PROJECT DESCRIPTION
and
ENVIRONMENTAL ASSESSMENT

by

U.S. GEOLOGICAL SURVEY
Earthquake Hazards Team

February 13, 1998

Title:

Los Angeles Regional Seismic Experiment, Part II (LARSE II)--A Seismic Imaging Survey

Located in:

San Fernando basin, Santa Monica, Santa Susana, and
San Gabriel Mountains, and Mojave Desert

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SECTION I: PROPOSED ACTION

A. Purposes and Need

The Southern California Earthquake Center (consisting of the California Institute of Technology, the University of Southern California, the University of California Los Angeles, and other universities) and the U.S. Geologic Survey will conduct a seismic imaging survey of the Los Angeles region in October 1998 as part of the National Earthquake Hazards Reduction Program. Four goals of this Program that our survey will address are as follows:

1) To elucidate the geologic structure beneath the Los Angeles Region so that we can better understand the processes by which earthquakes are generated. This goal includes identifying active faults and defining their geometry. It also includes determining the type and distribution of various rock layers in the subsurface.

The 1987 M 5.9 Whittier, and the 1994 M 6.7 Northridge earthquakes have awakened all of us to the fact that there are many active "blind" thrust faults in the Los Angeles basin. These faults can only be detected (prior to large earthquakes on them) by seismic imaging of the type we will perform. In order to accurately assess seismic hazards, we must know where these faults are located.

2) To acquire data needed for the prediction of strong ground shaking during future large earthquakes. Two important factors that contribute to strong ground shaking are the thickness and seismic velocity of sedimentary rocks. Shaking is stronger for greater thickness and for lower seismic velocities in sedimentary rocks. ("Seismic velocity" is the speed at which seismic waves travel through a given material.) A third factor contributing to strong ground shaking, that became evident during the 1994 M 6.7 Northridge earthquake is focusing of seismic waves by deep rock reflectors in the earth's crust. In pursuing goal 1, we will identify regions that are underlain by significant thicknesses of low-velocity sedimentary rocks, and we will identify deep rock reflectors. Thus, we will be able to predict areas that will shake strongly during future large earthquakes. Information on ground shaking can be used in designing buildings to make them safer.

3) To better locate earthquakes. Our survey will calibrate the permanent Southern California seismographic network, permitting us to more accurately locate earthquakes.

4) To communicate earthquake hazards information to the public. We hope to take advantage of LARSE II, as we did in previous LARSE surveys, to communicate earthquake hazards information to the public.

B. General Description of Proposed Action

The first surveys of LARSE, carried out in 1993 and 1994, imaged structures chiefly along “Line 1”, which extends northeastward from Seal Beach across the Los Angeles and San Gabriel Valley basins, the San Gabriel Mountains, and Mojave Desert (Figure 1). Line 1 was designed to investigate Earth structure near the 1987 M 5.9 Whittier Narrows and 1991 M 5.8 Sierra Madre earthquakes. The proposed surveys of LARSE II will image structures along “Line 2”, which extends northward from the coast at Santa Monica through the Santa Monica Mountains, San Fernando Valley, Santa Susana Mountains, Transverse Ranges, and western Mojave Desert. Of considerable interest on Line 2 is structure near the 1994 M 6.7 Northridge earthquake.

During our 1994 survey, we recorded offshore airgun blasts along the onshore part of Line 2 (Figure 1). In order to complete seismic imaging along Line 2 and make this imaging comparable to that on Line 1, the remaining tasks include detonation of onshore buried explosions (called an “active” survey) and “passive” recording of earthquakes.

Active Survey. In order to image structures clearly at 10- to 15-km depth (6-10 miles), one needs powerful sources of vibrations at the surface. With such sources, one can construct both “CAT scan-” and “sonogram-” like images of the subsurface. Such images were constructed along Line 1 (see enclosed article). Buried explosions are required for these powerful sources for the following reasons:

a) Vibrating-truck sources, such as used by the oil industry for oil exploration, are inadequate for producing clear images at these depths.

b) Natural earthquake sources are inadequate by themselves. Earthquake sources are irregular in distribution and uncertain in location. The “image” one gets using earthquake sources alone is fuzzy and inaccurate.

Buried explosions are detonated in 8-inch, partly cased drill holes below a depth of 60 feet. The total depth of each drill hole varies with charge size (Table 1). The explosive is a commercial ammonium-nitrate-based product that is pumped into the drill holes. The explosive is covered, or “tamped”, with approximately 60 feet of drill cuttings or gravel for containment. The explosive is inert until it is “primed” just prior to detonation on the night of the shot. Explosions are detonated at night, when wind and cultural noise are at their lowest levels at our seismograph sites.

Approximately 100 buried explosions, ranging in size from 50-4000 lbs., are planned along Line 2 for LARSE II (Table 1 and Appendix I). These explosions will be recorded by approximately 1000 seismographs spaced 100 meters (~300 feet) apart.

Drilling would take place during a 3-month period prior to the survey. Next, the drill holes would be loaded with explosive, capped, locked, and covered with dirt (for camouflage purposes) (Appendix I). After deployment of the seismographs, the explosions would be detonated one after another over a 3- to 5-night period.

Passive survey. We propose to deploy a line of 100 seismographs along Line 2 at approximately 1-km (0.6-mile) spacing to record distant and local earthquakes. These seismographs would remain in place for approximately 6 months.

Environmental Questions and Answers

The chief environmental concerns that are usually expressed about an explosion survey are as follows:

1) Will the shots trigger earthquakes?
2) Will the shots damage water supplies?
3) Will the shots damage man-made structures?
4) How far can the blasts be felt?
5) What do the blasts sound like?
6) Will the shots damage the landscape, archaeological resources, or endangered species of plants or animals?
7) Will your activities generate dust?
8) Will roads be closed during your operations?

