Docket No. SA-534

Exhibit No. 2-DW

NATIONAL TRANSPORTATION SAFETY BOARD

Washington, D.C.

1992 PG&E GEOLOGIC
HAZARD EVALUATIONS

(9 Pages)

Geologic Hazard Evaluations For Gas Transmission Lines 109 And 132 In San Bruno

Prepared by the Geosciences Department

November 1, 1992

Pacific Gas and Electric Company

Pacific Gas and Electric Company

Geosciences Department, F22A
One California Street, Room 2200
P.O. Box 770000
San Francisco, CA 94177
415/973-2792
Fax 415/973-5778

March 5, 1993

Mr. George Foscardo
Planning Director
City of San Bruno
567 El Camino Real
San Bruno, CA 94066

Dear George:

On December 17, 1992, we had an informative meeting with you and your staff and consultants to discuss questions and concerns regarding seismic safety as it applies to the replacement of our gas transmission pipelines through the San Bruno portion of the San Francisco Peninsula pipeline corridor. This meeting followed the submittal to you of an extensive and detailed report, "Geologic Hazard Evaluations for Gas Transmission Lines 109 and 132 in San Bruno," prepared by PG&E's technical staff and dated November 1, 1992. The review of this report conducted by your staff and consultants, particularly Consulting Engineering Geologist Murray Levish, raised four questions, which were addressed during the meeting. In this letter, we summarize the questions raised at the meeting, and provide additional information to clarify and document the issues.

1. **Crossings of Additional Possible Secondary Faults.** The possible existence of additional secondary faults was raised by Mr. Levish. The studies documented in the 1992 PG&E report identified and evaluated the Serra fault and several subsidiary faults located in the zone between the Serra fault and the main traces of the San Andreas fault (1992 PG&E report, p. 16). Mr. Levish and the PG&E technical staff agreed during the meeting that possible yet-to-be-discovered faults would have no more potential for surface fault displacement than the Serra and other known faults in this zone. Thus, for example, a minor thrust fault near Crestmoor Drive, as postulated by Mr. Levish, could potentially experience surface displacement of a foot or less.

   In response to both the specific question about thrust faulting near Crestmoor Drive and the general issue of unidentified additional minor secondary faults, the 1992 PG&E report included a generic analysis of the potential for pipeline displacements due to concurrent surface faulting amounts of as much as 1 foot of thrust deformation and 3 feet of horizontal shear deformation. The results indicated that the standard design planned for the pipeline replacement incorporates more than adequate ruggedness to mitigate such minor fault displacements (1992 PG&E report, p. 32). In certain locations where there are several bends in the pipeline, added safety will be provided by using heavier-walled pipe and long-radius elbows. The planned replacement pipelines will adequately mitigate the largest potential secondary fault displacements anticipated by Mr. Levish, as discussed in the meeting of December 17, 1992.

2. **Conservative Analysis of Backfill.** The planned installation of the new pipelines involves excavating trenches about 6 feet deep, into which the pipe is placed. The pipe is surrounded by and the trench is backfilled with sandy material that has been well compacted so as to support the overlying pavement and traffic loads. In addition to supporting traffic loading, sandy backfill allows the pipeline to move within the trenchline during an earthquake. In the PG&E analysis of earthquake-caused stresses on the buried pipeline, we assumed the backfill material had the mechanical properties of the local sedimentary rock along the pipeline route (1992 PG&E report, p. 29-30), which is much stronger and more dense than the planned backfill. The results of the analysis indicated that the pipeline would perform well, even assuming rock-like backfill. Thus, using sandy backfill material provides an added margin of confidence in the safety of the design. As agreed at the meeting on December 17, no further analysis is needed.

3. **Subsidence of Deep Fill.** The planned pipeline routes traverse several areas of man-made filled ground in San Bruno, and differential settlement can be a potential hazard in such areas. Although no areas of potential significant differential settlement were identified along the routes (1992 PG&E report, page 19), an analysis was performed for possible failure of an artificial fill along the route. This analysis considered an extreme case in which the fill was assumed to experience slope failure such that the pipeline was allowed to deform under its own weight, unsupported by the fill. The results indicate that the strains in the pipeline would be less than one-fourth of the reasonable tensile strain limits for the pipe (page 32). Thus, the planned pipeline has a very large capacity to withstand settlements of filled ground.

