, deterministic peak ground acceleration (PGA), expected damage factor, and damage ratio.

Real Time Seismology **Dr. Lind Gee (UC Berkeley)**

Lind Gee of the University of California Seismographic Station provided a descriptive overview of real-time seismology and the REDI (Rapid Earthquake Data Integration) system. The REDI project is a research program established at UC Berkeley in collaboration with the USGS, Menlo Park, for the rapid dissemination of earthquake information. It is the northern California equivalent of the CUBE (Caltech/USG Broadcast of Earthquakes) system, which has provided near real-time access to southern California earthquake parameters for the last three years. REDI is now providing earthquake information in 6 - 8 minutes. That response time will be improved by about 4 minutes with the implementation of the USGS real-time processing methodology. A long term goal of this project is the implementation of an early warning system.

REDI utilizes data from the Berkeley Digital Seismic Network, operated by UC Berkeley, and the Northern California Seismic Network, operated by the USGS Menlo Park. REDI incorporates both phase and wave form data to determine the location and magnitude of earthquakes and transmits this information to emergency response operators via electronic mail and commercial radio pagers. The pagers can either be used as a personal pager or connected to a computer for a graphical display of the earthquake information. REDI currently provides information on earthquake location and magnitude for events with magnitude > 1.8 and additional information on peak ground acceleration, velocity, and displacement for events with magnitude > 5.5. In the near future moment magnitude, moment tensor (mechanism), source duration and directivity and response spectra will be available as well. By the end of 1995 it is planned to have 16 Berkeley Digital Seismic Network installations in northern California and a densified network of strong ground motion stations in the San Francisco Bay Area.

Utilization of GIS in Response **Rich Eisner (OES)**
Regional Administrator, Coastal Region
Governor's Office of Emergency Services

The experience of Northridge pointed to the importance of having geologic data base and GIS capability as part of an emergency response capability after an earthquake. Utilizing near real-time seismic source and magnitude data enables responders to model and assess the impact of an earthquake while they await information on the actual event. The essential elements of GIS use are a pre-event complied data base of regional geology, building inventory, a base map library, and a loss estimation methodology such as that being developed by FEMA and the National Institute of Building Sciences. In addition,

access to the GIS should be provided to emergency operations centers at the state and regional levels through a wide area network.

During the response to the Northridge earthquake, information compiled by field investigators from the USGS, California Division of Mines and Geology (CDMG), and Earthquake Engineering Research Center (EERI), was displayed on conventional map display boards at the Information Clearinghouse in Pasadena. Unfortunately, the information, much of which was not available from other sources, was not transferred to the State's operations center at Los Alamitos. Integration of the clearinghouse information data base into a GIS via a wide area network is a prime objective of the current California GIS planning.

Recovery & Mitigation **Jim Buika (FEMA)/Ed Bortugno (OES)**

Ed Bortugno described the Hazard Mitigation Grant program and how it was being administered in the case of the Northridge earthquake. He emphasized the importance of establishing and maintaining good communications between the scientific, engineering and emergency management communities.

Jim Buika focused on the application and use of GIS technology to translate and transfer earth science information to emergency managers. In particular he described how FEMA and OES are applying this information in managing FEMA's Hazard Mitigation Grant program. He outlined the following objectives:

1) Develop a network of earth science information resources and points of contact;

   The technology exists to create a virtual network of earth science resources and sources, but there is no in-place organization. He identified the need to determine key players who can develop the critical data layers and create a repository of information.

2) Identify critical digital layers for the next strong Bay Area Earthquake;

   This will entail compiling extensive data sets from various, disparate databases. Data in simple spreadsheet format is helpful to GIS staff doing the compilation.

3) Identify critical information gaps and develop strategies for developing needed information;

   This entails incorporating damage inventory, digital photographs and videos, Global Positioning System (GPS) satellite locations, existing inventory and other information into a GIS database. GIS enables one to bridge the gap between damage to the built environment and earth science by superimposing structural inventories and earth sciences data layers.

4) Propose a model structure for merging GIS technology and earth science information with emergency management operations.