Answers to these questions are as follows and are elaborated in APPENDIX I

1) Our blasts will not trigger earthquakes. We have been performing this type of survey for more than 30 years, all over the world, in many different types of faulted areas, and with blasts larger than those proposed for LARSE II, and we have never triggered an earthquake. Our blasts are similar in size to freeway-construction or mine blasts and pose no greater hazard to triggering of earthquakes than do those blasts. Furthermore, we detonate our explosions near the surface, whereas the region where large earthquakes originate is generally 6 or more miles deep. Our signals are very weak by the time they reach that region. Finally, only our largest blast (located in a remote area of the Sierra Nevada Mountains) will have a size equivalent to a magnitude 2.5 earthquake. The Southern California region is shaken by an average of approximately 4 magnitude 2.5 earthquakes daily, and similar magnitudes are generated by mine blasts that occur nearly every workday of the year. Thus the hazard of our operation is not significant when put in proper perspective.

To our knowledge, the only events that DO trigger earthquakes are major earthquakes, like the M 7.3 Landers earthquake of June 1992, which triggered a M 5.2 earthquake in southern Nevada and numerous smaller earthquakes at several volcanic areas in the western U.S., including Mammoth Lakes, CA, the Geysers, CA, and Yellowstone National Park. The Landers earthquake represents 10's of millions times the energy in our shots.

2) We have performed tests before and after blasts that were detonated directly in water to determine if there were any residual nitrate, nitrite, ammonia, or pH changes. The results were negative (APPENDIX I). The explosive is completely consumed during detonation (APPENDIX I). In locations where there is a possibility of providing a conduit from an upper aquifer to a lower, that might lead to future pollution of the lower aquifer, we will seal off the drillhole with concrete or bentonite after the blast.

In our 30 years of experience, we have never damaged a spring or well, although we have shot within a few hundred feet of springs and wells. Except for cases where an explosion is detonated directly in a spring or well, the only events that affect springs and wells are major earthquakes. (Major earthquakes apparently increase upper-crustal porosity, by shaking and opening of cracks, and cause water tables to be lowered.)

3) In siting our shotpoints, we use tables of ground velocity that we have established from years of blasting experience in order to ensure that we are beyond the lowest damage threshold for human structures (2 in/sec; APPENDIX I). That is not to say that our blasts may not be felt (see 4 below).

4) Most blasts can be felt only within a few hundred feet of the shotpoint. The larger blasts can be felt for a few 1000 feet. We have made an effort to keep the shotpoints well away from houses in order not to disturb people at night. Unfortunately, a few people may feel the shots. Prior to LARSE 94 we communicated the purposes and effects of our activities with the public by way of city council meetings, radio, newspaper, and TV.

5) The blasts usually sound like a dull "thud." Occasionally, when steam is vented, a hiss or dull roar (like a small jet engine) will occur for a period of seconds following the blast.

6) Areas chosen for shotpoints are always areas that have been affected by grading or dumping, such as road pull-outs, abandoned roads, and dumps. There are almost never archaeological resources near the shotpoints nor endangered species of plants and animals. The drilling and blasting operation at each site affects an area approximately 30 to 50 feet in diameter, and we leave each site in a condition similar to the condition in which we found it. At perhaps 10% of our shots, collapse craters ranging in diameter and depth from 5-15 feet are generated. These develop immediately after the blasts. We fill these in.

7) Our activities do not generate significant dust. Drilling is done with water, and dust is not generated. The shots are contained underground, and detonation does not generate dust. In the few cases when venting occurs during a shot, steam (not dust) is vented.

8) Shotpoints 70 A, B, and C are near Lake Hughes Road; they are the only shotpoints near a paved road. It will be determined later whether the road needs to be closed. If needed, the road will be closed between midnight and 6 AM for reasons of public safety. In a small percentage of our shots, flyrock is generated within about 100 ft or less of the shotpoint. Flyrock is cleaned off the highways before they are opened to traffic.

SECTION II: ALTERNATIVES

Alternatives to the “active” survey, as proposed, include the following:

1) Move the lines,
2) Eliminate the study (No Action Alternative),
3) Eliminate certain shotpoints, such as the ones in the Santa Monica or Santa Susana mountains, the San Fernando Valley, or the vicinity of the San Andreas fault,
4) Use vibrator trucks instead of explosions,
5) Use earthquakes instead of explosions.

The consequences of each of these alternatives are as follows:

1) LARSE was planned in the early 1990’s, and the survey lines were chosen to investigate Earth structure along 2 key transects, or lines, across the Los Angeles region. Line 1 was chosen to investigate structure along a transect that passed through or near the epicenters of 1987 M 5.9 Whittier Narrows and 1991 M 5.8 Sierra Madre earthquakes. Line 1 also investigated the structure of the Los Angeles and San Gabriel Valley basins and the structure of the San Andreas fault. Line 2 was chosen to investigate the structure along a transect through the epicenter of the 1994 M 6.7 Northridge earthquake. In addition, Line 2 will address the structure of the San Fernando Valley basin, the mountain ranges on either side, and the structure of the San Andreas fault. The various surveys along Lines 1 and 2 were to include active explosion, passive earthquake recording, and offshore airgun surveys. All these surveys are complementary to one another and must be conducted along the same lines to be effective. We have conducted all three types of surveys along Line 1 and have conducted an offshore airgun survey along Line 2. To complete the imaging along Line 2, we still need the active explosion and passive earthquake surveys. We can not move Line 2 at this point and obtain a complete image of the subsurface along the line.

2) The active explosion survey and passive earthquake recording proposed herein are complementary to the offshore airgun survey that was conducted in 1994. Raypaths for seismic waves generated in the active explosion survey would "reverse" the raypaths for seismic waves generated in the airgun survey. Without raypath "reversal", models or images of subsurface structure can not be well “constrained”. That is, the models and images can take multiple forms. For example, the depth of sediment-basement contact can be traded off against the seismic velocity of the sediments above the contact or the basement rocks below the contact. In short, with airgun data alone, we will not be able to construct accurate models or images along Line 2.