   Mr. Levish raised a question about the potential for settlement of the deep fills emplaced at locations along the frontage road for Highway 280, with possible amounts of settlement of as much as one percent of the fill depth; for example, 1 foot of settlement for 100 feet of fill. The capacity of the pipeline is more than adequate to accommodate such minor displacements. As agreed at the meeting on December 17, 1992, no further analysis of this consideration is needed.

4. **Alquist-Priolo Special Study Zones.** In 1972, the State of California established the Alquist-Priolo Special Study Zone Act to prohibit the construction of structures for human occupancy across known active surface-fault rupture areas. As a result of this Act, detailed geologic maps have been prepared to identify the locations of known active surface faults, such as the San Andreas fault, and the zones within which detailed investigations of the locations of individual fault traces are required. High-pressure gas pipelines are not covered by the statement or intent of the Alquist-Priolo Act. Even so, PG&E, as a prudent owner and operator of such facilities, has conducted detailed fault location studies to identify the locations of the primary traces of the San Andreas fault and adjacent secondary faults to assure that we have accurately identified and characterized potential surface faulting hazards to the replacement pipelines. We have mitigated these hazards by relocating the pipelines to avoid crossing the main San Andreas fault traces, and by using a pipeline design that can accommodate minor or secondary faulting. Thus, PG&E has met the spirit of the Alquist-Priolo Act, both in using the Act's data base for fault evaluation, and in mitigating the potential hazards of surface faulting along the pipeline routes.

We appreciate the opportunity to work together with you to bring to closure the above four items identified in our review meeting on December 17, 1992. We believe that these discussions, in combination with the 1992 PG&E report, represent a sound and prudent basis for completing the design of the replacement of Pipelines 109 and 132 in the City of San Bruno. Please call me at Redacted if you have any further questions.

Sincerely yours,

[redacted]

Redacted

Senior Seismologist

cc: Redacted

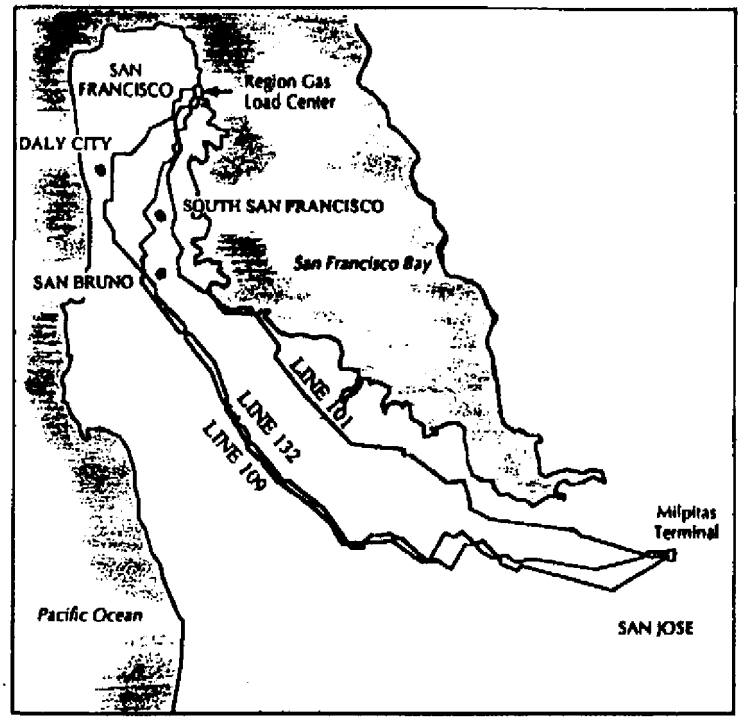
PUBLIC INFORMATION FACT SHEET
GAS LINES 109/132 REPLACEMENT PROJECT
DALY CITY, SOUTH SAN FRANCISCO AND SAN BRUNO

PURPOSE OF THIS FACT SHEET

This fact sheet provides information on a natural gas pipeline project that PG&E is starting in May. The following information will explain why this project is necessary, how we will keep you informed, and how we will try not to inconvenience you during construction. If you have any questions or concerns, please call the Line 109/132 Project Hotline at [redacted]
For any other gas or electric service issues, please call the PG&E Customer Services office at [redacted]

WHY DOES PG&E NEED TO DO THIS WORK?