   The organization following the recent Northridge earthquake may be used as a model. During Northridge, earth science information was applied in a number of ways to response, recovery and mitigation problems. Jim proposed moving one step beyond this model by creating a formal data management "clearinghouse" where earth science and structural

information would be merged. He proposed that CONCERT draft a paper proposing such a structure to USGS, FEMA and NASA. A particular point would be to get personnel assigned to the task.

A particular issue raised by Jim involved locating damaged structures in special flood plain hazard areas. He proposed a model for the hazard evaluation and assessment process that takes a multi-hazard approach. The goal of this approach would be to present local government with a hazard evaluation that reflected an integrated assessment from all hazard types for use in developing a viable and cost effective mitigation strategy. For example, a zoning official may consider an application for a permit to rebuild differently, knowing that a structure could be susceptible other types of hazards in future events. The official may wish to specify further mitigation measures over and above mitigating for a repeat of the hazard that caused the damage. This approach was applied successfully in the Santa Clarita Valley following the Northridge earthquake.

GIS Applications **Dave Kehrlein (OES)**

Dave Kehrlein of the Governor's Office of Emergency Services provided a powerful description of just what occurs in the minutes, hours and days following a major disaster, and how the forces at play affect information processing demands. In addition to the technical aspects of providing information to emergency management decision-makers, he emphasized the importance of the relationship of the social fabric and makeup of a community with the build environment in determining how services are delivered. In a compelling chronology, Dave traced the status of four key parameters (intelligence, available information resources, potential information resources, and stress) immediately following a large earthquake disaster.

Drawing heavily on the experience from the recent Northridge earthquake, Dave described how all four parameters except stress are initially low. Within a few hours, intelligence, and resource potential and availability increase (though much of the resource potential is not yet accessible), but the stress level becomes very great, and no amount of resources are able to fully satisfy the demand for information. Gradually, more and more information processing resources are brought to bear and the stress level begins to abate somewhat and focus on particular issues, until the available information processing capability is able to fulfill the demand. Information must be rapidly brought to bear on a wide range of issues that will result in key decisions, including damage estimation, surveying the damage, location of Disaster Application Center (DAC), demographics of applicants and victims, staffing patterns, outreach zones for public assistance, Disaster Field Office (DFO) location and staffing, insurance issues, and others.

Both EQE and FEMA provided useful maps of Modified Mercalli Intensity (MMI) which were processed through the GIS shop at the DFO. Caltech provided a map of epicenters. These maps and predictive tools are very useful since most damage is not apparent form the street. In time, ATC-20 (Applied Technology Council) assessments were provided to the GIS shop for geocoding and integration into a damage database. For the future, Dave outlined the need for agreements with local governments to exchange data, linking of hand-held computers with GPS positioning to the master database, and statistical estimates for initial inputs. Goals might include providing illustrative, operational, and analytical map products, and analysis for siting DACs within two hours of the event. Another application involves providing decision support for hazard mitigation through comparison and analysis.

National GIS Resources **Paul Bryant (FEMA)**

Paul Bryant from FEMA Headquarters in Washington , D.C., reviewed FEMA's program to develop a rapid damage assessment methodology. He described FEMA's automated construction estimation program in which an inspector enters data into some 300 fields, and then using a point-and-click accessible, expert system, produces a construction estimate that is generally accurate to within 3%. Paul noted that the time required for inspection could be further reduced for major steel structures if plans were available on-line.

Future plans for FEMA's automated inspection system include the application of the TIGER II files and automatic route assignments to inspectors. Also, FEMA is working to compare actual losses with estimates. The approach involves a cluster analysis of strong motion acceleration data verses damage, census classification, year built and code applied. This work is intended to support FEMA's loss estimation program. This will be a multi-hazard system, applicable nationwide and capable of responding to damaging events caused by wind, hurricane surge, flood, fire, hazardous materials incidents, and other disaster situations. Providing an appropriate Federal response and recovery effort in allocating PUSH packages (food, water, tents, generators, etc.) and other Federal resources would be the goal. FEMA has a T-1 communications line to the National Photographic Interpretation Center (NPIC) for rapid acquisition of image data, and a considerable number of resource, engineering and demographic databases. The intent is to make information available over the Internet using the Mosaic graphical browser software.