3) If certain shotpoints were eliminated, the following consequences would occur:

<u>Shotpoints in the Santa Monica or Santa Susana Mountains:</u>
These remote sites provide areas where we can safely detonate the larger explosions needed to image to seismogenic depths (10-15 km, or 6-9 miles). The causative fault for the Northridge earthquake is hypothesized to originate as a (south-dipping) “back-thrust” off of a “master” thrust fault that dips northward

from a point approximately 15-20 km (9-13 miles) deep beneath the Santa Monica Mountains to a point as far north as the San Andreas fault. Without large shotpoints in the Santa Monica and Santa Susana Mountains, we would not be able to shed any light on this hypothesis. We need to know how faults, like the Northridge fault and the hypothesized “master” thrust fault are interconnected beneath the Los Angeles region in order to have any hope of predicting the occurrence of future earthquakes.

Shotpoints within San Fernando Valley:
Shotpoints in the San Fernando Valley are critical to imaging the base of the sediments in this region. Without knowledge of the depth of sediments, or the seismic velocity of these sediments, we can not predict strong ground motions from future large earthquakes.

Shotpoints near the San Andreas Rift Zone:
From data acquired along Line 1 in 1994, we discovered a previously unknown “master” thrust fault that originates at great depth (23 km, or 14 miles deep) near the San Andreas fault and extends upward to the south to points beneath the San Gabriel Valley (where it is approximately 14 km, or 8 miles deep). This fault appears responsible for the 1987 M 5.9 Whittier Narrows earthquake and possibly other earthquakes. One of the objectives of LARSE II is to investigate whether the same or a similar “master” thrust fault also exists along Line 2. This fault was imaged best from shotpoints near the San Andreas fault. Without these shotpoints, we have no chance of confirming or denying the existence of such a “master” thrust fault beneath the northwestern part of the Los Angeles region.

In summary, in order for us to obtain a coherent image of the subsurface beneath the northwestern part of the Los Angeles region, we need a fairly continuous distribution of shotpoints. Elimination of any group of shotpoints degrades the image seriously. It is never possible to predict where an image can safely be degraded while still allowing us to make sense of what we see.

4) Experience has shown that seismic energy from vibrator trucks penetrates reliably only through the upper crust. To obtain a clear image of the crust below 6-10 miles depth requires explosions (usually of 500 lb. size or greater). In addition, it is more difficult to analyze seismic velocities from data where vibrator trucks are used as sources (because first-arriving energy is “emergent” and not sharp and “impulsive”).

5) Imaging of the subsurface using earthquakes alone as sources of seismic energy has been carried about as far as is possible, and still, no image detailed enough to use in earthquake hazard reduction is available.

SECTION III: AFFECTED ENVIRONMENT

A. Topography

Not affected by proposed action.

B. Climate

Not affected by proposed action.

C. Air Quality

Not affected by proposed action.

D. Geology

Not affected by the proposed action. Also, no earthquakes will be triggered by the blasts (see Section I).

E. Soil Quality

In all cases, drilling would occur in areas already impacted by grading or dumping. Therefore, no significant impact of the proposed action is anticipated.

F. Water Quality

Water quality has been tested before and after explosions directly in water and no change except a temporary (two week) increase of suspended particles has been detected (Appendix I). Also, in our 30-year experience, we have never damaged a spring or a well (Section I).

G. Vegetation/Wildlife

In general, drillhole sites are placed so as to have minimal impact on vegetation. Access to the sites is by existing dirt roads. Off road driving is needed only to get the drill rig 10-50 ft. off traveled roads. Seismographs will be carried off road manually, and the digging of the sensor holes will be done by hand shovel.

Site SP59A, which is located in the SE corner of section 32 next to Forest Service Road 5N27, is near San Francisquito creek a habitat of the unarmored three spine spickleback fish a fully protected endangered species at the Federal level. In order to avoid impacting the environment of this fish, we will not drill at this site until the creek has dried (August or September). During drilling, which is described above and in Appendix I, we will not allow loose sediment to be dispersed in the creek bed. The drilling, loading, and shooting vehicles will be carefully driven and properly maintained such that no oil or petroleum products will spill into the creek. As described above and in Appendix I, all charges are buried; hole depth at this site is 160 ft. (Table 1). The explosion will be contained within the hole and will not have any effect on surface water.

H. Resource Use Patterns

Lake Hughes Road just south of Lake Hughes and possibly other short sections of paved and gravel roads may be closed to traffic between midnight and 5 AM during one or more of the nights during which the buried explosions are detonated.

I. Archaeological Resources

Sites will be investigated as needed.

SECTION IV: MITIGATION MEASURES

1) Drilling Stemming. During the drilling, water is combined with a foaming agent to flush cuttings from the hole. Cuttings and water will be contained behind a one-foot high berm built about ten feet from the drillhole on its downhill side to prevent runoff. The cuttings produced during drilling along with crushed stone are used to fill the drillhole once it has been loaded with the blasting agent (the blasting agent is loaded to within 50 feet of the surface and cuttings are used to fill the hole for the purpose of containing the explosion.)

2) Reclamation. Should there be slumping at the shothole after detonation, it will be filled with imported fill. Any casing protruding from the hole will be cut off two feet below the surface and removed from the site. The drilling area will be raked and recontoured.

SECTION V: EXPERIMENT CALENDAR

JULY thru SEPTEMBER	--drilling
AUGUST thru SEPTEMBER	--surveying of the seismographic sites
SEPTEMBER and / or OCTOBER	--loading
OCTOBER	--main experiment

