Healthy Community Research of Suisun City
Project of California Healthy Communities Network/Tides Center
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Pipeline and Hazardous Material Safety Administration
Technical Assistance Grant (TAG)
DTPH56-09-G-PHPT17

Final Report Cover Letter

Objective: Evaluate safety of aging hazardous liquid and natural gas transmission pipelines in the Suisun City pipeline corridor.

This TAG report study was awarded to The Tides Center and Anthony Moscarelli who represents Healthy Community Research of Suisun City, a project of California Healthy Communities.

The objectives of this study also included:
Addressing the issue of transmission pipelines and their lifespan in corrosive wetland soil; and development of a pipeline safety plan that addresses issues of aging pipelines.

We contracted Professor Robert Curry, PhD of Watershed Systems to compile data and write this report. Professor Robert Curry's report has become a culmination of mutual work between Anthony Moscarelli, who collected local information, and his work to place that information in a risk-based scientific context.

We feel that our objectives were met by this report given the limitations of the available funding.

We believe that further areas of studies, regarding these pipelines, that opened up to us during our investigation would have been beneficial for the local area. Sadly we were limited by time, money, and overall scope of our Grant parameters.

Thank You,

Anthony Moscarelli

Anthony Moscarelli
Project Coordinator

Evaluation of safety of aging hazardous liquid and natural gas transmission pipelines in the Suisun Pipeline Corridor, California

Robert R. Curry PhD, RPG 3295

3-4-11

Geotechnical Hazard Report Prepared for:

California Healthy Communities Network
and
Tides Foundation

Watershed Systems
600 Twin Lanes
Soquel, California 95073

Executive Summary:

Two groups of hazardous fuel pipelines pass through the community of Suisun City, at the San Joaquin River delta in San Francisco Bay. These include jet fuel transmission pipelines delivering fuel to Travis Air Force Base and the regional trunk high pressure natural gas transmission lines operated by Pacific Gas and Electric Company (PG&E). Both pipeline systems are more than 50 years old and now pass through suburban residential and commercial neighborhoods.

This study uses information available to the public, as well as Freedom of Information Act (FOIA) requests and cooperative pipeline operator supplied information to evaluate potential public safety issues with these pipelines. We conclude that the jet fuel lines are in poor condition and need to be decommissioned as soon as planned substitute lines are completed. We also recommend that Congress reconsider classifications for so-called gathering lines that are, in fact, used for fuel transmission and deliveries in urban areas rather than gathering in oil fields.

We conclude that PG&E must continue its gas transmission system upgrades to allow more comprehensive and thorough routine inspections of pipeline integrity. Aging steel pipelines do not last forever and those over 50 years old need to be carefully and frequently monitored. We also recommend further study of questions raised during this study about operating parameters such as pressure surges and safety issues such as shutoff valves and emergency response planning.

Introduction:

This report was commissioned by the Healthy Community Network and the Tides Foundation under the direction of Anthony Moscarelli, Project Coordinator with the Healthy Communities Network of Suisun, California and Suisun resident. Moscarelli obtained support from the Pipeline and Hazardous Materials Safety Administration (PHMSA) program of the U.S. Department of Transportation for this effort. The purpose of this consultant report is to evaluate the factors that contribute to pipeline safety in a primarily residential area where urbanization today dominates a formerly rural agricultural site.

The specific objectives of this report are to provide public agencies and interested members of the public with information that will better inform them of safety hazards associated with pipeline corridors that carry potentially hazardous materials through residential neighborhoods. The Suisun, California site that is the focus of this report exemplifies many of the limitations that are of concern to pipeline safety professionals.

The Suisun area:

Suisun City is in Solano County, California. This was one of the original 1850 Statehood counties and now has a 2010 population of 427, 837 with a surface land and water area of 909 square miles. It is located primarily in the Sacramento- San Joaquin river delta where these rivers enter San Francisco Bay. Suisun City has a 2010 population of 28,962 and is located along the route of the 1869 Transcontinental Railroad 45 miles southwest of Sacramento and 45 miles northeast of San Francisco.

Adjacent to Suisun City is Travis Air Force Base. This airbase was originally established in 1942 as a temporary bomber base to support World War II efforts in the Pacific. The 945-acre site was activated as *Fairfield-Suisun Army Air Base* in May 1943 and developed into the largest West Coast air terminal by the end of WWII. Establishment of the USAF and construction of a new 10,000-foot runway led to the creation of *Fairfield-Suisun AFB* in 1947 which was later renamed *Travis* AFB in 1951 to honor Brigadier General Robert F. Travis who was killed in a plane crash there.

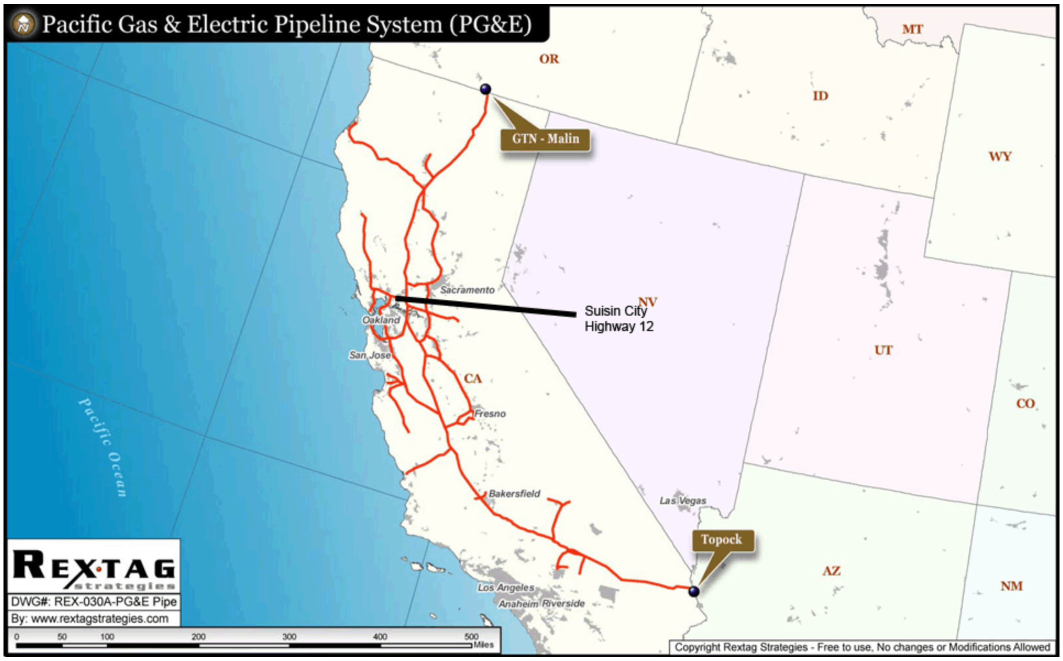
Suisun City was created about 1850 during the Gold Rush when it was realized that homesteads could not include tidelands which were all reserved by the U.S. Government. The intent of this restriction was to promote commerce and thus shipping and trade businesses started in Suisun City for the gold rush miners. Sacramento was closest to the Sierra and thus dominated the market and could charge higher fees/prices. San Francisco was too far away. Suisun City with lower prices soon became a town of shippers, merchants, bars, and brothels.

Completion of the Transcontinental Railroad connected Suisun City to the rest of the nation. Its location at tidewater on both San Francisco Bay and the Sacramento River and along the railroad right-of-way created a major impetus to use the corridor for multiple commodities including pipelines and electrical transmission facilities.

In the 1960s and 1970s Suisun City experienced rapid growth as the San Francisco Bay Area's suburban ring expanded to formerly rural Solano County. In the 1960s Interstate Highway 80 was constructed two miles (3 km) outside the city effectively moving commercial traffic away from railways and water conveyance but bulk commodities such as refined petroleum could still be delivered by ships or regional pipelines.

In the 1940's the Travis AFB energy needs' required pipelines to supply both aviation fuel and natural gas. From 1946 to 1968 an aviation gas pipeline carried fuel for about 2.4 miles eastward from Sheldon Oil at tidewater in downtown Suisun City out through the unincorporated portion of Solano County east of the city, which was then rural farmland, to the airbase gate. This pipeline followed State Highway 12, known then as Road 68 or Rio Vista Road, eastward to the southern end of the air base.

In the late 1940's Pacific Gas and Electric followed the same Highway 12 route in the unincorporated part of Solano County to supply the southern end of the airbase from its 16-inch high-pressure natural gas transmission line. In 1965 an additional 32-inch natural gas transmission line was installed. These lines are part of the statewide high-pressure natural gas distribution system that enters the state directly across the Colorado River from Topock, Arizona at the Topock Compressor Station and connects to the TransCanada Gas Transmission Northwest system at Malin, Oregon. They carry natural gas from throughout the southwest and from western Canada to provide PG&E's primary supply. Figure 1 shows the general high-pressure supply pipeline system in California and the approximate location of the Highway 12 Suisun City section. This "backbone" system is the primary gas supply for PG&E's service area in the Central California and the San Francisco and Monterey Bay areas. This statewide backbone is today made up of 30-42-inch diameter sections up to 40-feet long that were laid beginning in the 1940's (cf., PG&E "pipeline 002").