In 1985, PG&E began the Gas Pipeline Replacement Program that will replace all aging natural gas pipelines in the system over a 25-year period. The purpose of this program is to maintain safe and reliable gas service to our customers. As part of this program, plans were made to replace the three natural gas pipelines that supply the Peninsula between San Francisco and Milpitas. We call these Lines 109, 132, and 101.



The old pipeline sections will be replaced with higher quality pipe using modern construction methods. The replacement of Line 101 was completed in 1989. The older portions of Lines 109 and 132 will be replaced by the year 2000. The current phase will be built from May 1993 to May 1994 in Daly City, South San Francisco and San Bruno.

EXISTING PIPELINES TO BE REPLACED IN 1993-1994

The section of Line 109 to be replaced in '93-'94 runs through Daly City, South San Francisco and San Bruno along Skyline Boulevard and in the San Francisco Watershed area. The short sections of Line 132 to be replaced in '93-'94 are located near Claremont Drive and along Skyline Drive and Skyline Boulevard in the City of San Bruno and in the San Francisco Watershed area. The existing lines cross the San Andreas fault in two locations along Skyline Boulevard, and also go through several residential back yards. We plan to replace these pipelines in new locations to reduce the seismic risk and environmental impacts along the lines. The maintenance access to the lines will also be greatly improved. All gas will be removed from the old pipelines and they will be sealed for safety and abandoned in the ground.

PUBLIC BENEFITS

The new lines will continue to provide safe, reliable gas to Daly City, South San Francisco and San Bruno, as well as the rest of the San Francisco Peninsula. The new lines should last for another 80 to 100 years.

NEW ROUTE DESCRIPTIONS

The new route for Line 109 starts at Redacted in Daly Redacted Redacted Redacted Redacted Redacted

ROUTE SELECTION CRITERIA AND CONSIDERATIONS

Prior to the selection of a final route, we performed a number of environmental and geological studies. We worked closely with the agencies and city departments involved to get input into the route selection. In choosing this new route, we used the following items as criteria:

- Lessen construction impacts on residential areas.
- Lessen seismic hazards.
- Lessen construction in environmentally sensitive areas.
- Maintain high level of gas system reliability and safety.
- Minimize cost to our customers.

CONSTRUCTION METHODS AND IMPACTS

We are looking for construction to start in May 1993 and to last through May 1994. Construction will occur as fast and as safely as possible. We will do all we can not to inconvenience our customers during construction. Each home and business will be personally notified of the construction schedule on their street about one week in advance. The average length of time of construction directly in front of a home or business will be about one week. Construction will generally be performed Monday through Friday between 8:00 a.m. and 4:00 p.m. except along Junipero Serra Boulevard where work will take place from 7:00 a.m. to 6:00 p.m. Traffic flow may be delayed during this period, but at least one lane will be kept open and access to all homes and businesses will be provided.

The construction of Lines 109 and 132 will result in some noise, which is being limited by the daytime construction when fewer people will be affected. The trench will be filled or steel-plated at the end of each working day. All construction debris will be removed. In the event any landscaping is damaged by construction, it will be restored.

See the attached map for the schedules in specific areas. The project schedule may change due to weather, available manpower, and soil conditions.

FOR MORE INFORMATION, PLEASE CONTACT:

PG&E Line 109/132 Project Hotline.....[redacted]

Redacted

PG&E

PG&E's LINE 109/132 REPLACEMENT PROJECT

Scale: FEET 0 1000 2000 3000 4000 5280 FEET
MILE 0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1.0 MILE

Legend:

Existing mains

New mains

Redacted

Redacted

Section	Description and Location of Work	Scheduled Start Date	Scheduled Finish Date
A - B	Redacted	May, 1993	July, 1993
B - C		July, 1993	Oct., 1993
C - D		May, 1993	Aug., 1993
D - E		Aug., 1993	Oct., 1993
E - F		Jan., 1994	Apr., 1994
F - G - H		Oct., 1993	Dec., 1993
I - J - K		Oct., 1993	Dec., 1993
L - M		Jan., 1994	Apr., 1994
M - N		Jan., 1994	Apr., 1994

SUMMARY

PG&E is replacing portions of Gas Transmission Lines 109 and 132 on the San Francisco Peninsula. Although our older gas transmission facilities met the design and construction standards at the time they were installed, some do not meet present-day standards, and have been the recent subjects of review and replacement. Replacement priorities are based on age, construction factors, condition of the pipe, and exposure to seismic hazards. Sections of pipelines in seismically vulnerable areas are given the highest priority for replacement.