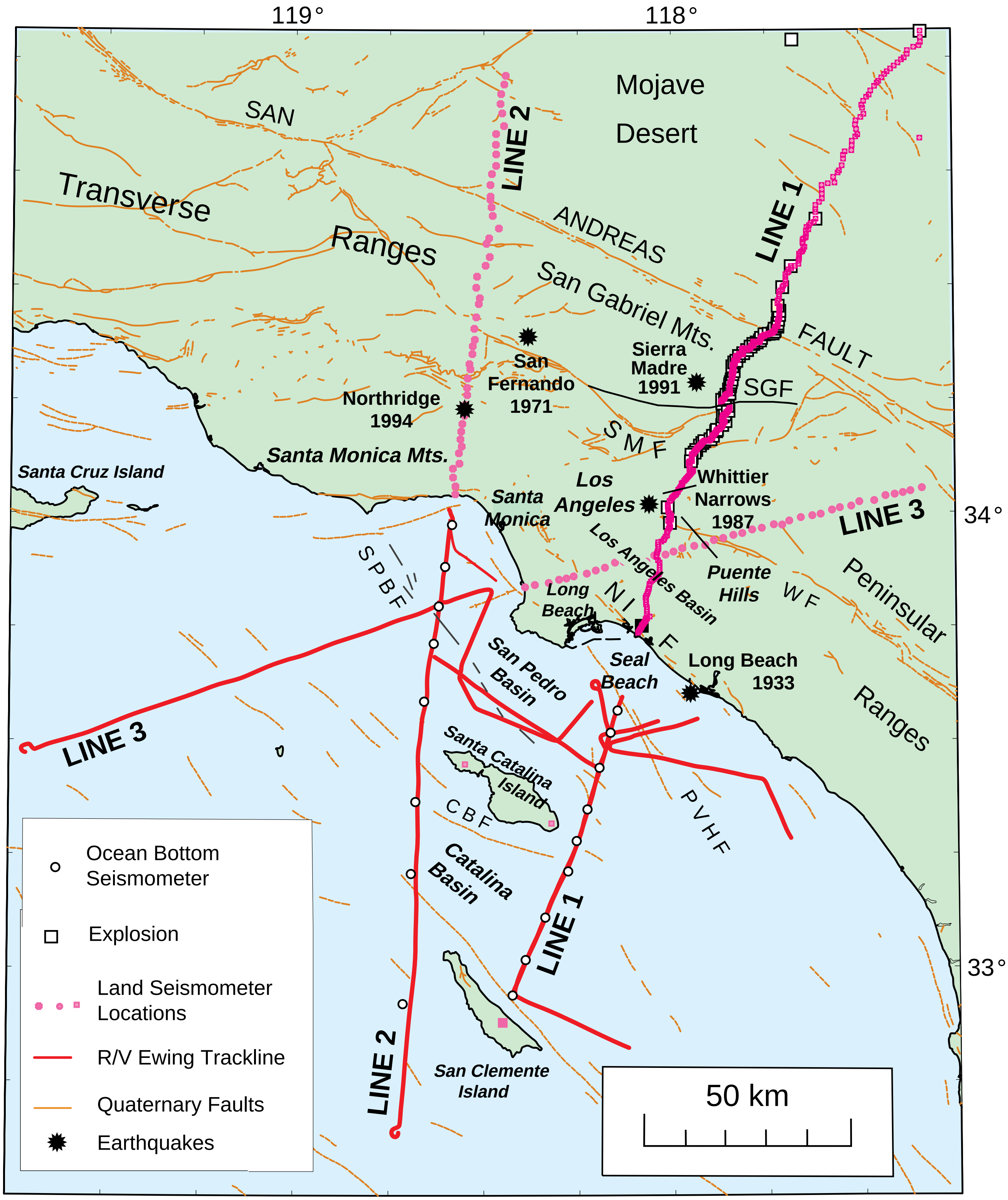

Figure 1. Fault map of the Los Angeles region showing the 1994 LARSE I survey. Airgun sources are along the R/V Ewing Trackline and explosive sources are shown with boxes.

TABLE 1.

Shotpoint (numbers reflect appx kilometers north of coast)	Range	Township	Quarter	section	Permit size	Drill hole Depth	Nearst Road	Miscellaneous
2A	R16W	T1S	SE	28	250	80		
2B	R16W	T1S	SW	28	250	80		
3	R16W	T1S	NE	29	2000	160		
4B	R16W	T1S	SE	20	3000	180		
4A	R16W	T1S	NW	20	250	80		
5B	R16W	T1S	SE	17	500	90		
6	R16W	T1S	SW	8	250	80		
7B	R16W	T1S	NW	8	500	90		
8A	R16W	T1S	SE	5	100	60		
9A	R16W	T1S	SW	4	1000	120		
9B	R16W	T1S	SW	4	1000	120		
9C	R16W	T1S	NE	4	500	90		
10A	R16W	T1N	SW	34	250	80		
11A	R16W	T1N	NW	34	500	90		
12	R16W	T1N	NE	27	250	80		
13B	R16W	T1N	SW	23	250	80		
14C	R16W	T1N	NW	23	250	80		
14D	R16W	T1N	NW	23	100	60		
17	R16W	T1N	NW	11	100	60		
21	R16W	T2N	SE	26	25	60		
23A	R16W	T2N	SE	23	100	60		
24	R16W	T2N	NE	23	250	80		
25	R16W	T2N	SE	14	250	80		
26A	R16W	T2N	SE	11	250	80		
27A	R16W	T2N	NE	11	100	60		
28	R16W	T2N	SE	2	100	60		
29A	R16W	T3N	SE	35	250	80		
30B	R16W	T3N	SW	35	500	90		
30A	R16W	T3N	SW	35	500	90		
31A	R16W	T3N	SW	26	1500	140		
32	R16W	T3N	NE	27	500	90		
33A	R16W	T3N	SE	22	1000	120		
33C	R16W	T3N	NE	22	1000	120		
34	R16W	T3N	NE	22	1000	120		
35B	R16W	T3N	NW	14	500	90		
36A	R16W	T3N	SE	11	100	60		
36B	R16W	T3N	SE	11	100	60		
37A	R16W	T3N	NW	11	100	60		
38A	R16W	T3N	SE	2	250	80		
39A	R16W	T3N	NW	1	25	60		
40B	R16W	T4N	SW	25	250	80		
41	R16W	T4N	SW	25	2000	160		
42	R16W	T4N	NW	25	500	90		
43A	R16W	T4N	NE	23	500	90		
44	R16W	T4N	NE	13	500	90		
45A	R16W	T4N	SW	12	100	60		
47B	R16W	T4N	SE	1	100	60		
47A	R16W	T4N	NE	1	250	80		
48A	R16W	T4N	NE	1	250	80		
49A	R16W	T5N	SE	36	100	60		
50A	R16W	T5N	SW	25	250	80	USFS road 6N21	

TABLE 1.