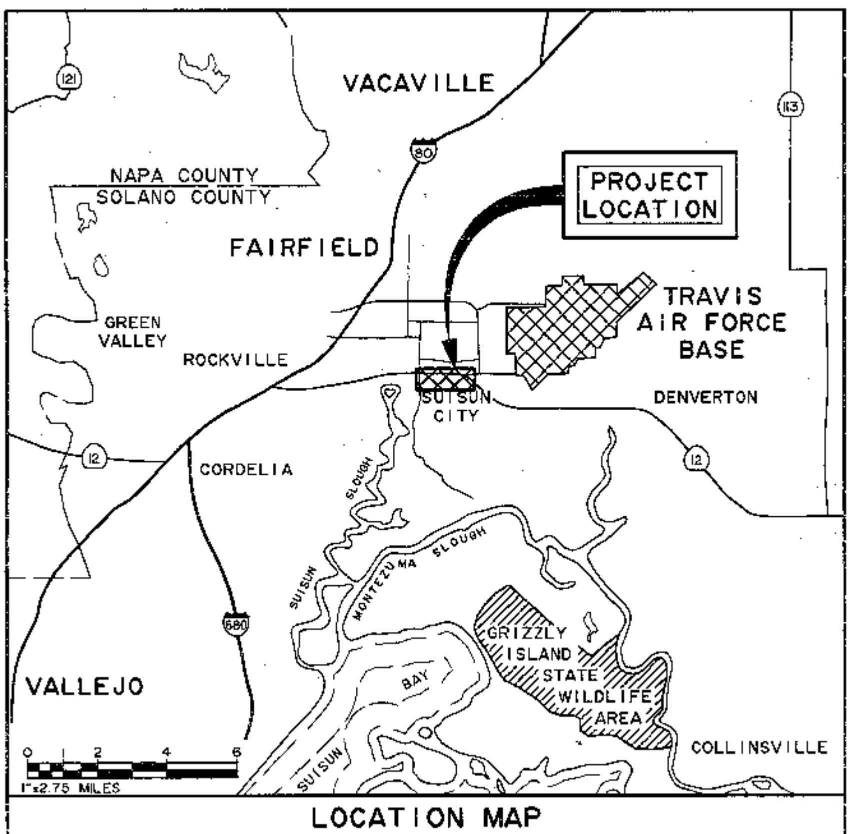


Fig. 1 Location maps in context of PG&E statewide primary supply line system. Sources: RexTag (http://www.rextagstrategies.com/) and Dept. of Navy, 2008

In the late 1950's the airbase fuel storage tanks leaked creating a clean-up issue. This created an environmental reason to limit the amount of fuel storage on the base and drove completion of fuel supply pipelines.

In 1968 the Army Corps of Engineers took on the project of running two pipelines to the base following the same route as the aviation gas pipeline. This again followed the same Highway 12 southern route to the airbase. In 1970 the project was completed.

In 1975 the City of Suisun City annexed 2 miles of Solano County land that included the pipeline corridor and began expanding eastward toward Travis AFB. Suisun City then approved building sub-divisions following Highway 12 and the pipeline corridor.

During the period 1992-96 the California Department of Transportation replaced and relocated over a mile of aviation pipeline for Highway 12 widening. During this time the 6-inch petroleum product pipeline was decommissioned and only an 8-inch line remains. The U.S. Army Corps of Engineers constructed the present aviation fuel pipelines, capping the 6-inch line in 1968.

Another long-distance commodity pipeline transporting JP-8 jet fuel passes just west of the Highway 12 study corridor carrying fuel from the Concord area refineries to Sacramento and on to Reno. It is owned and operated by a company called SFPP -- Kinder-Morgan. This 20-inch pipeline crosses Highway 12 and passes directly through Suisun City but generally follows the I-680/I-80 corridors. It was upgraded in 2004 replacing an older 14-inch pipeline. A branch line is now proposed to supply Travis Air Force Base, and thus allow the JP-8 lines along and under Highway 12 to be retired (Kinder-Morgan Draft Environmental Assessment, 2009).

Soils and geology of the Suisun pipeline corridor:

This subject is an important element of our evaluation of pipeline failure probabilities. Corrosion of high-carbon steel pipelines and subsurface fate of leaked fluids are both influenced by soil and shallow groundwater conditions.

The Suisun Marsh is locally claimed to be the largest contiguous estuarine wetland in the continental United States, totaling over 116,000 acres (Solano County 2006). Part of this wetland complex is encompassed by the Travis Air Force Base and much of Suisun City. The Solano-Colusa Vernal Pool Region encompasses a majority of the county's central and eastern areas. Pools in the region are often comprised of both small playas and hog-wallow depressions, and may occur singly or in small groups. Typically, pools are alkaline and may display whitish saline deposits when dry (USAF 2007). The regional soils have a claypan or shallow restrictive layer that originally was characterized by standing water in the spring and early summer. In the urbanized Highway 12 corridor, the pools have been filled but the claypan still exists at a depth of 2 to 4 feet. The

Highway 12 corridor route is also called Suisun Slough on older topographic maps, although that waterway is now largely confined to a ditch along the south side of that road. Multiple freshwater emergent wetlands associated with sloughs are also located near the Air Force base, and the primary Suisun Marsh is located just to the south (USAF 2007; USFWS 2007).

A USDA Soil Conservation Service soil survey of Solano County was first completed in 1930 and updated with a published soil survey monograph in May, 1977 (USDA, 1977). The survey reflects conditions when much of the present pipeline routes were beginning to be urbanized and farmlands were being filled and drained. This older soils map has now been transferred to a digital vertical aerial photo format base but the resolution is low and the interpretations are out-of-date. The areas of interest along Highway 12 corridor are listed primarily as*: AsA—Antioch-San Ysidro complex, 0 to 2 percent slopes*. The soils data were compiled in 1975 and plotted on older aerial photos. An example of conditions existing when the soil survey was compiled is available at:

http://soils.usda.gov/survey/online_surveys/california/solano/maps/ca_solano-31.pdf.

Contemporary aerial photo base maps (June 30, 2005) upon which the older soils data are superimposed are available from the USDA Web Soil Survey at:

http://websoilsurvey.nrcs.usda.gov/app/WebSoilSurvey.aspx

Some of the local wetland soils have been drained for so long that their characteristics may no longer qualify them as statutory wetlands, and grading, filling, and construction of drainage ditches and channelized waterways has lowered seasonal water tables to 5 or more feet below ground surface[1]. Pipelines along the Highway 12 Suisun corridor have been laid in both native sandy-clay soil materials and in up to 13 feet of fill of unknown origin (Michael Baker Jr, 2010, *op cit,* Fig 4. cross section A-A').

The native Antioch Series soils have low to very low permeability (USDA, SCS, 1977, Soil Survey of Solano County). Surface gradients are nearly flat (less than 2 %). Thus, rain-season runoff is impaired and ponding along roadways and low areas is common. Urban development by Suisun City along the Highway 12 corridor has required use of buried storm drains and excavated drainage channels to carry runoff to nearby tidewater.

[1] According to a report prepared by Michael Baker Jr., Inc. in May 2010 titled*: JP-8 underground transfer release site investigation – proposed plan for free-phase interim product removal action, Suisun City, California*. This report focused on remediation of the leaking JP-8 jet fuel pipeline that was investigated between March and May of 2010 along the Highway 12 corridor.

Qualifications of the investigator:

Robert Curry is a U.C. Berkeley PhD in Geology and Geophysics who has compiled geologic hazard reports on many pipeline projects. At the time of the proposal for the Trans-Alaska Pipeline project in 1968 Curry was serving as scientific adviser to the U.S. Senate Public Works Committee and prepared a major evaluation of the proposed pipeline routes and hazards. This work was supported by the U.S. Geological Survey, for whom Curry worked part-time. The scientific review and Senate advisory position led to the requirements for Environmental Impact Assessment Statements for the National Environmental Policy Act that was passed in 1969.

Extensive pipeline project reviews included those for the Northern Tier Pipeline from the Great Lakes to Seattle, for a Trans-Canada pipeline alternative to the Alaska Pipeline and other western U.S., offshore, and national pipeline projects. In the past decade investigations have included spills and hazards associated with pipelines in the San Francisco Bay area including review of a proposed playing field on the sites of older PG&E high pressure gas pipelines near Tracy, and investigation of spills and maintenance of Texaco Trading and Equilon Pipeline Company operations for the nearby city of Martinez.

A brief resume of the author is attached to this report.

Investigations, reports and materials reviewed:

Anthony Moscarelli assisted in very thorough review of available materials from Solano County, local utilities, the Public Utilities Commission, the California Department of Transportation, the California Department of Fish and Game, and City of Suisun records. He also reviewed the proceedings in a California Supreme Court case that sought consideration of the jet fuel pipeline hazard issues (Solano County Super. Ct. No. FCS031099 *et seq*). He secured records of pipeline testing, installation, and safety evaluation from the U.S. Department of Defense, U.S. Air Force, and Travis Air Force Base. That base was the destination for the JP-8 jet fuel pipeline, and the older liquid fuel pipelines that originally supplied fuel to the airbase. These fuel pipelines are co-located with the Pacific Gas and Electric natural gas transmission line in the now-suburban corridor. Many of the liquid fuel line records could only be secured with tedious Freedom of Information Act (FOIA) requests and then only after initial denials that testing, installation, and construction records existed.

Moscarelli was available to conduct field reviews of real-time pipeline repairs, interviews with repair crews, and to photograph excavations, test-points or lack thereof, and pipeline repair and replacement materials.

Robert Curry compiled additional maps, aerial photos, and reference materials to support analysis of site conditions.

This report is based only on available documents and materials. It specifically does not attempt to evaluate adequacy of site engineering, metallurgical limitations, or any other specific analyses of on-site conditions. Robert Curry was asked to develop information on failure modes for public hazard analysis and probabilities of those kinds of failures. No engineering or soils and foundation testing were performed for this report. All conclusions are based on available data that could be derived by persistent members of the public.

Field and office investigations have focused on the following primary questions:

1. What do we know about the long-term safety of the hazardous materials pipelines that are located in the Highway 12 public right-of-way with adjacent residential and commercial properties?
2. How well-informed are local emergency responders about risks associated with these pipelines?
3. How does the geologic substrate into which the pipelines were constructed affect their lifetimes, maintenance requirements, and public risk?
4. What has been the history of operations and maintenance of the Highway 12 corridor pipelines?
5. How much do the local City, County, and State-wide regulators and emergency response agencies know about that O & M?
6. Have the standards and recommendations of the California Public Utilities Commission and other regulators for operations and maintenance been implemented and updated, if needed, in a timely fashion?

Findings:

Condition and maintenance of Suisun pipelines:

There are multiple pipelines that follow the Highway 12 corridor. Two historic lines have been used for the Air Force Base fuel supply. The JP-8 8-inch line is currently used for kerosene-based jet-fuel. An older 6-inch line was decommissioned after the 8-inch line was installed next to it in 1968. Pacific Gas and Electric (PG&E) operates both 32-inch and 16-inch high-pressure natural gas transmission lines as well as local distribution natural gas lines. All of these pipelines pass through an urban corridor along Highway 12 and supply Travis Air Force Base as well as distant points. The natural gas lines were first installed in 1949 (16-inch line “210-B”) and 1965 (32-inch line “210A”).