Appendix A

GIS in Emergency Management
Workshop Participants

name	agency address	phone; voice	phone; fax	email	interest
Lcdr Craig Lee Allen	Commander Naval Base San Francisco 410 Palm Ave, Treasure Island San Francisco, CA 94130-0411	415/395-3904	415/395-4076		earthquake preparedness
Mr. Don Arns	SRI International 333 Ravenswood Menlo Park, CA 94025	415/859-4258	415/859-4175	arns@sri.com	GIS/Emergency Response
Ms. Tammy Baier	NASA Ames MS T28-N Moffett Field, CA 94035-1000	415/604-0342	415/604-0997	baier@pioneer.arc.nasa.gov	emergency preparedness
Dr. William H. Bakun	USGS 345 Middlefield Rd M/S 977 Menlo Park, CA 94025	415/329-4793	415/329-5163	bakun@andreas.wr.usgs.gov	seismology
Ms. Chelsea Baylor	City of Berkeley Emergency Services 2065 Kittredge, St. K Berkeley, CA 94704	510/644-8736	510/644-7708	chb1@ci.berkeley.ca.us	emergency svcs/eqk
Dr. Michael Blanpied	USGS 345 Middlefield Rd M/S 977 Menlo Park, CA 94025	415/329-4669	415/329-5163	mblanpied@isdmnl.wr.usgs.gov	rock mechanics;real-time info transfer
Mr. Ed Bortugno	CA/OES 101 8th St Oakland, CA 94607	510/286-0820	510/540-3581		emergency response
Mr. Art Botterell	CA/OES 2800 Meadowview Rd. Sacramento, CA 95832	916/262-1843	916/262-1840	acb@oes.ca.gov	emergency public information
Mr. Paul Bryant	FEMA National 500 C St. Washington, D.C. 20472	202/646-3607	202/646-4652	pbryant@fema.gov	emergency management
Mr. James K. Buika	FEMA Region IX Bldg 105, Presidio San Francisco, CA 94129	415/923-7193	415/923-7147		emergency management/mitigation
Mr. David Burr	IGC 3644 Altamont Way Redwood City, CA 94062	415/365-1196	408/281-1268		data/applications
Mr. Roger Butler	US Army, Corps of Engineers 211 Main St., Rm 712 San Francisco, CA 94105-1905	415/744-3150	415/744-3435	R.=BUTLER%IM%SPN@SMTP@SPD.USACE.ARMY.MIL	automation
Mr. P. D. Caldwell	Chevron 6001 Bollinger Cyn Rd, Rm A3264 San Ramon, CA 94583	510/842-4356			environmental/safety GIS
Mr. Bill Cole	William Cotton & Associates 330 Village Ln Los Gatos, CA 95030	408/354-5542	408/354-1852		engineering geol./hazards
Mr. Mike Dillabough	US Army, Corps of Engineers 211 Mail St. San Francisco, CA 94105-1905	415/744-2802			earthquake faults
Mr. Ron Eguchi	EQE International 18101 Von Karman Ave Irvine, CA 92715	714/833-3303	714/833-3391		loss estimation
Mr. Rich Eisner	CA/OES 101 8th St Oakland, CA 94607	510/540-2713		rke@oes.ca.gov	
Mr. Robert E. Ekstrand	Consultant 5567 Copeland Place San Jose, CA 95124-6102	408/356-7647	408/356-6966	EkstrandR@delphi.com	remote sensing

Appendix A (continued)