51B	R16W	T5N	NW	25	1000	120	USFS road 6N21	
52B	R16W	T5N	NW	24	1000	120	USFS road 6N21	
53B	R16W	T5N	SW	13	250	80	USFS road 6N21	
54A	R16W	T5N	NW	13	250	80	USFS road 6N21	
56A	R16W	T5N	NE	12	2000	160	USFS road 6N21	
57A	R15W	T5N	SE	6	2000	160	USFS road 6N21	
59A	R15W	T6N	SE	32	2000	160	USFS road 6N27	
62	R15W	T6N	SE	20	1000	120	USFS road 6N24	
63A	R15W	T6N	NE	20	250	80	USFS road 7N01	
63B	R15W	T6N	SE	17	250	80	USFS road 7N01	
64A	R15W	T6N	SE	17	250	80	USFS road 7N01	
64B	R15W	T6N	NW	16	250	80	USFS road 7N01	
64C	R15W	T6N	NW	16	250	80	USFS road 7N01	
65A	R15W	T6N	SE	9	250	80	USFS road 7N01	
66A	R15W	T6N	SE	9	1000	120	USFS road 7N01	
66B	R15W	T6N	SE	9	250	80	USFS road 7N01	
66C	R15W	T6N	SE	9	250	80	USFS road 7N01	
66D	R15W	T6N	NW	10	250	80	USFS road 7N01	
66E	R15W	T6N	NW	10	250	80	USFS road 7N01	
67A	R15W	T6N	SE	3	1000	120	USFS road 7N01	
70A	R15W	T7N	NE	33	250	80	USFS road 7N09 L.H. rd. (hwy)	
70B	R15W	T7N	NW	34	500	90	USFS road 7N09 L.H. rd. (hwy)	
70C	R15W	T7N	SW	27	250	80	USFS road 7N09 L.H. rd. (hwy)	
71A	R15W	T7N	NW	27	250	80	USFS road 7N08	
72A	R15W	T7N	SW	22	250	80		
73A	R15W	T7N	NE	22	50	60		
74A	R15W	T7N	NW	15	1000	120		
75A	R15W	T7N	SW	10	500	90		
76	R15W	T7N	NW	10	250	80		
77	R15W	T7N	NW	3	250	80		
78	R15W	T8N	SE	33	500	90		
79	R15W	T8N	SE	28	500	90		
81	R15W	T8N	SE	21	500	90		
83	R15W	T8N	SE	16	500	90		
85	R15W	T8N	NE	9	500	90		
87	R15W	T8N	NE	4	500	90		
89A	R15W	T9N	NE	33	500	90		
91	R15W	T9N	NW	27	1000	120		
93	R15W	T9N	SE	15	1500	140		
95	R15W	T9N	NE	10	1000	120		
97	R15W	T9N	NW	3	1000	120		
99	R15W	T10N	NE	34	4000	160		2 holes
101	R15W	T10N	SE	23	2000	160		
143					6000	180		2 holes or 3 holes @ 160 ea

APPENDIX I:
LAND SURVEY

NATIONAL
RIDGE
LEONA
ANDREAS
VALLEY
QUARTZ HILL
LEONA VALLEY
PALMDALE
SIERRA
PELONA
FOREST
CASTAIC
VALENCIA
SANTA CLARITA
NEWHALL
CANYON COUNTRY
ACTON
SAN
GABRIEL
ANGELES
SANTA SUSANA
MOUNTAINS
SYLMAR
SAN FERNANDO
PACOIMA
SHADOW HILLS
SUNLAND
TUJUNGA
LA CRESCENTA
LA CANADA FLINTRIDGE
CHATSWORTH
GRANADA HILLS
NORTHRIDGE
CANOGA PARK
RESEDA
FERNANDO
VALLEY
VAN NUYS
NORTH HOLLYWOOD
BURBANK
GLENDALE
ALTADENA
PASADENA
WOODLAND HILLS
TARZANA
ENCINO
SHERMAN OAKS
STUDIO CITY
HOLLYWOOD
WEST HOLLYWOOD
BEVERLY HILLS
WEST LOS ANGELES
CULVER CITY
MOUNTAINS
TOPANGA
PACIFIC PALISADES
SANTA MONICA
OCEAN PARK
VENICE
LOS ANGELES
HUNTINGTON PARK
ALHAMBRA
SAN MARINO
SOUTH PASADENA
MONTEREY PARK
EAST LOS ANGELES
MONTEBELLO
COUNTY
COUNTY


A3
TEHACHAPI
MOJAVE
ROSAMOND
LOS ANGELES
ANTELOPE ACRES
LAKE HUGHES
QUARTZ HILL
LEONA VALLEY
PALMDALE
DEL SUR
NATIONAL
FOREST
ANGELES
RIDGE
SIERRA
Double Mtn.
Covington Mtn.
Twin Lakes
Moody's Pk.
Cummings Mtn.
Cottonwood
Los Angeles Aqueduct
Fairmont Butte
Little Buttes
Oak Creek
Cache Creek
Standard Hill
Soledad Mtn.
Sawtooth Mtn.
Jupiter Mtn.
Red Mtn.
Bouquet Reservoir
EARTHQUAKE
VALLEY
PELONA


A4
TEHACHAPI
MOJAVE
LOS
ANGELES
A N T E L O P E
ROSAMOND
Caliente
Stevenson Peak
Eagle Nest
Harper Pk.
Keene
Woodford
Bear Mtn.
Twenty
Creek
Cummings Mtn.
Moody's Pk.
Double Mtn.
Covington Mtn.
Twin Lakes
Cottonwood
Hayes Spr.
Scharf Spr.
Taylor Pk.
Bush Spr.
Stallion Springs
Oak Flat
Monolith
Cameron
Cache Creek
Soda Spr.
Pine Spr.
Cross Mtn.
Tolly Spr.
Corral Spr.
Hungry Spr.
Stewart Pk.
Cache Pk.
Kelso Pk.
Emerald Mtn.
Standard Hill
Soledad Mtn.
Tropico Hill
Willow Springs
Little Buttes
Holiday Valley
Julia Lake
Tollgate
Eagle Pk.
Bowen
Black Mtn.
Bear Valley Springs
Sand Canyon
Oak Creek
TO LAKE HUGHES
TO LANCASTER

DRILLING OPERATIONS AND SEISMOGRAPH INSTALLATION

1a) Drilling. Each hole will be 8 inches in diameter and between 60 and 160 feet deep. A mobile water-well-drilling rig is used; it is mounted on a 3-axle diesel truck, weighing 25 to 30 tons. A second truck carrying water, drill stem, and other accessories accompanies the drill rig.