PG&E's lines are regional transmission lines and are connected to the California natural gas pipeline system, carrying natural gas to Sacramento and the San Francisco Bay area (see upper portion of Figure 1, Pacific Gas and Electric Pipeline System). The older line has had sections replaced locally, and some of the replacement sections are up to 20-inches in diameter. Several grades of pipeline have been used for replacements with differing pipe wall thickness and differing operating pressure limits (MOP) and specified minimum yield strengths (SMYS) [2].

All of the 2^+-mile length is rated for the same maximum operating pressure of 650 PSI. This value is therefore the limiting minimum value for all segments of the pipeline. A tabulation secured by Mr. Moscarelli from PG&E lists pipeline coatings, girth weld types, and joint and seam types for 11 separate segments of the older pipe 210-B and for 16 separate segments of the newer 210-A pipeline within the 2^+-mile distance. Although the pipelines are parallel, the mile-point terminations of each pipe's segments are different and the dates of placement of the segments are different. Some segment lengths are as short as 3 feet while the longest is 4165 feet. A PG&E spreadsheet is reproduced as Table 1. This tabulation is a critical portion of this report because it reveals some of what the PG&E pipeline database includes and how those data could be parsed to establish local pipeline conditions and risk. There is also reported to be a PG&E list of the utility's "100 pipeline segments needing close monitoring or improvements" have been made available to the public[3].

The PG&E operator-tabulation of many pipeline segments and changing pipeline diameters and characteristics indicates that the operator has done considerable maintenance and upgrading in this 2-3 mile long High Consequence Area transmission line[4]. The quality of the data and detail are in marked contrast to that of the same operator in the vicinity of the 2010 San Bruno natural gas pipeline failure and explosion where initial reports did not accurately identify the characteristics of some of the pipeline segments[5].

A Public Map Viewer for nationwide pipelines is available on the internet here for Solano County . A copy of a portion of the Solano County map is presented here as Figure 2. While security considerations may limit public information, an important function of this National Pipeline Mapping System provided by the US Department of Transportation to the general public is a listing of the operators of

[2] Based on a tabulation of 2 to 3 miles of pipelines along Highway 12 provided to Anthony Moscarelli by Charles Lewis of PG&E in 2009.

[3] Steve Johnson, San Jose Mercury News 2/12/11 http://www.mercurynews.com/bay-area-news/ci_17367758

[4] High Consequence Areas – see Appendix A for definitions of HCAs.

[5] See http://www.ntsb.gov/Dockets/PipeLine/DCA10MP008/458194.pdf

pipelines in corridors[6]. For the 2 miles of the Suisun City Highway 12 corridor the NPMS database provides information on presence and ownership of primary pipelines. For natural gas lines, depending on where along that 2-mile segment one queries the database, between 9 and 12 active (in service) pipelines features are listed belonging to PG&E. In addition to lines 210A and 210B, other appurtenant structures attached to those pipes carrying designations of DFDS, DREG, and STUB are listed as operated by PG&E[7]. Other pipelines are listed as abandoned. No hazardous liquid pipelines are listed in the NPMS along the Highway 12 corridor not because such lines do not exist but because the hazardous liquid pipeline operator is not required by and does not report to PHMSA. In this author's opinion, the National Pipeline Mapping System is not intuitive and not easily used by the general public, although it may include complete information for the pipelines that are in the database if one is willing to learn to use it and accept the scale limitation of 1:24,000 (two inches to the mile).

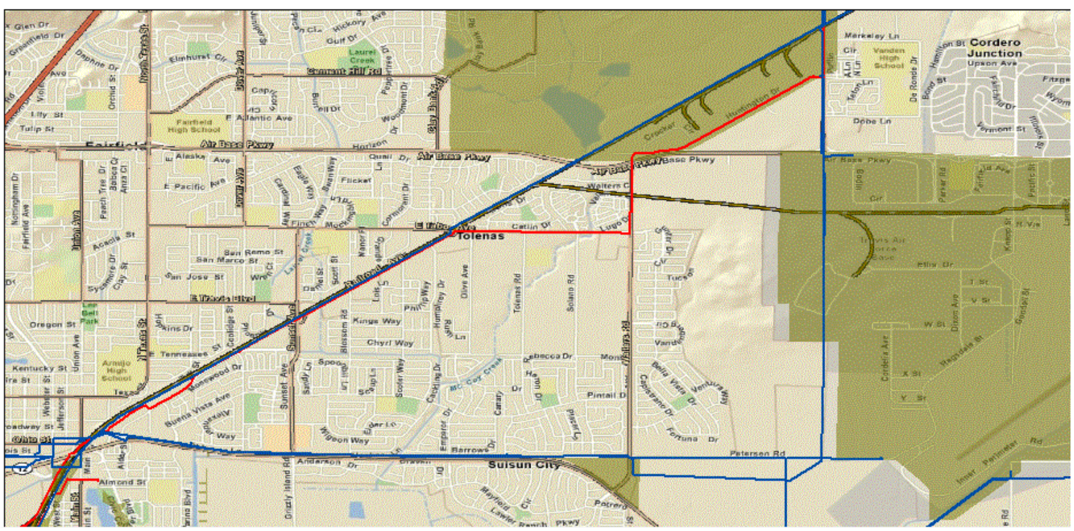


Figure 2. Pipeline map of study area vicinity – National Pipeline Mapping System. This is the public map version. Blue lines are natural gas, red are hazardous liquids. [www.npms.phmsa.dot.gov.](http://www.npms.phmsa.dot.gov)

[6] The NPMS is updated and maintained with mandatory annual submissions of pipeline geospatial data by pipeline operators. One important function of the NPMS is to support queries by members of the public to identify which hazardous liquid and gas transmission pipeline companies operate pipelines in a specific county or zip code. This is intended to allow local governments to locate transmission pipelines within or near their communities and to determine areas that could be impacted by releases from these pipelines. PHMSA will provide raw NPMS geospatial data to county and state officials upon request – (PHMSA, Office of Pipeline Safety, Oct., 2010, p 10).

[7] DFDS: Dual-feed, Dual service lines; DREGS : tap lines to distribution regulators; STUB: Stub pipes for future connections. Locations of these ancillary pipes and structures is not shown.

Transmission Line ID	Starting Mile Point	Ending Mile Point	Year of Construction	Pipe Diameter in Inches	Segment Length in Feet	Pipe Wall Thickness	Coating	Girth Weld	Joint Type	% SMYS @ MOP	SMYS	Seam Type	MOP (psig)
210 A	**9.7700**	9.9433	1965	32	915	0.360	HAA	Arc	Butt	48.2	60000	DSAW	650
210 A	9.9433	10.1332	1965	32	1465	0.360	HAA	Arc	Butt	48.2	60000	DSAW	650
210 A	10.1332	10.4313	1965	32	2302	0.360	HAA	Arc	Butt	48.2	60000	DSAW	650
210 A	10.4313	10.9300	1965	32	3849	0.360	HAA	Arc	Butt	48.2	60000	DSAW	650
210 A	10.9300	10.9300	1965	32	8	0.360	HAA	Arc	Butt	36.1	60000	DSAW	650
210 A	10.9300	11.2300	1965	32	1573	0.360	HAA	Arc	Butt	48.2	60000	DSAW	650
210 A	11.2300	11.2300	1988	32	3	0.360	HAA	Arc	Butt	48.2	60000	DSAW	650
210 A	11.2300	11.2600	1988	34	279	0.562	HAA	Arc	Butt	32.8	60000	DSAW	650
210 A	11.2600	11.2600	1988	32	3	0.360	HAA	Arc	Butt	48.2	60000	DSAW	650
210 A	11.2600	12.0000	1965	32	3937	0.360	HAA	Arc	Butt	48.2	60000	DSAW	650
210 A	12.0000	12.1700	1965	32	937	0.360	HAA	Arc	Butt	48.2	60000	DSAW	650
210 A	12.1700	12.3800	1965	32	1104	0.360	HAA	Arc	Butt	48.2	60000	DSAW	650
210 A	12.3800	12.3800	1980	32	14	0.360	PT	Arc	Butt	48.2	60000	DSAW	650
210 A	12.3800	12.6600	1980	34	1588	0.524	PT	Arc	Butt	35.2	60000	DSAW	650
210 A	12.6600	12.6600	1980	32	26	0.360	PT	Arc	Butt	48.2	60000	DSAW	650
210 A	12.6600	**12.8400**	1965	32	950	0.360	HAA	Arc	Butt	48.2	60000	DSAW	650
210B	**10.5300**	10.9800	1949	16	2376	0.281	HAA	Arc	Butt	44.1	42000	SMLS	650
210B	10.9800	11.1600	1993	16	966	0.375	HAA	Arc	Butt	33.0	42000	ERW	650
210B	11.1600	11.1900	1993	20	147	0.375	HAA	Arc	Butt	33.3	52000	DSAW	650
210B	11.1900	11.4500	1993	16	1370	0.375	HAA	Arc	Butt	33.0	42000	ERW	650
210B	11.4500	11.4800	1993	20	157	0.375	HAA	Arc	Butt	33.3	52000	DSAW	650
210B	11.4800	11.5000	1949	16	1079	0.281	HAA	Arc	Butt	44.1	42000	SMLS	650
210B	11.5000	11.5400	1988	16	255	0.375	HAA	Arc	Butt	33.0	42000	ERW	650
210B	11.5400	12.2500	1949	16	4165	0.281	HAA	Arc	Butt	44.1	42000	SMLS	650
210B	12.2500	12.4100	1988	16	924	0.375	HAA	Arc	Butt	26.7	52000	ERW	650
210B	12.4100	12.5700	1949	16	918	0.281	HAA	Arc	Butt	44.1	42000	SMLS	650
210B	12.5700	**12.9900**	1949	16	2583	0.281	HAA	Arc	Butt	44.1	42000	SMLS	650

TL ID - PG&E Transmission Line Name
Coat - Pipe Coating HAA = Hot Applied Asphalt, PT = Polyethylene Tape
Girth Weld - Circumferential weld type A = Arc Weld
Joint Type - Circumferential weld type BUTT = BUTT welded
% SMYS @ MOP - Percentage of Specified Minimum Yield Strength at Maximum Operating Pressure
SMYS - Specified Minimum Yield Strength in psi
Seam Type - Longitudinal Seam Type DSAW = Double Submerged Arc Welded
SMLS = Seamless, ERW = Electric Resistance Welded
MOP - Maximum Operating Pressure of the pipeline in psi.