GIS in Emergency Management Workshop Participants

name	agency address	phone; voice	phone; fax	email	interest
Dr. John R. Evans	USGS 345 Middlefield Rd M/S 977 Menlo Park, CA 94025	415/329-4753	415/329-5163	evans@andreas.wr.usgs.gov	strong motion reporting for response
Mr. Todd Fitzgibbon	USGS 345 Middlefield Rd M/S 975 Menlo Park, CA 94025	415/329-4942	415/329-4936	tfitz@sierra.wr.usgs.gov	GIS & geology
Gale Foss	Monterey Co. Planning & Bldg. Insp. 240 Church St., Rm 116 Salinas, CA 93901	408/755-5861	408/755-5487	gfoss@igc.apc.org	GIS/automated mapping
Mr. Len Gaydos	USGS Ames Research Center 242-Y Moffett Field, CA 94035	415/604-6368		lgados@gaia.arc.nasa.gov	remote sensing/GIS
Dr. Lind Gee	UC Berkeley 475 McCone Hall, UC Berkeley Berkeley, CA 94720	510/643-9449		lind@perry.berkeley.edu	earthquake hazards
Ms. Karen Glatzol	Port of San Francisco Ferry Bldg, Suite 3100 San Francisco, CA 94111	415/274-0515	415/274-0528		GIS, emergency mgmt, environ. sciences
Mr. Tom Hamner	FEMA Region IX Bldg 104, Presidio San Francisco, CA 94129	415/923-7176	415/923-7147		
Dr. Ruth Harris	USGS 345 Middlefield Rd M/S 977 Menlo Park, CA 94025	415/329-4842	415/329-5163	harris@jog.wr.usgs.gov	
Lt. Col. Richard Hoffman	Sixth Army Presidio San Francsico, CA 94129	415/561-5010	415/561-5587		
Mr. Preston Holland	LBL 1 Cyclotron Rd. Mail Stop 50E Berkeley, CA 94720	510/486-6774	510/486-5686	PJHolland@lbl.gov	database access to basic geol & geophys data for Bay Area
Mr. Jerry G. Hughes	RIT Research Corp 10864 River Dr. Forestville, CA 95436	707/887-1565		j.hughes@ieee.org	EOSTAT imaging
Lt. Col. Clark Hunt	Sixth Army 6067 Knoll Park Ct. San Jose, CA 95120	408/268-1317	415/561-6125		emergency management
Mr. Jeff Jensen	US Army, Corps of Engineers 211 Mail St. San Francsico, CA 94105-1905	415/744-3296	415/744-3312		
Dr. William B. Joyner	USGS 345 Middlefield Rd M/S 977 Menlo Park, CA 94025	415/329-5640	415/329-5163	joyner@samoa.wr.usgs.gov	strong ground motion
Mr. Alex Kennett	REFLO Team IX 15231 Perry Lane Morgan Hill, CA 95037	408/779-1773	408/778-2105		emergency management
Mr. James Kiehl	City of Palo Alto Palo Alto, CA 94303	415/496-6953			
Dr. Stephanie A. King	Stanford University Blume Earthquake Ctr. Stanford, CA 94305-4020	415/725-3168	415/725-8662	sking@cive.stanford.edu	seismic risk in GIS
Dr. Anne Kiremidjian	Stanford University Terman Hall 238 Stanford, CA 94305-4020	415/723-4164	415/725-8662	ask@cive.stanford.edu	earthquake engineering/GIS
Dr. Gard K. Kiremidjian	K^2, Inc. 14120 Berry Hill Court Los Altos Hills, CA 94022	415/941-8336			