Drilling of the holes will be drilled under our supervision by a contract driller. Careful consideration is given to accessibility, material to be drilled in, and locations where damage, environmental and physical, will be minimal and restorable. An effort is made to select sites in areas already disturbed, e.g., gravel pits, dumps, abandoned roads, washes, or dry lake beds. Generally it is unnecessary to clear a pad for the drill sites. The drill rig will remain at each site for 1 to six days. The holes are lined with iron or PVC casing when necessary in order to keep them from collapsing before loading time. After drilling and before loading, each hole is capped by a piece of metal which is tack-welded onto the top of the pipe.

b) Loading. Four or five days before a shot is detonated, the lower portion of the holes are loaded with the blasting agent, which will arrive via a pump truck. The remaining 60 feet is filled (stemmed) with the drill cuttings. Once loaded, the holes will be padlocked shut and buried under dirt and brush until the night of the actual shooting. The shot holes are not primed, that is, a detonator is not attached, until a few minutes before detonation.

c) Shooting. Shots are fired one at a time, 1-2 minutes apart, over multiple nights. Shotpoint areas are checked for clearance before each shot. Noise from the shot is a muffled thud which may be heard up to one half mile away. Depending on the size of the charge and coupling of energy into the ground, ground roll may be felt from a few hundred feet to as much as 1 mile away. The shooting team will be positioned about 400 feet from the shotpoint when shooting.

d) Cleanup. We anticipate some subsidence in about 10% of the holes after a shot, especially in unconsolidated alluvium. When the experiment is completed, pipe at each shot hole is cut off and capped two feet below the surface and the area around the hole is filled and recontoured.

2) Seismographs. A seismograph consists of the following components: a recorder with a maximum size of 10x10x15 in.; a car battery with a maximum size of 10x12 in.; and one or more sensors of cylindrical shape with a maximum size of 6 in. in diameter and 8 in. in height. For security reasons, all components of the seismographs will have to be buried in a shallow hole inside a plastic garbage bag and covered with brush. The ground disturbance caused by such burial is smoothed upon pickup.

The actual ground motion produced by the seismic source is minute (millionths of an inch), and as such, the recording instrument must be very sensitive and background noise at its lowest. Because of this, shooting and recording are done at night (between 2 and 4:30 A.M.), when ground motion from moving cars, people, pumps, wind, etc., are at a minimum.

3) Safety Qualifications. Seismic experiments are routinely performed by scientists from SCEC and the USGS.

Drilling activity will be overseen by at least one project supervisor.

Loading and shooting crews will be composed of USGS staff, who have had explosive handling courses. Experience of individuals in handling and detonating explosives ranges from 10 to over 30 years.

TABLE 3

FRACTIONAL GROUND VELOCITY (FGV) AND MULTIPLYING FACTOR TO PRODUCE EQUIVALENCE WITH A SHOT IN WET ALLUVIUM (RA)

Shotpoint Type	FGV	RA
Wet alluvium	1.00	1.00
Dry alluvium	0.24	16.44
Hard rock	0.49	4.16
Lake	1.12	0.80
Ocean	3.49	0.08

REFERENCE

Kohler, W.M., and Fuis, G.S., 1989, Empirical relationship among shot size, shotpoint site condition, and recording distance for 1984-1987 U.S. Geological Survey seismic-refraction data: USGS Open-file Report 89-675, 107 p.

TABLE 5A

DISTANCE IN FEET BEYOND WHICH 90% OF SHOTS WILL PRODUCE SHAKING VELOCITY LESS THAN 2.0 IN/SEC

Shot Size (lb)	Distance (feet) Hard Rock	Wet Alluvium	Lake	Ocean	Dry Alluvium
10	384	504	537	892	357
50	502	663	708	1197	466
100	565	749	800	1362	523
500	747	998	1069	1855	690
1000	844	1133	1215	2126	779
1500	908	1222	1310	2306	837
2000	956	1289	1383	2443	882
2500	995	1344	1443	2556	918
3000	1029	1391	1493	2653	948
4000	1085	1469	1578	2814	999
5000	1130	1533	1647	2947	1041
6000	1169	1587	1706	3061	1076
8000	1233	1678	1804	3251	1134
10000	1285	1752	1884	3407	1182

TABLE 5B

DISTANCE IN FEET BEYOND WHICH 99.87% OF SHOTS WILL PRODUCE SHAKING VELOCITY LESS THAN 2.0 IN/SEC

Shot Size (lb)	Distance (feet) Hard Rock	Wet Alluvium	Lake	Ocean	Dry Alluvium
10	735	982	1051	1822	679
50	979	1321	1418	2509	903
100	1111	1506	1618	2892	1023
500	1502	2059	2218	4064	1379
1000	1716	2365	2551	4728	1573
1500	1856	2567	2771	5173	1701
2000	1964	2722	2941	5519	1799
2500	2052	2850	3080	5804	1879
3000	2128	2960	3200	6051	1947
4000	2254	3142	3399	6464	2061
5000	2357	3293	3564	6806	2154
6000	2445	3422	3705	7102	2234
8000	2592	3637	3941	7599	2367
10000	2713	3815	4135	8011	2476

CC: M. Irvin

A9

DU PONT
ESTABLISHED 1802
E. I. DU PONT DE NEMOURS & COMPANY
INCORPORATED
WILMINGTON, DELAWARE 19898

FABRICATED PRODUCTS DEPARTMENT

May 4, 1987

Ed Criley
U.S. Geological Survey
345 Middlefield Road
MS 977
Menlo Park, CA 94025

Dear Ed:

This is in response to your request for information on the post detonation products of Tovex® Extra Special marine watergel.