TABLE 1: Pipeline segment database for Suisun City Highway 12 corridor provided by Charles Lewis of PG&E on 12-21-09

The many segments of pipe in this short portion of PG&E's corridor are probably in part the result of welding and engineering safety standards. Because welding changes the metallurgical and physical (coefficients of expansion) characteristics of steel pipelines beyond the actual areas of the welds, pipeline engineers often require short sections ("pups") to be welded between longer sections rather than merely butting two long sections together. Thus the short sections of 32-inch pipe placed in PG&E pipeline 210A in 1965 and 1988 may have been deliberately installed to provide transitions and reduce friction associated with pipeline bends or valves[8].

[8] US Department of Transportation 49 CFR Part 195, "Transportation of Hazardous Liquids by Pipeline", Subpart F, Paragraph 195.452, "Pipeline Integrity Management In High Consequence Areas."

The Jet Fuel lines operated by Kinder-Morgan for the US Air Force are termed “gathering” lines by the state and federal regulating agencies. Gathering pipelines are generally used to convey locally derived gas and oil to a central point in an oil or gas field. If they are under 8- 5/8ths inch diameter they are *not* subject to FERC, DOT and other federal regulatory safety requirements, usually operate at low pressures, and are generally considered part of a well field (PHMSA, 2010). Operating pressures obtained through discussions with a Kinder-Morgan representative were 200psi static and 400psi when pumping. The US Department of Transportation (DOT) regulates all “low stress” gathering pipelines through its PHMSA (Pipeline and Hazardous Materials Safety Administration). The regulations are under revision to better protect wetlands and sensitive habitats but low-pressure hazardous liquid fuels are not generally considered as a public safety hazard, even in “High Consequence” urbanized areas. This subject is discussed further under the section of this report titled “Regulatory Concerns”.

These jet fuel pipelines are also called “receipt” pipelines (Receipt Pipeline (A-2228-1/2, and A-27351) on the Navy Corrosion Control Incorporated 2009 Cathodic Protection Report performed for the Air Force (Corrpro, 2009). That report states that *“…receipt pipelines are 53 years old… casings at Lawler Ranch and Grizzly Island are filled with water and should be drained and sealed…”* and recommends that *“due to depth of burial and positioning between the highway and wetlands, the repair would be difficult and costly”.* They further state that the pipeline from Suisun City to the Air Base will be decommissioned once replacements are in place elsewhere. A small portion of a figure from that report is included in this report as Plate 1 (p.31) indicating that the “pipe (is) behind fence in yards of houses”. Anthony Moscarelli reports in January 2011 that the new 20-inch jet fuel pipeline is behind schedule and has been installed only from the Air Force base to Walters Road near the edge of the base at this time. It thus does not yet replace any of the jet fuel lines that pass through the Suisun High Consequence Area along Highway 12.

Jet Fuel transported to Travis Air Force Base through Suisun City is refined kerosene. It is a hazard Class 3 substance (flammable liquid) which carries the following warnings: *Handling and Storage*: ***Precautionary Measures:*** *Liquid evaporates and forms vapor (fumes) which can catch fire and burn with explosive force. Invisible vapor spreads easily and can be set on fire by many sources such as pilot lights, welding equipment, and electrical motors and switches. Fire hazard is greater as liquid temperature rises above 85F.*

Pipeline Materials:

The original liquid fuel lines were coated with a coal-tar coating. According the California State Fire Marshal (1993, 1997), a statistical analysis of historic failures and repairs of statewide pipelines found that such older protection coatings yielded essentially the same failure rates as bare steel pipe. The bare pipe external corrosion rates in this multiple-regression analysis had 11.77 incidents per 1000 mile-years while coal tar or asphalt enamel wrapped pipelines had 11.59 incidents per 1000 mile-years. These compare with incident rates of 1.58 for mill (factory) -applied tape. The natural gas pipelines constructed prior to 1980 are coated with hot applied asphalt, and that coating characterizes over 92 percent of the 2^{+}-mile tabulated high-consequence area pipe lengths. Only 7.7 % of the pipe is noted as "polyethylene wrapped".

Corrosion:

Corrosion of pipelines may occur from many causes. Pipeline operators must monitor and avoid buildup of corrosive acid fluids or chemicals that may damage pipe materials and must protect pipes from external rusting and other soil corrosive conditions. Pipelines are constructed of "high carbon" steel primarily for strength. High carbon steel is not stainless steel and is subject to chemical alteration by both conveyed fluids and external environments. Corrosion may be both internal and external. The PHMSA Gas Integrity Performance Measure Reports, seen at http://primis.phmsa.dot.gov/gasimp/performancemeasures.htm present corrosion statistics that have been reported to that agency between 2004 and 2009. A third class of corrosion-like pipeline damage is caused by stresses such as over-pressurization, subsidence, or tectonic forces. These are often classified as Stress Corrosion Cracking (SCC) (ASME, 2008).

A 2006 geotechnical report for a proposed Wal-Mart Supercenter near the southeast margin of our study area presented a commissioned corrosion susceptibility report (Karn and Associates, 2006). The soils of that proposed development site are the same as those of the eastern pipeline corridor. That report stated:

"The soils at the project site are considered to be "corrosive" to ductile/cast iron, steel, and dielectric coated steel based on the resistivity measurements. Therefore, corrosion control in the form of coatings and cathodic protection is warranted for all buried metallic pressure pipelines…. All underground pipelines should be electrically isolated from above grade structures, reinforced concrete structures and copper lines in order to avoid galvanic corrosion problems."

Cathodic Protection:

Pipelines laid in soils in and near wetlands and filled wetlands are particularly susceptible to corrosion and must be well-protected. Pipeline coatings have long been used to reduce corrosion but by their very nature, long metallic conduits may conduct electrical currents that lead to molecular breakdown of the steel. The preferred method of protection against breakdown of pipeline materials is by the application of an electrical current to the metallic pipes, valves, supports, and associated metal tanks that provide electrons in excess of any electrical imbalances to neutralize charge-related corrosion. This is done with *cathodic protection.*

The corrosion process occurs with the removal of electrons (oxidation) of the metal and the consumption of those electrons by some other reduction reaction, such as simple oxygen-reduction of iron. $Fe \rightarrow Fe^{2+} + 2e^-$ $O_2 + 2H_2O + 4e \rightarrow 4OH^-$ This is the familiar rust reaction where the corroding iron oxidizes. The excess electrons have to be absorbed somewhere, which in the above case creates 4 hydroxyl ions. The strategy of cathodic protection is to supply an electrical charge that prevents that oxidation-reduction potential reaction from progressing. This charge must counteract the natural tendency of any metal to achieve a lower free-energy state. It takes much energy to reduce iron ore to metallic iron in a smelter, and the more energy it takes, the more unstable, at surface temperatures and humidity, will be the resulting metal. Corrosion of a metal in the presence of an oxidant will occur if the reduction potential of the metal is less positive than the potential of the oxidant. For example, oxygen can corrode (reduce) iron easily but cannot reduce platinum or gold.

The U.S. Army Corps of Engineers has released a manual on cathodic protection that provides an excellent simple summary of the two primary strategies that supplement pipeline coatings (US ACOE, 2004). In the following direct excerpt, CPS is an abbreviation for Cathodic Protection System:

> *General. USACE uses CPSs in combination with protective coatings to mitigate corrosion of hydraulic structures immersed in fresh, brackish, or salt water. Protective coatings alone generally cannot offer complete corrosion protection because they usually contain some pinholes, scratches, and connected porosity, and over time these imperfections become increasingly permeable. As coatings degrade with time, these imperfections, commonly known as holidays, have a profound effect on overall coating integrity because of underfilm corrosion. CPSs, when used in conjunction with protective coatings, have been effective in controlling corrosion. CPSs consist of anodes that pass a protective current to the structure through the electrolyte environment. CPSs can be one of two types, sacrificial anode or impressed current anode. Hybrid CPSs installed on structures can include both types of anodes to provide protective current.*
>
> *(1) Sacrificial CPSs. Sacrificial CPSs, also referred to frequently as galvanic CPSs, employ sacrificial anodes such as specific magnesium- or zinc-based alloys, which are anodic relative to the ferrous structure they are installed to protect. This inherent material property enables sacrificial anodes to function without an external power*

source, so they generally need very little maintenance after installation. However, by design, sacrificial anodes are consumed by corrosion during their service life and must be replaced periodically in order to ensure continuing protection of the structure. Therefore, these anodes should be installed in accessible locations on the structure. Sacrificial anode CPSs are generally recommended for use with a well coated structure that is expected to be well maintained or subjected to a minimum of damaging wear during its design life. (Note that in this EM the terms "sacrificial" and "galvanic" may be used interchangeably.)

(2) Impressed current CPSs. Impressed current systems employ anodes that are made of durable materials that resist electrochemical wear or dissolution. The impressed current is supplied by a power source such as a rectifier. All impressed current CPSs require periodic maintenance because they employ a power supply and are more complex than sacrificial systems. However, impressed current CPSs can be used effectively with bare or poorly coated structures because these systems include much flexibility in terms of the amount of protective current delivered and the ability to adjust it over time as conditions change.

It is this *impressed current option* that is used along the Highway 12 corridor through Suisun City by both PG&E and the Air Force.

The two PG&E natural gas regional transmission lines are cathodically protected together. The operator indicates (personal communication Charles Lewis of PG&E to Mr. Moscarelli, 2010) "*the rectifiers and anodes are located outside of the study area. There is one pipe-to-soil potential monitoring station located within the study area. This station is located at Village Drive and Highway 12."* Mr. Lewis indicates that the pipe-to-soil (P/S) potentials are checked every 2 months. He forwarded a tabulation of test potential readings at 2-month or less intervals. The testing appears to be careful, with retesting a day later when readings vary by about 100 millivolts or more from that of the prior reading. The rectifier for the impressed direct current is reported to be in Cordelia, which is a location along the gas transmission line about 8 miles west of the Village Drive monitoring point where there is a gas line pumping plant.