GIS in Emergency Management Workshop Participants

name	agency address	phone; voice	phone; fax	email	interest
Mr. Dave Kehrlein	CA/OES 2800 Meadowview Ave. Sacramento, CA 95832	916/262-1699	916/262-1697		GIS in emergency management
Mr. John Lane	City of San Jose OES 845 N. San Pedro San Jose, CA 95110	408/277-4595			pre-earthquake damage estimation
Mr. Ben Lashkari	EQE International 44 Montgomery St., #3200 San Francisco, CA 94104	415/989-2000			ground motion & damage assessment
Mr. Jim Lienkaemper	USGS 345 Middlefield Rd M/S 977 Menlo Park, CA 94025	415/329-5642	415/329-5163	jlienk@isdmnl.wr.usgs.gov	
Lonnie Long	US Army, Corps of Engineers 211 Mail St. San Francsico, CA 94105-1905	415-744-3024	415/744-3310		
Mr. Roberto Lugo	USGS 345 Middlefield Rd M/S 531 Menlo Park, CA 94025	415/329-4334			
Mr. Grant Marshall	USGS 345 Middlefield Rd M/S 977 Menlo Park, CA 94025	415/329-4868	415/329-5163	gmarshall@isdmnl.wr.usgs.gov	GIS
Mr. Robert S. Mattson	Commander Naval Base San Francisco 410 Palm Ave, Treasure Island San Francisco, CA 94130-0411	415/395-3987	415/395-4076		
Dr. Jill McCarthy	USGS 345 Middlefield Rd M/S 977 Menlo Park, CA 94025	415/354-3140	415/354-3191	mccarthy@octopus.wr.usgs.gov	
Mr. Frank E. McClure	Consulting Structural Engineer 54 Sleepy Hollow Lane Orinda, CA 94563	510/254-8231	510/254-4602		
Ms. Marcia McLaren	PG & E 1 California St., Rm 2211 San Francisco, CA 94106	415/973-0543	415/973-5778		GIS/seismology
Ms. Lilia Medina	Dept. of City Planning, San Francisco 1660 Mission St. San Francisco, CA 94103	415/558-6254	415/558-6426	limedina@igc.apc.org	seismic emergency response
Mr. Randy Middleton	self 1085 Tasman Dr. Sunnyvale, CA 94089	408/734-1188			
Mr. Carl E. Mortensen	USGS 345 Middlefield Rd M/S 977 Menlo Park, CA 94025	415/329-4856	415/329-5163	cmortensen@isdmnl.wr.usgs.gov	earth science information in emergency management
Mr. Jules R. Moyaert	IGC 4764 Gentian Ct. San Jose, CA 95111	408/281-1268			business GIS
Ms. Lalliana Mualchin	CALTRANS 1801 30th St., West Bldg Sacramento, CA 95814	916/227-8735			earthquake hazards
Mr. Henry A. Mumm	CA Dept of Conservation 801 K St., Ste. 1921 Sacramento, CA 95816	916/323-1360			
Mr. Michael Murphy	US Army, Corps of Engineers 2100 Bridgeway Sausalito, CA 94956	415/331-0404	415/331-0449		GIS

GIS in Emergency Management Workshop Participants

name	agency address	phone; voice	phone; fax	email	interest
Mr. Neil S. Nelson	US Army, Corps of Engineers 630 Samsome St., Rm 911 San Francisco, CA	415/705-2408	415/705-1425		emergency management
Mr. Jeff Nolan	Weber, Hayes & Assoc. 120 Westgate Dr. Watsonville, CA 95076	408/722-3580	408/722-1159		
Mr. Steve O'Brien	US Air Force 3436 Shelden St. Sacramento, CA 95838	916/649-2540			emergency management
Capt Joellen Oslund	FEMA- US Navy 5366 Crown Ct. Castro Valley, CA 94552	510/537-2156			
Mr. Pete Paluzzi	Santa Clara Co. OES PO Box 2244 Cupertino, CA 95015-2244	408/865-1930	415/604-3080	palizzi@ames.arc.nasa.gov	earth science, GIS, info systems, WWW applications
Ms. Jeanne Perkins	Association of Bay Area Governments PO Box 2050 Oakland, CA 94604	510/464-7934	510/464-7970	JeanneP@abag.ca.gov	
Dr. Richard Pike	USGS 345 Middlefield Rd M/S 975 Menlo Park, CA 94025	415/329-4952	415/329-4936		liquefaction/??? analysis
Dr. Daniel Ponti	USGS 345 Middlefield Rd M/S 977 Menlo Park, CA 94025	415/329-5679	415/329-5163	dponti @isdmnl.wr.usgs.gov	Quaternary geology, active faulting, GIS
Dr. Will Prescott	USGS 345 Middlefield Rd M/S 977 Menlo Park, CA 94025	415/329-4860	415/329-5163	wprescott@isdmnl.wr.usgs.gov	GPS
Dr. Michael Riechle	California Division of Mines & Geology 801 K St., MS 12-31 Sacramento, CA 95814-3531	916/323-8553	916/445-3334		
Mr. Douglas J. Rick	Monterey County Gov't 240 Church St. Salinas, CA 93901	408/755-5138	408/755-5487		all workshop topics
Ms. Vivienne Roumani-Denn	UC Berkeley 230 McCone Hall Berkeley, CA 94720	510/643-7041	510/643-6576	vromani@library.berkely.edu	GIS
Dr. Guillermo Santana	UC Berkeley 1301 South 46th St., Bldg 451 Richmond, CA 94804-4698	510/231-5628	510/231-9471	santana@eerc.berkeley.edu	earthquake engineering
Dr. William U. Savage	PG & E 1 California St., F22A San Francisco, CA 94111	415/973-3116	415/973-5778	wus1@pge.com	earthquake hazards, rapid earthquake notification
Ms. Janet Sawyer	Woodward-Clyde Federal Services 500 12th St., Suite 100 Oakland, CA	510/874-1730			seismic hazards
Ms. Diane Schallert	California Division of Forestry 1920 20th St. Sacramento 95816	916/227-2653	916/227-2672	diane@frrap1.cdf.ca.gov	emergency response
Auv Seng	US Army, Corps of Engineers 211 Mail St. San Francisco, CA 94105-1905	415/744-3460	415/744-3351		GIS
Mr. Bob Smith	US Army, Corps of Engineers 211 Mail St. San Francisco, CA 94105-1905	415/744-3324	415/744-3320		GIS