Ninety-seven percent of the post detonation products are gaseous, consisting of: water vapor (62.8%), nitrogen (20.46%), carbon dioxide (9.7%), hydrogen (2.4%), carbon monoxide (1.26%) and ammonia (0.38%). The remaining solids consist of sodium carbonate (2.8%), and sodium silicate (0.1%). Tovex® Extra Special marine watergels are formulated and oxygen balanced to detonate under confined borehole conditions without any additional source of oxygen necessary for complete detonation.

Tovex® Extra Special marine formulation watergel has been widely used for deep hole and submarine blasting approximately fifteen years.

Very truly yours,

T.I. Jerman /tjw

Theodore I. Jerman
Technical Specialist

TIJ/tjw
I:11

BETTER THINGS FOR BETTER LIVING

A10

IRECO Incorporated

Eleventh Floor Crossroads Tower
Salt Lake City, Utah USA 84144
Telephone (801) 364-4800
Telex: 388353

6 May 1987

Mr. Ed Criley
U.S. Geologic Survey
M.S. 977
345 Middlefield Road
Menlo Park, CA 90425

Dear Mr. Criley:

Emulsion blasting agents are inherently very water resistant. The continuous phase of the emulsion is oil, which surrounds each droplet of the aqueous phase (inorganic nitrate solution). Borehole water which comes in contact with the emulsion contacts only the continuous oil phase. The leaching of inorganic nitrates from the emulsion would therefore be minimal and would not present a significant pollution hazard.

We would expect that the detonation would consume 100% of the emulsion in the borehole and that the products of detonation (carbon dioxide, nitrogen and water) would not present a significant pollution hazard.

Bulk emulsion blasting agents are widely used throughout the world and I know of no instances where the groundwater has been contaminated by their use.

Very truly yours,

IRECO Incorporated

Herbert G. Knight, Jr.
Manager, Environmental Affairs

HGK/hbg

cc: S.R. Poulter
M.D. Lott
L.D. Lawrence

R5826

IRECO Incorporated

TABLE 1 — REVISED COPY

NORTHERN TESTING LABORATORIES

800 UNIVERSITY PLAZA WEST, SUITE A — FAIRBANKS, ALASKA 99709
2505 FAIRBANKS STREET — ANCHORAGE, ALASKA 99503

Client: U.S Geological Survey
Address: 345 Middlefield Road
Menlo Park, California 94025
Attn: Gary Fuis

Date Arrived : 08-28-87
Time Arrived : 1500
Date Sampled : various
Time Sampled : various
Date Completed: 09-22-87

Sample numbering scheme: 70 A,B,C – 1, 2 (SP; water test; location; before/after)

Source: Environmental Water

Sample ID #: 082087-18W through 34W

USGS Measurements using equipment borrowed from USFWS

Lake	NTL ID#	LOCATION SP	SAMPLE DATE	TSS mg/l	ALKALINITY mg/l	HARDNESS mg/l	CONDUCTIVITY umhos/cm	NITRATE-N mg/l	pH*: Time interval between blasting and sampling (if applicable)	pH*: Time interval between sampling and testing	pH value	Dissolved oxygen*: Time interval between blasting and testing (if applicable)	Dissolved oxygen (mg/l) (readings taken at 3 sites 0–100 ft apart)		
Salcha River gravel pit lake	082087-18W	55 B - 1	08-14-87	4.8	30.7	27.8	720	0.72							
	082087-19W	55 B - 2	08-21-87	61	30.9	28.8	750	0.48							
	082087-20W	55 C - 1	08-14-87	4.8	29.8	27.8	730	0.62							
	082087-21W	55 CC - 1	08-14-87	8.8	30.9	27.8	770	1.2							
	082087-22W	55 C - 2	08-21-87	87	30.9	27.8	760	0.55							
Bonanza lake	082087-23W	70 A - 1	08-22-87	< 1	36.3	40.3	880	< 0.1	—	3½-4hr	6.86	—	8.60	8.90	8.90
	082087-24W	70 A - 2	08-25-87	113	36.5	39.4	880	0.20	6½hr	5–6hr	6.76	60-66hr	8.00	8.30	—
	082087-25W	70 B - 1	08-22-87	7.0	37.6	38.4	890	< 0.1	—	3½-4hr	6.86	—	8.85	9.20	9.10
	082087-26W	70 B - 2	08-25-87	19	38.7	41.3	900	0.1	6½hr	5-6hr	6.88	—	—	—	—
	082087-27W	70 C - 1	08-22-87	1.6	37.6	40.3	880	< 0.1	—	3½-4hr	7.00	—	—	—	—
	082087-28W	70 C - 2	08-25-87	4.8	37.6	40.3	890	< 0.1	6½hr	5–6hr	7.00	60-66hr	7.85**	—	—
Manley lake	082087-29W	74 A - 1	08-21-87	4.7	9.9	15.4	470	< 0.1	—	5½-6hr	6.04	—	9.40	8.20	8.65
	082087-30W	74 A - 2	08-26-87	221	13.3	16.3	550	0.25	9½-10½hr	3½hr	5.84	8-9hr	—	—	6.15
	082087-31W	74 B - 1	08-21-87	< 1	9.9	15.4	470	< 0.1	—	5½-6hr	6.23	—	—	—	—
	082087-32W	74 B - 2	08-26-87	356	14.4	17.3	560	0.79	9½-10½hr	3½hr	5.84	8-9hr	—	4.60	6.80
	082087-33W	74 C - 1	08-21-87	1.0	11.1	15.4	460	< 0.1	—	5½-6hr	6.29	—	—	—	—
	082087-34W	74 C - 2	08-26-87	265	14.4	18.2	330	0.88	9½-10½hr	3½hr	5.43	—	—	—	—

Dissolved oxygen: These readings were made in open water, not in sample containers.