The jet fuel lines are protected by cathodic systems and the cathodic electrical current can be monitored at more closely-spaced intervals than can the PG&E gas lines. Within the 2^+-mile study section there are reported to be 12 jet fuel line test points where impressed current values can be measured. The data supplied by the military base in response to FOIA requests (Corrpro, 2009) indicates that cathodic potential test station #10 at Lawler Road and station #7 at Grizzly Island crossroad had casings that were filled with water. This was interpreted because both the casing and the pipeline had similar high negative amperage readings, indicating that current was flowing between them. The Jet Fuel lines are surrounded with a casing at only three locations, and only one (test station 12 where the pipeline crosses under Highway 12) had electrical readings made in 2008 and in 2009 that indicate that its seals may still have been in-tact (Corrpro report, App. G.).

The 2009 Corrpro report on cathodic protection of the jet-fuel lines is helpful because it discusses how these pipelines are protected. This report focuses on the Air Force base pipeline system, but also includes discussion of conditions in the Highway 12 corridor. The following is a direct quote:

> *The transfer line cathodic protection system includes the receipt line from Kinder Morgan, and the issue/receipt pipelines in bulk storage. The transfer pipelines were provided with coal tar coatings when originally constructed. The first cathodic protection systems within the base were installed on the receipt line between the offsite marina and the meter station on base. An impressed current cathodic protection system was installed near the South base access gate in 1956, with an oil-cooled 36 volt – 50 ampere rectifier and a point surface anode bed. An impressed current cathodic protection system was also installed at the meter station in 1956. This system consisted of a 20 volt – 20 ampere air cooled rectifier with a point surface anode bed. The receipt piping at that time included the 8 inch diameter jet fuel line and a 6 inch diameter avegas line. Santa Fe Pipeline operated the receipt lines at that time, and actually installed the cathodic protection systems in 1956. The receipt lines and the transfer lines were electrically isolated at the Marina station and the meter station. A bond box installed in 1956 tied the pipelines together to prevent interference. In 1971, an impressed current cathodic protection system was installed on the extension to "G" pumphouse. This cathodic protection system consisted of a 48 volt – 20 ampere rectifier with a point surface anode bed.*
>
> *In the early 1980's, the section of 8 inch diameter jet fuel receipt line was replaced between the marina manifold and Highway 12. When the section of pipe was replaced, it was afforded test stations and galvanic anodes. The 6 inch diameter avegas pipeline had been taken out of service, and was capped at Highway 12. In 1997, the 8 inch diameter jet fuel receipt pipeline along Highway 12 was replaced, to accommodate road widening. The new pipeline was provided with ten (10) cathodic protection test stations, five (5) of which were at cased road or stream crossings. The new pipe was welded to the line replaced in 1980 on the west end, and to the original 1956 pipeline at the intersection of Highway 12 and Woodlark Road. The cathodic protection systems installed in 1956 remain in operation. The cathodic protection system at pumphouse G was taken out of service in 2006. The transfer lines to pumphouses B, C, G and H were bonded into the cathodic protection systems as they were constructed. In 2008, the fuel lines were electrically isolated at pumphouses 705 and 708, and bonded together. The issue lines from the tanks were also bonded in the vaults.*
>
> *Jet fuel is received at Travis Air Force Base via an 8 inch diameter pipeline which originates off site near the marina in Suisun City. Kinder Morgan Pipeline Company provides the jet fuel for the base, at a valve station near the marina. The 8 inch diameter receipt line parallels Highway 12, and enters the base near the South shipment receiving gate. The pipe then runs across base to a manifold on Ragsdale Road, which is operated by Kinder Morgan. The offsite receipt line is owned by the base. The jet fuel is then received in an 8 inch diameter pipeline at*

the manifold in bulk storage. In 2008, markers were installed on 500 foot centers along the receipt line, and at each test station and road crossing.

The Corrpro description of the route of the pipelines differs somewhat from the more detailed description that is included in the August, 2001, Naval Engineering Facilities Service Center, Pressure Test Report TRA-01-11 by Worley International. That report describes the JP-8 pipeline as a 6.88 mile 8-inch pipeline that receives aviation fuel (JP-8) from a Kinder-Morgan facility located at Concord, California through an existing interconnection with a Kinder-Morgan 20.5 mile 8-inch pipeline at Suisun City and delivers product to bulk storage at Travis Air Force Base. It goes on to describe the route of the delivery as *"travel[ing] north from the Kinder-Morgan facility at Suisun City, California, under paved roads and through commercial and residential areas. It crosses north under Driftwood Drive, crosses Lotz Way, bends east across Civic Center Boulevard, crosses through the edge of Marino Shopping Center, and runs in an easterly direction on the south side of Highway 12 until it reaches Woodlark Drive Subdivision. At this point the pipeline crosses Highway 12 in a northeasterly direction, enters the Woodlark Drive Subdivision, crosses Fulmar Drive, then turns south and crosses Peterson Road (also known as Scandia Road). The pipeline passes through numerous valve pits containing low point drains and high point vents and mainline block valves. Upon reaching the shoulder of Peterson Road the pipeline turns and runs east approximately 1.3 miles until it enters near the South Gate of TAFB."*

Assessing Risks

We assessed risks to this short 2^+-mile-long section of pipelines using the following tools and analyses: 1) historical information on local pipeline leaks and repairs, 2) statistical information from world-, national-, and state-wide sources on failure rates and modes, and 3) anecdotal and public record information on responsiveness of operators to local public concerns.

Risk is a concept that describes and measures the combination of the likelihood of a negative outcome and the severity of consequences that result from that outcome. The higher the risk number, the more "risky" is the combined likelihood *and* severity of a particular event.

Likelihood is measured as *probability* (a number between 0 and 1 that represents the chance of some consequence occurring) or as *frequency* (a number that represents how many times a consequence occurs during a fixed time period).

Consequence is measured in a variety of ways, depending on the nature of the consequences being considered. For example, if the consequences involve human health or safety, then consequences may be measured by fatalities or injuries. If consequences involve environmental damage, they may be measured by the cost required to repair the damage and restore the affected environment (adapted from PHMSA Stakeholder Communication on Risk Assessment).

We must remember that the widely touted pipeline industry information on the safety record of pipelines in the United States is based on a largely rural pipeline system. There is no question that hazardous liquid transportation by pipeline is far less subject to disastrous failures than are other modes of transportation such as tanker trucks, or ships, but we also must consider that when a failure occurs in an urban area, the consequences are often greater than would be expected based simply on frequency of failures. Quantification of measures of risk and consequence often result in very non-intuitive data and measurement units such as the recent US onshore pipeline transport volume figure of "*3.9 trillion barrel-miles per year".*

Historical Incident Studies:

There have been several recent studies that try to assess pipeline transport risks. Among these is a contemporary analysis of nationwide risks prepared by the Office of Pipeline Safety of PHMSA[9]. This study focused on onshore gas and hazardous liquid pipelines. This and other US domestic studies are based on "incidents" reported to PHMSA (see Definitions, Appendix C). These data are accessed here. There are three classes of "incidents" where *serious, significant*, and simply *incident* each have specific threshold definitions based operator-reported costs, injuries, fatalities and hospitalizations. A different approach to risk assessment was prepared in 1996 for the same Office of Pipeline Safety by the Federal Emergency Management Agency (FEMA). This report attempts to look only at *natural* hazards such as earthquakes, landslides and hurricanes as they may affect hazardous pipelines. A comprehensive statistical approach was presented by the State of California Fire Marshal's office in March of 1993 based on multiple regression analyses of pipeline leak and failure data for California for the decade of 1981 to 1990. A similar regression study in California looked at low-pressure crude oil pipelines and concluded that the incidence rates were similar to higher pressure transmission lines (Calif. Fire Marshal, 1997).

Additional analyses of "incidents" can be found in many publications such as the 2010 PHMSA study [Regulatory Analysis - Rural Onshore Hazardous Liquid Low-Stress Pipelines (Phase 1)], as well as in the U.K. (Hill, 1995), the Netherlands (TNO, 1982) and Canada (Stephens, 2000). PHMSA tabulates national pipeline mileage of various types annually and those data are available here. There are no sophisticated mathematical manipulations that need to be performed to convert statistics on incidents to future probabilities. All of the sciences calculate probability in similar well-defined fashions. Even the insurance industry uses the same math (Grossi and Kunreuther, 2005).

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9 PHMSA, October, 2010, Building Safe Communities: Pipeline risk and its application to local development decisions.

The California Fire Marshal's contracted statistical study attempts to present data on as many variables of pipeline characteristics as can be determined from records and to compare those with "incident" rates on those pipelines. Obviously, older pipelines may have more causes of failure or leaks, both because the pipes have been in the ground longer and because standards are higher for pipes laid more recently. Separating these two factors is an example of a goal of multiple regression analysis.

The 1993 California Fire Marshal Hazardous Liquid Pipeline assessment looked at leak data for 7800 miles of regulated in-state liquid pipelines based on data from 1981 through 1990. The results were presented in term of incidents per 1000-mile years. The range of results were tabulated in order of increasing severity to reveal an incidence of reported leaks of any size of 7.1 incidents per 1000 mile years up to 0.02 to 0.04 fatalities per 1000 mile years.

The primary findings indicate that there was an approximate 7 percent reduction in leak rates per year during the decade of the 1980's. The study also concluded that pipelines located within 500 feet of a rail line do not pose a higher risk than those located father away, that external corrosion cause 59% of the leaks followed by third party damage causing 20% of the leaks and that older pipelines operated at increased temperatures had the highest incident rates.

A significant finding pertinent to the current study that follows from the California Fire Marshal study was that incident rates are over 3 times greater within Standard Metropolitan Statistical Areas (SMSAs) in comparison to those outside of those areas. This may in part be an artifact of likelihood of reporting the incident and in part because pipelines in such areas have a higher incidence of third-party damage.