GIS in Emergency Management Workshop Participants

name	agency address	phone; voice	phone; fax	email	interest
Mr. Scott N. Smith	SRI International 333 Ravenswood Ave Menlo Park, CA 94025	415/859-2747		scotts@crvax.sri.com, or scott@chaos.sri.com	GIS
Mr. Eric Spry	Pacific Meridian Resources 1312 Oxford St. Berkeley, CA 94709	510/654-6980		spry@crl.com	GIS; natural resources
Dr. Paul Spudich	USGS 345 Middlefield Rd M/S 977 Menlo Park, CA 94025	415/329-5654	415/329-5163	spudich@isdmnl.wr.usgs.gov	ground motion
Ms. Robyn Starr	Computer Resources Group 240 Angelita Ave. Pacifica, CA 94044	415/359-7604	510/238-2281		recovery & GIS decision support
Mr. Michael Stevens	Dames and Moore 221 Main St., Ste. 600 San Francisco, CA 94105	415/896-5858	415/882-9261	mstevens@crl.com	GIS
Mr. Arthur Tarr	USGS MS 966 Denver Federal Ctr., box 25046 Denver, CO 80225	303/273-8570	303/273-8600	atarr@gldrtv.cr.usgs.gov	GIS data bases
Dale Tenbroeck	CALTRANS 1120 N St. Sacramento, CA 95814	916/654-3102			emergency response
Mr. Ken Topping	Ken Topping Consulting 1196 Bayan St. Pasadena, CA 91103	818/584-3875	818/793-7304	kentopping@delphi.com	GIS & information systems management
Dr. Tousson Toppozada	California Division of Mines & Geology 801 K St., MS 12-31 Sacramento, CA 95814-3531	916/322-9309	916/445-3334		
Ms. Elizabeth Wegenka	USGS (now at USFS, Salt Lake City) 345 Middlefield Rd M/S 531 Menlo Park, CA 94025	415/329-4365	415/329-0459	lwegenka@dragon.wr.usgs.gov	GIS
Dr. Carl Wentworth	USGS 345 Middlefield Rd M/S 975 Menlo Park, CA 94025	415/329-4950	415/329-4936	cwent@sierra.wr.usgs.gov	geology
Mr. John Wesling	Geomatrix Consultants 100 Pine St., 10th Floor San Francisco 94111	415/434-9400	415/434-1365		seismic geology & engineering geology
Mr. Everet Wilcox	US Army, Corps of Engineers 211 Mail St. San Francsico, CA 94105-1905	415-744-3460			map/data sharing
Dr. Raymond C. Wilson	USGS 345 Middlefield Rd M/S 998 Menlo Park, CA 94025	415/329-4892	415/329-5394	rwilson@mojave.wr.usgs.gov	earthquake-induced landslides
Mr. Danny Yu	US Army, Corps of Engineers 211 Mail St., 8th Floor San Francsico, CA 94105-1905	415-744-3318	415-744-3320		GIS
Mr. Eugene M. Zaitzeff	self 4079 Valerie Dr. Campbell, CA 95008	408/378-3311			GIS
Dr. Mary Lu Zoback	USGS 345 Middlefield Rd M/S 977 Menlo Park, CA 94025	415/329-4760	415/329-5163	zoback@andreas.wr.usgs.gov	