Note: Underlining indicates measurement made before shot (see sample numbering scheme)

* See note at end of table regarding measurement procedure

** See accompanying graph of D/O vs depth.

REPORTED BY: Diane L. Shaw (signature)
Diane L. Shaw, Chemistry Supervisor

DATE: 11-12-87

Table A1. -- Water quality measurements in lakes before and after shots.

TABLE A2

Water quality changes in Oly lake (lat. 68° 44'N., long. 148° 55'W.), North Slope, Alaska. A shot of charge size 960 lbs. was detonated at midnight 7/8/88.

Species	Change in concentration (measured within 12 hrs. of the shot) in milligrams/liter
1. Dissolved oxygen	range: 0.3-1.7 mg/l average change: 0.9 mg/l
2. Nitrogen as nitrate and nitrite	0.015 mg/l
3. Nitrogen as ammonia	0.040 mg/l
4. Phosphorus as phosphate	0.0033 mg/l

(changes were measured by Prof. Michael C. Miller, University of Cincinnati).

Changes in total suspended solids were measured in a time sequence over a 1 week period - see Figure A1 on the following page.

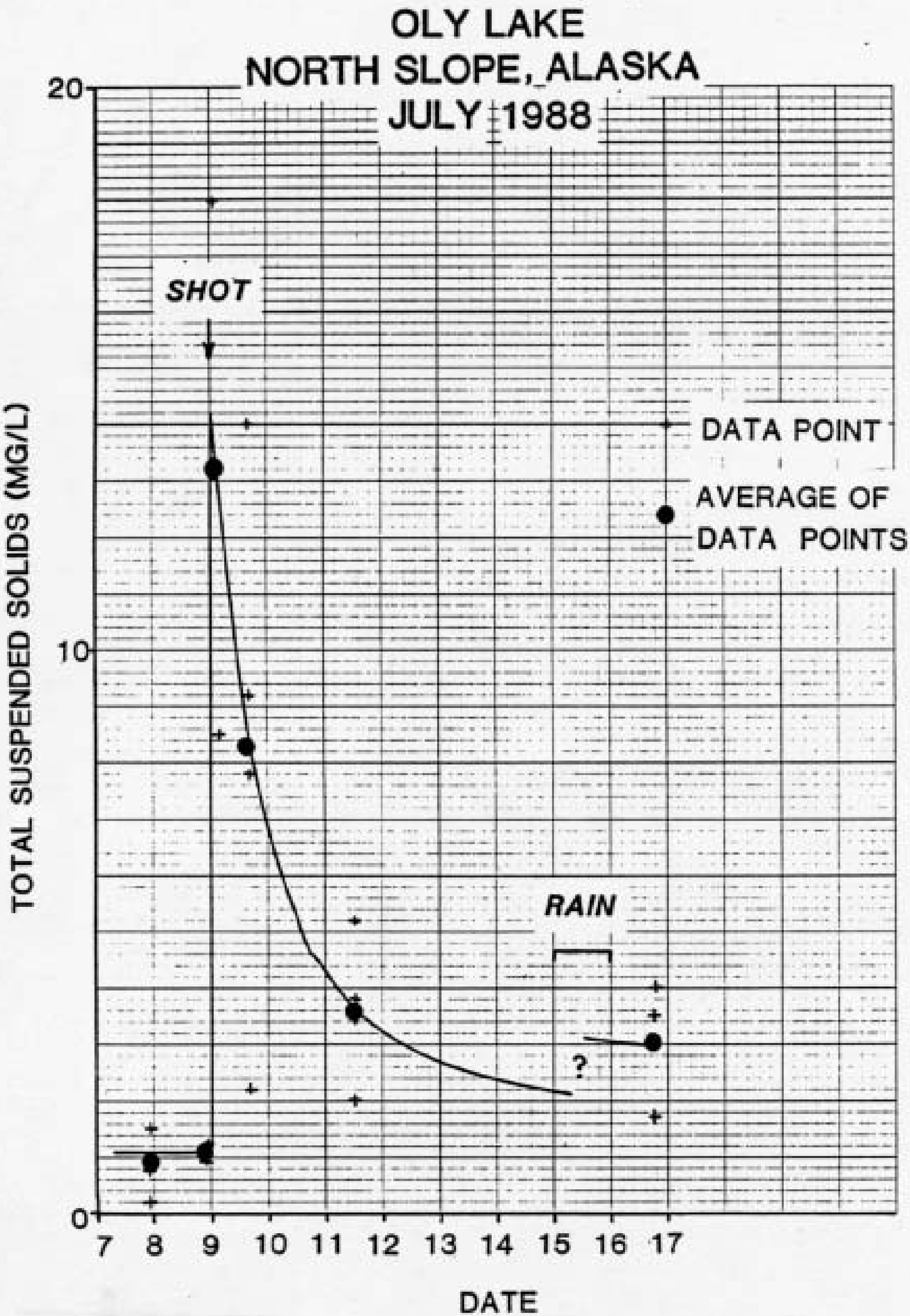

Figure A1.-- Oly lake - suspended solids as a function of time after shot.

APPENDIX II:
LIST OF PROSPECTIVE PERMITTORS

1. U.S. Department of Agriculture, Forest Service (USFS), Saugas District. Chief contact, Mike Wickman (805-296-9710).

2. U.S. Department of the Interior, Bureau of Land Management (BLM). Chief contact, Mike Hogan (760-384-5423).

3. Los Angeles County Department of Parks and Recreation. Chief contact, Jim Park (213-738-2965).

4. California Department of Parks and Recreation. Chief contact, Richard Rozzelle (213-738-2965).

5. Los Angeles City Department of Recreation and Parks. Chief contact, Alonzo Carmicheal (213-485-8168).

6. Los Angeles County Department of Public Works. Chief contacts Michael Anderson (818-458-6104) and T.A. Tidemanson (818-445-7630, 310-861-0316). Permit granted Aug. 2, 1994, for seismograph sites along Big Dalton Creek, Walnut Creek, La Canada Verde Creek, and Coyote Creek.

7. Los Angeles Unified School District.

8. Cal State Northridge. Chief contact, Prof. Gerry Simila (818) 677-3543.

9. We are also submitting requests to a number of private individuals and companies.