Past pipeline leaks:

No known leaks have been reported on the primary PG&E gas transmission lines within the Highway 12 study corridor. PG&E conducts surveys on both its lines annually in this suburban area. The following leaks were found in those annual surveys. A minor 2-inch "upstream tap valve" leak was reported in 1999 near Laurel Creek near the western end of the Highway 12 project, and 2 minor above-ground leaks were reported near Woodlark Drive cross-street at Highway 12 in 2009. One of these was reported to be a leaking closure (valve) on an above-ground blow-down stack. The other was a pinhole leak on an above ground pipe nipple. The leaking closure valve was removed in 2010 as part of a project to retrofit the main pipelines to accommodate in-line inspection (ILI) "Smart Pigs". That work has been completed. The 1999 leak was "eliminated" by lubricating the valve. According to PHMSA, a release of gas that can be eliminated by adjustment, lubrication or tightening *and* is <u>not hazardous</u> is not a reportable leak.[10]

PG&E maintains leak survey logs. One method of responding to reported possible leaks is to probe with an instrument such as a "*Sensit CGI*" hand-held device that detects various gases, including blended natural gas. The detector is placed over a probed hole in the soil and reads a concentration value for the chosen gas. In 2010 Anthony Moscarelli reported a methyl mercaptan smell in his yard about 25-feet from one of the pipelines, and it was promptly reviewed by PG&E field personnel who confirmed that there was no evidence of a natural gas leak.

The jet fuel lines have had leaks within the Highway 12 corridor also. A Utility and Site, Inc. contracted worker working for AT&T opened a utilities vault at Highway 12 and Lawler Ranch Parkway on February 24, 2009 and detected a strong odor. Upon looking down into the vault he saw a standing fluid a few feet deep. He moved away from it and made an 811 telephone call to find who owned pipelines at that location. The 811 operator told him that there were not any pipelines listed at that location. He made multiple phone calls before he contacted the Suisun City Fire Department. The Fire Department contacted Travis AFB and they responded. The same contract worker, who asked to remain anonymous, provided this information to Anthony Moscarelli that day. Plate 2 of this report shows the relationship between the telephone utility vault and the jet fuel line.

It was ultimately determined that a ball-valve had leaked the jet fuel, partially filling the jet-fuel valve vault and the adjacent utility vault. The jet fuel migrated into the storm drain system that drains southward toward tidewater. Initial responses and investigations concluded that the spill was limited and that pumping from the storm drains had been able to collect all spilled fuel within about a two month period. J.T. Baker was called in by Kinder-Morgan to remediate the site of the spill after their drilling demonstrated that soils were contaminated as well as storm water in the drain. The Baker remediation report (2010) was completed May 10, 2010 after drilling and monitoring began in March 2010, more than a year after the release occurred,

Baker's remediation plan focused on recovery or immobilization of the free-phase liquid jet fuel that contaminated the Highway 12 right-of-way, the neighboring

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[10] PG&E classifies leaks as Grade 1 through Grade 5 leaks. Grade 1 leaks (also referred to as "hazardous" leaks) represent existing or probable hazards to persons or property and require immediate repair or continuous action until conditions are no longer hazardous. PHMSA classifies *reportable leaks* as those that must be reported within 30 days per FORM PHMSA F 7100.2 (01-2002). The criteria for reporting are seen in the instructions to operators at: Trans_incident_instructions.pdf. These criteria are changing.

subdivision homes, and the storm drain. Continued monitoring will be necessary to establish that contamination is remediated.

Repairs and replacement of pipeline sections:

PG&E has followed its protocols with annual inspections and is or has just completed upgrading its transmission pipelines to allow smart pigging. Until that is successfully completed and proven to be effective, the alternative of visual and surface inspection (Direct Assessment) of the pipeline route will be necessary. The adequacy of this allowed method remains controversial. PHMSA regulations allow for three legally acceptable methods of integrity management, including Direct Assessment. In all cases the pipeline operator must conduct a pre-assessment to evaluate the threats to the pipeline and to select an assessment method best suited to the particular threat. This circular logic requires knowing what the threats may be before you assess their risk. In other words, the pipeline companies must know what threats their lines face before selecting an inspection method to find them.

Kinder-Morgan is behind schedule to replace its Highway 12 corridor line with a new connection from its 950 psi LS-25 line between Concord and Sacramento along Highway 80. That 20-inch line is reported to be operated at 80% of its maximum safe rating (SMYS). Kinder-Morgan is aware that its Highway 12 lines are old and past due for replacement. Based on the cooperation Mr. Moscarelli has received from PG&E, they too may be aware of risks to their local gas transmission facilities.

The Pipeline Safety Trust has compiled a record of 19 PG&E transmission line incidents between 2002 and the end of 2009. There were two injuries, no fatalities, and the majority of incidents were caused by third party accidents such as inadvertent back-hoe operations (Pipeline Safety Trust). One fatality and 8 injuries were reported involving PG&E distribution lines between 2004 and 2009. These data are all from the PHMSA database. Those spreadsheets are very large to accommodate all the reported variables, and their analysis was beyond the scope of this modest study. The only incident reported by PG&E for 2010 was the San Bruno gas line explosion that killed 8 and injured 51.

Failure probabilities and Risk Assessment

We are aware that this study is being conducted during a period of active upgrading of pipeline facilities at the study site. We are also acutely aware that public concern over the PG&E transmission pipeline system in California and gas transmission throughout North America has led to legislative and internal efforts to improve public health and safety. The fact that a major pipeline explosion with 8 fatalities happened at San Bruno near PG&E's San Francisco headquarters on September 9th, 2010 during the course of this Suisun City safety study heightens the timeliness of this very modest investigation.

The California Fire Marshal's statistical analyses covered only hazardous liquid pipelines, and excluded so called "gathering" lines, which is the classification of the present low-pressure Kinder-Morgan jet fuel lines. The San Bruno explosion greatly affects the statistical validity and ranking of PG&E's record of incidents. One can argue that only the long-term record for PG&E transmission pipelines should be considered and that the San Bruno event was a statistical outlier. However, the similarities between that San Bruno pipe and the Suisun City Highway 12 corridor are enough alike to merit serious considerations. Both areas have pipe segments installed in the middle of the last century in areas now urbanized. Both carry high pressures. Both are characterized by many short sections of girth-welded seams and double-submerge welded primary longitudinal seams. We do not know about transient pressure surge characteristics of the larger Suisun pipeline but its operating pressures are higher (650 psi vs 400) and the asphalt coatings are similar, as would be expected for pipelines of that age.

On the positive side, PG&E has been responsive and has anticipated public concerns about the Suisun system. Their data base on pipeline conditions appears realistic for Suisun, and their pipeline staff has been open with information exchange. All this happened before the San Bruno failure. One suspects that the PG&E internal rankings of risks to portions of their transmission system include the urbanized portions of the Suisun Highway 12 corridor.

What we know about the contemporary maintenance levels of both Kinder-Morgan and PG&E pipelines within the Highway 12 corridor argue that comparisons to San Bruno are only superficial. Further work is necessary to establish what, if any, automated shut-down systems exist in and near Suisun City, and what response time and procedures would be in the event of a pipeline failure along Highway 12. Emergency valves, pump stations, and safety communication systems need to be evaluated in a fashion that meets Homeland Security concerns while still providing local governments, emergency personnel, and citizens with assurances that gas and fuel transmission line systems can continue to be good neighbors for the remaining 6 or more decades of fossil fuel availability.

Emergency Response Access:

Inquiries by local resident Moscarelli have provided the following information:

City of Suisun City's Emergency Response Plan

The Suisun City Fire Department (SCFD) consists of three paid staff with responsibility for the management of the Department including the Fire Chief and two Fire Captain - Station Officers. Forty-five dedicated volunteers staff one engine 24 hours per day 7 days per week with a minimum crew of three. Most nights and weekends are staffed with four to eight volunteers (Officers and Firefighters), who are available to respond to the community's needs.

The Suisun City Fire Department is staffed to provide fire protection and emergency services to the residents of Suisun City. The department contains two divisions: Fire Operations and Emergency Preparedness. Service areas include fire suppression, emergency medical response, and fire prevention, as well as preparation for and response to natural and human-caused disasters. The Department also responds to public assist calls, supports public educational programs in the City's schools and manages the public nuisance weed abatement program within the City.

Anthony Moscarelli asked the Fire Chief about having a formal emergency plan available for pipeline incidents. He was informed that there was not any formal plan other than to evacuate the area. He was told that even that eventuality was not in formal form.

The SCFD station location is at 621 Pintail Drive. Pintail Drive runs parallel to and north of Highway 12. The SCFD station on Pintail Drive is an estimated 1840 feet north of the PG&E pipelines. Pintail Drive runs parallel to the PG&E pipelines with the eastern end about 1905 feet north and at the western end about 1385 feet. Pintail Drive is one of two main egress points from the housing sub-divisions north of the PG&E pipelines. In a recent 2007 traffic study Pintail Drive was rated 'C' in an A-F traffic rating with 'A' being the best. The 'C' rating is based on a two lane residential street with no turn lanes. Left turns hold up traffic. The housing sub-divisions north of Highway 12 have eight other ingress or egress points in 3.05 miles that feed into Highway 12. The sub-divisions streets mostly feed into Pintail Drive as an evacuation route from the Highway 12 area.

Any emergency incident related to the PG&E pipelines could effectively block the SCFD access to the affected neighborhoods. In certain conditions residents attempting to leave could block Pintail Drive and almost any accident scenario would result in closure of Highway 12.

The subdivisions south of Highway 12 could also be affected. They are within the possible blast radius of a natural gas explosion. Lawler Ranch Parkway is one of three main exit points from the housing subdivisions to the south of the PG&E pipelines. Lawler Ranch Parkway's two main exit streets feed into Highway 12. There is one other exit street that is also a 'C' rating type that parallels Highway 12. Lawler Ranch Parkway runs parallel to the PG&E pipelines with the eastern end being about 1270 feet south and the western end an estimated 2520 feet away.

San Bruno's 2010 pipeline blast destroyed homes up to 600 feet from the point of the explosion. Measurements show that homes were also destroyed up to 180 feet away at 90 degrees from the direction of the blast. This pipeline operated at almost 60% of the pipeline pressure that is in the Suisun City Corridor. It is realistic to assume that it is possible for greater damage in Suisun City in a worst case scenario.