The greatest seismic hazard to our pipelines on the San Francisco Peninsula is the San Andreas fault. The effects of a scenario earthquake on the San Andreas fault, which for this study was taken to be a repeat of the 1906 earthquake, are likely to be strong ground shaking, surface fault rupture, ground distortion adjacent to the fault, seismically induced liquefaction, slope failure, and differential settlement.

To evaluate these effects, PG&E has conducted studies along the existing and preferred new routes for Lines 109 and 132 to ascertain the level of hazard. Investigations included aerial reconnaissances from helicopters, visual inspections from motor vehicles, and site visits on foot. We reviewed written eyewitness accounts and photographic records of the 1906 earthquake effects to assess the characteristics of surface faulting and ground deformation. We reviewed pertinent published and unpublished maps and the relevant literature, and conducted detailed geologic mapping of key sites. Records of exploratory soil borings and trenches in the vicinity of the pipeline routes were studied. Aerial photographs taken before and after urbanization were analyzed. We compared our independent interpretation of the landscape features indicative of active faulting with Alquist-Priolo Special Study Zone maps, and with the fault mapping by others.

The results of our studies in San Bruno indicate that the most vulnerable areas are pipeline crossings of the San Andreas fault, where future displacements could be as large as 10 feet. Lines 109 and 132 will be rerouted to avoid this hazard. In addition to surface faulting on the primary fault, it was recognized that, during a 1906-type earthquake, ground rupture also could occur on related subsidiary faults. For this study, we have assumed subsidiary strike-slip faults are capable of as much as 3 feet of right slip across a zone that is 10 to 70 feet wide. Thrust deformation of 1 foot at a dip angle of 20 to 40

degrees was postulated for the Serra fault, and 3 inches of reverse slip at a dip angle of 80 degrees was postulated for the faulted Franciscan/Merced contact. Distortion of the ground, or warping, occurred during the earthquake in 1906, decreasing with distance from the fault and becoming insignificant beyond 450 feet. For this study, we evaluated the effects of as much as 3.2 percent of warping parallel to the San Andreas fault, based on the amount of distortion observed in 1906. Two areas of possible slope instability were identified: an artificial fill area of low to moderate hazard on the north side of San Bruno Avenue between Glenwood and Alpine, and an area of low hazard near Glenview Drive south of its intersection with Earl Avenue. Liquefaction and ground settlement are not hazards to Line 109 and 132 through San Bruno.

Segments of the pipelines and the surrounding soil were modeled, and the pipelines were subjected to finite element analyses using the assumed parameters for faulting and ground distortion. The results of the engineering analysis found that the likely maximum compressive strain along the new sections of Lines 109 and 132 is less than 1.6 percent. This is well below the strain limits recommended to ensure the integrity of the pipeline.

The inherent ruggedness provided by the design specifications for new high-pressure pipelines is adequate to mitigate the potential hazards to Line 109 identified during these studies. Existing Line 132 was found to have similar levels of inherent ruggedness, despite the fact it was originally installed using no special seismic design considerations. By building to existing codes, minor fault displacements, minor slope failures, and differential settlement are not significant hazards to buried welded steel pipe.

Existing pipeline design and construction standards provide for adequate safety; however, PG&E has elected to provide extra safety at selected locations. We will avoid the potential for slope instability on the north side of San Bruno Avenue by placing the pipe on the south side of the street. We plan to use pipe having a 0.5-inch wall thickness at the potential locations of high strain along the new segments of Lines 109 and 132, and also along existing Line 132 where we will replace a small segment of the pipeline at the intersection of Redacted Additionally, we plan to install long-radius bends at selected turn points. These measures will mitigate the potential high compressive strain on a small segment of existing Line 132, and will help to ensure that a maximum strain level of 1.6 percent is well within the capacity of the new 24-inch, X-60 grade pipe.