Conclusions:

If one considers the 2010 San Bruno pipeline explosion that killed 8, injured 51 and is estimated to ultimately result in $763 million in damages for PG&E as having a 2 percent chance of occurrence in 100 years for short sections of natural gas transmission pipelines of ages 50 years or older, then the Suisun City Highway 12 corridor 3 mile-long may have about a 1 percent probability of failure in any given year. Statistical estimations are hampered because we do not know how much of the San Bruno section of pipeline was in similar condition, nor do we know how much or little maintenance and inspection had been performed in the past decade. The Suisun City pipeline corridor will soon become less hazardous when the aviation liquid fuel lines are retired and if automatic shutoff valves are moved closer to that city for the gas lines, that may further reduce hazards. Such shutoff valves would at least allow firefighting crews to enter the area earlier and possibly save more lives.

This study has raised as many questions as it attempted to answer. Appendix B outlines some of these questions. The fact that issues of pipeline safety are being questioned and that PG&E is cooperative in working with the public to address those questions strongly argues for increased safety and public awareness. If the jet fuel lines are indeed moved and if they do not simply shift the hazardous liquids risk from one urban area to another, this risk will be reduced in the near future. It is well to remember that neither pipeline operator deliberately placed their pipelines in small metropolitan High Consequence Areas. The environmental impact process that was presumably in effect at the time of the city annexation of the pipeline corridor lands should have brought this risk to the attention of the public. A newly developing regulatory environment may be able to change this public awareness and municipal responsibility problem.

APPENDICES

APPENDIX A:

Regulatory Concerns:

An excellent congressional staff summary of the inconsistencies and incomplete regulation of hazardous materials pipelines in the United States was prepared for hearings before the House Committee on Transportation and Infrastructure, Subcommittee on Railroads, Pipelines and Hazardous Materials in June of 2010.

That subcommittee hearing focused on the question of which pipelines are regulated; which pipelines are exempted from regulation; and any gaps that may exist in the current statutes or regulations (US House of Representatives, 2010).

On February 1, 2000, in the wake of several pipeline ruptures, the Pipeline and Hazardous Materials Safety Administration (PHMSA) issued a final rule requiring pipeline operators to evaluate the potential consequences of failure of their pipeline segments that could affect a *high consequence area* (HCA), and set priorities for inspecting, operating, and maintaining the pipeline based on whether people, property, or the environment might be at risk should a pipeline failure occur. According to PHMSA, pipeline segments that could affect an HCA represent about 44 percent of the total hazardous liquid pipeline mileage in the United States.

High Consequence Areas (HCAs) are regulated by PHMSA and are undergoing further regulatory review as this is written. The numerous exceptions to regulation of hazardous liquid pipelines are focused on a complicated and virtually unenforceable set of conditions that attempt to judge the degree of hazardousness of a pipeline segment based upon a large number of factors including what it is near, how many people it may affect if it ruptures at various points in time, the diameter of the pipe, the sensitivity of habitats, and the degree of urbanization and number of other pipelines surrounding it. The proposed regulations can be viewed at the following PHMSA website. Basic analyses of past pipeline failures and explosions in the US and Canada have resulted in recommended setbacks that may limit fatalities (Stephens, 2000). These data and analyses are based on pipeline diameters and operating pressures carrying natural gas and has been reduced to a simplified safety radius around many transmission pipelines of 660 feet for pipelines of 24-inches diameter or greater. This safety radius is not practical for areas like the Highway 12 corridor where residential developments and shopping centers are already less than 660 feet away. Some commercial facilities are within 50 feet of hazardous pipelines.

This kind of condition is not uncommon in the U.S. and PHMSA has now required that pipeline segments that are potentially hazardous within HCAs be identified by the operators. After they are identified, the operator is required to comprehensively assess the structural integrity of those pipeline segments that could affect HCAs, using a variety of assessment methods determined appropriate by the operator. Based on these assessments, operators must take prompt action to repair any defects that could reduce a pipeline's integrity. Integrity management assessments (IMAs) must be performed at least once every five years. In practice, identification of potentially hazardous pipeline segments is being based on the specified minimum yield strength and the operational history of that pipeline segment within the past 5 year period. Public concern is currently being expressed that those structural integrity assessments could in-part be met by spiking pressures for brief periods to establish a record of use at pressures closer to the theoretical maximum operating pressure limits[11]. In general, pipelines are operated at only 50 percent or less of their rated MOP. Such activities to reduce costs of integrity assessments have not been verified by any responsible agency or the pipeline operator.

No method of assessment of structural integrity is foolproof. Static pressure testing using a non-compressible fluid such as water is considered the most reliable method but pinhole leaks can still escape detection, especially in older pipelines that have corrosion byproducts such as rust flakes or wax residues within the test sections. Such testing is very expensive, requiring shut-down of the pipelines, and disposal of the water pumped into the pipe after testing.

According to PHMSA as reported in the 2010 House hearing on the Safety of Hazardous Liquid Pipelines, the first round of operator-performed assessments was completed in February 2009. U.S. pipeline operators reported that they made 31,855 repairs to hazardous liquid pipeline segments that, if left unaddressed could have affected HCAs. Of those, 6,831 defects were considered to be so serious that immediate repair was required under the regulations; another 25,024 hazardous liquid defects had to be repaired within a 60- to 180-day time period. An example of an immediate repair would be wall loss of more than 80 percent. Certain dents (by size) must be repaired within 60 and 180 days, and 50 percent or more wall loss must be repaired within 180 days.

Federal regulations allow pipeline operators to determine the best method(s) of assessing the structural integrity of their pipelines, using one or more of the following three approaches: in-line inspection (ILI), hydrostatic testing, or direct assessment. Alternative assessment methods can be employed if they can be shown to be effective.

ILI, also known as "pigging[12]", is used to detect wall thickness and the amount of corrosion in the line providing the operator with information on operability and safety. Pigs have been an integral part of maintaining pipelines since the beginning of the 20th Century. The earliest devices were basic utility pigs, better known as scraper pigs. Updated versions are still in use today, scraping and scrubbing pipes to remove liquid and solid buildup. For structural integrity analyses we understand that PG&E uses advanced ILI devices, including the

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[11] San Francisco Chronicle, January 11, 2011, report by Jaxon Van Derbeken. ..".. The utility said the spike was 'part of our operating practice,' and that it runs its lines at their maximum once every five years. It did not elaborate on its reasons for doing so".

[12] The tools are called *Pipeline Inspection Gauges,* or P.I.G.s

General Electric "*PipeImage* PIG"[13]. These devices yield a data-stream that can be linked to location along the pipeline and positions in the pipe. In practice, a trained reviewer in the utility's pipeline offices reviews an electronic record of "images" of the full internal circumference of the pipe where a computer-enhanced image is rolled by the viewer representing the smart-pig's progress through the pipe. Welds, corrosion pits, dents, and other irregularities that the computer is programmed to recognize are highlighted and may be studied in more detail.

This author was allowed to observe this process in 2007 in the Gas Transmission Engineering facility at PG&E's regional headquarters in Walnut Creek, California. In routine use, the ILI devices are limited to pipeline sections where pipe bends or valve constrictions are greater than 3 times the pipe diameter. In fact the magnetic flux technology (MFL) can detect corrosion by sensing magnetic leakage and can determine whether the corrosion is internal or external. They can also measure changes in the thickness of the walls. The primary shortcoming is that a majority of older transmission pipelines cannot accommodate smart pigs due to bends, valves, junctions, access points, or other structural constrictions. New technologies are being developed with smaller and smaller diameter ILI devices to permit inspection of existing pipelines that were laid before the present technologies were developed.

Hydrostatic testing involves filling a section of pipe with water and increasing the pressure to a level significantly above the normal operating pressure. Pressure loss in a closed system indicates a leak. The primary purpose of hydrostatic testing is to detect and remove sections of the pipeline that contain defects (including corrosion pits or cracks) by causing them to leak or rupture while the pipeline is filled with water.

Direct assessment involves obtaining information from existing records on pipelines, taking measurements of the pipeline, excavating and examining the pipe, and analyzing post-assessment data. Direct assessment is often the only means of assessment for unpiggable pipelines where an interruption of service would be impractical.

APPENDIX B:

Unanswered questions and further work:

This study identified several areas of continuing concern. Further investigations may answer basic questions such as locations and characteristics of pipeline

[13] No product endorsement is implied. This is simply an example of the technology used in the past by PG&E.

shutoff valves, surge pressure characteristics, safety concerns and operator experience during shut-down to avoid sudden pressure transients (water hammer), and coordination between operators and emergency responders.

Other issues of a broader geopolitical nature that cannot be readily addressed on the local level include the fundamental regulatory problems of so called “gathering pipelines” and “receipt pipelines”. This regulatory classification needs serious reconsideration where it is being misapplied to hazardous fuel lines operated in High Consequence suburban areas. Either the California Public Utilities Commission or a similar regional regulatory or oversight body needs to address Congress to further refine the ongoing reconsideration of both environmental and public safety considerations of pipelines of 8-inches diameter or less.

Finally, local Solano County and Suisun City entities need to cooperate with local residents to insure that future spills and leaks do not lead to contamination of critical San Joaquin River delta water immediately adjacent to Suisun City. The pathway for transport of fuel leaked from the Jet Fuel facilities in February, 2009, has not been definitively determined. The locations of storm drains carrying runoff to the San Joaquin River delta tidewaters along Suisun City should be clearly mapped and the opportunities for transport of fluids through the surrounding drain-rock, as may have occurred in 2009 and 2010 need to be tabulated and made available to State Water Resources Control Board and County personnel.

APPENDIX C:

Definitions:

Incident - An Incident involves a release of gas from a pipeline and:

- A death, or personal injury necessitating in-patient hospitalization; or
- Estimated property damage, including cost of gas lost, of the operator or others, or both, of $50,000 or more; or
- An event that is significant, in the judgment of the operator, even though it did not meet the criteria above.

Leak - An unintentional release of gas from the pipeline that is not an “Incident”. This would include any unintentional release of gas from a pipeline that does not result in an injury, death, or $50,000 or more in property damage. Leaks also exclude those non-Incidents that can be eliminated by lubrication, adjustment, or tightening.

Failure – Failure is a general term used to imply that a part in service:

- Has become completely inoperable; or
- Is still operable but is incapable of satisfactorily performing its intended function; or
- Has deteriorated seriously, to the point that it has become unreliable or unsafe for continued use.
- Note: A Failure does NOT involve a release of gas.

From http://primis.phmsa.dot.gov/gasimp/performancemeasures.htm

HCAs – include unusually sensitive environmental areas (defined in 49 C.F.R. 195.6), urbanized areas, and other populated places as delineated by the United States Census Bureau, and commercially navigable waterways.

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Plates & Drawings

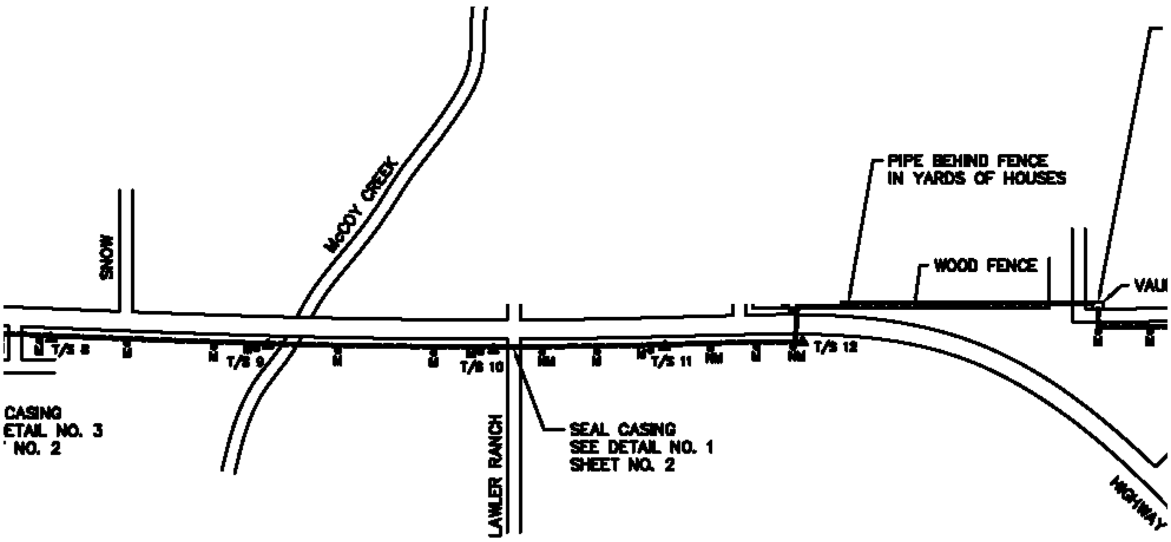

Plate1 - A portion of the JP-8 Jet Fuel pipeline along Highway 12

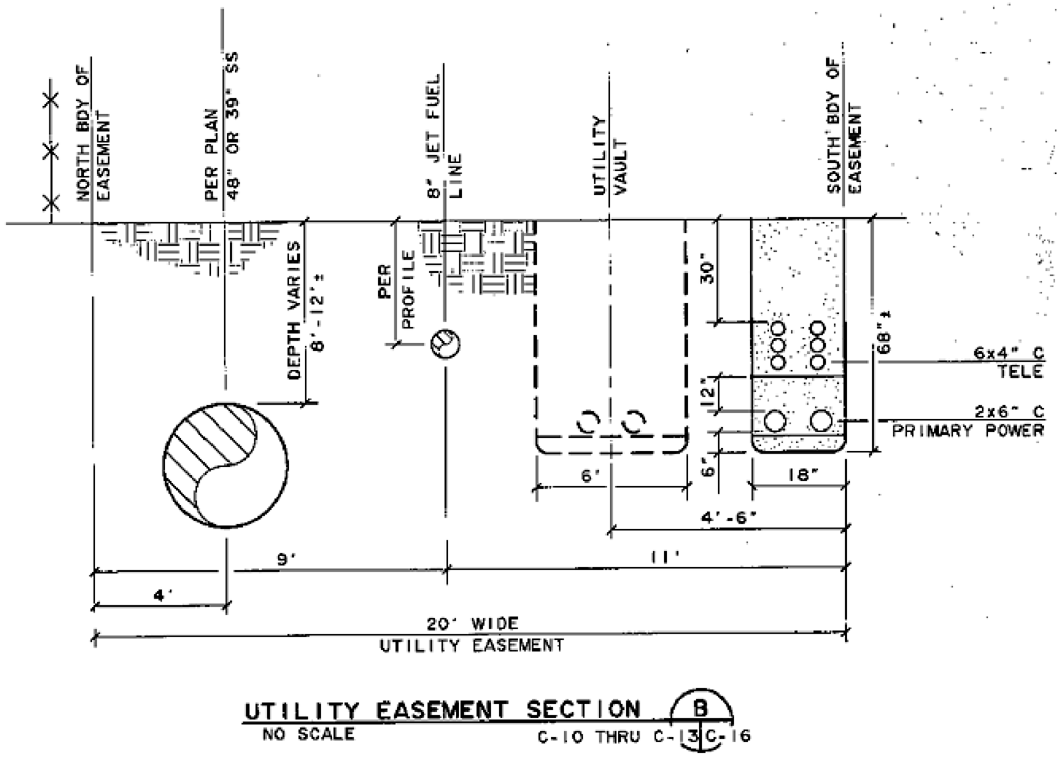

Plate 2. Diagrammatic representation of Right-of-Way on south side of Highway 12. View East. The large pipe is the sewer line; the small pipe is the Jet Fuel line. The distance between the Jet Fuel line and the telephone vault is about 9.5 feet. Figure is from US Navy, 1993, Figure C-16 (secured through FOIA, 2010).

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Robert Curry is the Principal of Watershed Systems, a consulting rubric that he has operated since 1980. This consultancy focuses on Watershed Science which is seen as the interface between geomorphic and geologic processes, surface and groundwater hydrology, and ecologic processes operating at the watershed scale. Curry is an emeritus professor of earth and environmental sciences in the University of California system, having retired from full-time teaching at the University of California Santa Cruz in 1995. While continuing contract research through the UC System after 1995, he helped found and created a curriculum in Watershed Science in the Watershed Institute and Earth System Science at California State University Monterey Bay, where he has most recently taught Water Resources Law and Policy and other watershed and geology courses.

Education

- PhD – Rates and Forms of Mass Wasting and Climatic History of the Sierra Nevada
University of California Berkeley, 1967
- MSc – Geobotany and plant ecology of the Tenmile Range, Colorado
University of Colorado, 1961-62
- B.A. – Geology, University of Colorado, 1960

Registrations

- Professional Geologist – California #3295, 1971
- Certified Erosion Control Specialist - 1980

While employed as a university professor at U.C. Santa Barbara, U.C. Berkeley, and University of Montana, Curry served in numerous federal state and regional government and public service roles. These included Research Hydrologist with the U.S. Geological Survey, Science Advisor to the United States Senate Public Works Committee, and advisor to the Office of the US President's Science Advisor, California's Assembly Natural Resources Committee, several National Academy of Sciences and Engineering advisory panels, and the Ford Foundation funded National Coal Policy Project through Georgetown University. International efforts have included a research fellow status with the French National Academy, several Canadian advisory positions, and an ongoing research and public policy project with the Chilean government agricultural advisory organization FIA. In addition to faculty appointments, other academic roles have included chairing the research programs in the California Water Resources Center for over 10 years, serving as Provost of a U.C. Santa Cruz College, serving as Chair of a Santa Cruz academic department, and founding and directing research for the Watershed Institute at Cal-State Monterey. Public service roles have included Director of Research for the Sierra Club National Office, president of the California chapter of the Society for Ecological Restoration, and help drafting California's Forest Practices Act and U.S. Forest Service cumulative hydrologic effects guidelines.

Professor Curry has earned an international reputation through his work on geologic hazard evaluation, having publicly predicted the failure of the Teton Dam, halted construction of a major dam on the Aconcagua River in Chile based on probable geomorphic and hydrologic effects and seismic hazards, evaluated serious hazards associated with Chinese waterpower development schemes in China and Tibet, and publicly revealed flaws in safety of major projects in Canada (Revelstoke Dam on the Columbia River) and the United States (Richard B. Russell dam on the Savannah River, the Lawrence Livermore proposed BioWeapons Lab; the Diablo Canyon Nuclear Reactor in California, Ramparts Dam and Project Chariot, Alaska). Curry was able to assess the probable causes of the Santa Barbara oil spill of 1969 and evaluated the risk of what later became the 1989 Exxon Valdez disaster in Prince William Sound through the nation's first federal impact assessment in 1970. Through his US Senate advisory appointment, Curry was instrumental in development of risk assessments for the proposed Lyons, Kansas nuclear waste repository and he helped write that seemingly insignificant section of the National Environmental Policy Act in 1969 [§102.2(c)] that requires an Environmental Impact Statement for major federal projects.

Dr. Curry has taught at the University of Alaska, the Geobotanisch Institut at Göttingen, College of the Atlantic in Maine and the University of Montana where he was a professor of geology, hydrology and glacial geology for ten years. Upon accepting the position of Provost at the University of California Santa Cruz in 1979, Curry returned to California and began teaching a wider variety of courses in Geomorphology, Soil Science, Wetland Delineation, Climate Change, Water Resources, Energy Resources, and quantitative environmental sciences.

Professor Curry was elected Fellow of the Geological Society of America in 1977, was appointed co-chair of the Georgetown University's Center for Strategic and International Studies' Coal Policy Project in 1976, and was appointed Provost at the University of California Santa Cruz in 1979 and a Packard Foundation Research Fellow at California State University in 1998. He has published over 100 professional watershed science, cumulative impact, climate history, and public policy papers, is a Registered California Geologist (#3258) and belongs to a wide variety of professional organizations in geological, biological, and ecological fields. After retiring from full-time university teaching, Dr. Curry is now consulting to State and local governments, tribal and foreign governments, and private parties, particularly for complex legal cases. Some of these have been reviewed and supported to the Supreme Courts of California and Montana and federal Courts of Appeal.

Between 1992 and 1996 Professor Curry directed and performed reconnaissance and detailed wetland delineations for the California Regional Water Quality Control Board Lahontan Region from the mountains of the Oregon border to the shores of the Colorado River in the Mojave Desert. He has also evaluated risks associated with hazardous pipelines along the Northern Tier of Montana, Idaho and Washington; reviewed off-shore and on-shore petroleum pipelines in California and Alaska, prepared testimony and developed studies of conflicting risk assessments for a primary natural gas transmission line in Central California, and prepared reports on petroleum pipeline leaks in the San Francisco Bay Area.