

MANUFACTURED GAS IN CALIFORNIA, 1852–1940: BASIS FOR REMEDIAL ACTION

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ABSTRACT: California was a relatively late entry (1852) in the manufactured gas industry. However, its gas entrepreneurs showed considerable invention and enterprise in establishing more than 250 separate gas plants, this in a total geographic environment approximating a whole nation of separate-operating and now environmentally endangering, conditions. Virtually all of the many gas generation processes and patent variations were employed in the state, and a wide variety of geologic conditions have created an even wider variety of fate and transport conditions related to their tar and other residuals. A complex development of holding companies and other management forms also need interpretation as to the level of operational understanding present at the many former manufactured gas plants and other coal tar sites. As with all locations worldwide, a close understanding of the conditions surrounding technical operation and waste management options is essential to correct planning for environmental remediation.

INTRODUCTION

By 1852, the California Gold Rush was in its third year and Statehood in its second year. San Francisco was the focus and the funnel of the Mecca that was California. Immigration and importing were wide open and the city was populated with the defiant, the desperate, and the dedicated. Among these immigrants were three Irish brothers late of Newark, New Jersey, all tradesmen connected with iron founding and iron work. There was money to be made, and the Donahues had the energy, the skill, and the nose for it. Commercial manufactured gas was in its 47th year since William Murdoch's industrial gas plant at Soho, Smethwick District, Birmingham, England; books on the subject abounded.

Peter Donahue, the eldest and father-figure, soon read that wrought and cast iron, clay, lime, and coal could be used to produce gas. The brothers pitched in and the San Francisco Gas Company came to life in August 1852. Two years later, just 98 km up from the mouth of the Sacramento River at Sacramento City, sailing ships unloaded the newly fabricated gas retorts, condenser, and purifier for California's second manufactured gas plant—designed and built by the Donahue brothers (Peter, James, and Michael) and supplied with Australian coal, transshipped from the Donahue's Union Iron Company dock, at San Francisco, as offloaded from clipper ships.

Marysville, at the head of Sacramento River navigation, was the site (1857) of construction of California's third manufactured gas plant (MGP), completing the introduction of manufactured gas, from the Gold Rush port to the Sierra foothills and the supply center for the placer mines.

The Pacific coast had its first gas lights and at a time when perhaps no more than 400 manufactured gas plants existed in the entire young nation. Portland would follow as the second-State entry for manufactured gas in 1859 (Murray 1863).

This paper has been written to present a basis for constructive discussions, planning, and conduct of remedial action at former manufactured gas plant (FMGP) and related sites, where such efforts are indicated in review of the facts. With this paper, the writer does not adopt or present any form of advocacy of particular types, breadth, or depth of environ-

mental response. His forthcoming specialty technical book (Hatheway 1999b) is at the printers. In addition to what is listed in the Bibliography and References appendixes, the writer's research has included the proceedings and periodicals as well as annual and statistical reports of the companies discussed.

REVIEW OF APPLICABLE GAS MANUFACTURING PROCESSES

Manufactured gas was discovered over a thirty year period, centered mainly in England and Scotland but also involving advances made in Belgium, France, and Germany. William Murdock, the brilliant self-read Scots engineer at Birmingham, actually fielded the world's first commercial manufactured gas plant in the Soho District, in 1805. It was, however, the frantic efforts of the Moravian German Friedrich Winzler that brought us the opposite fact of the first commercial gas works being an urban commercial street lighting company—the Chartered Gas Light & Coke Company of London, for which the historic credit goes to Winzler. Known as “Winsor” in London, where he concentrated most of his efforts from 1804, his promotions led to establishment of the Chartered gas works in 1812, with his removal about 1819 by reason of his less-attentive management style.

These discoveries sequentially involved pyrolytically heating coal, wood, or oil; in time, essentially all other natural organic matter was found to be useful in creating some form of ignitable illuminating gas.

Gas Manufacturing Processes Employed in California

Basically speaking, any gas manufacturing process should be adaptable to any location, given the economics of making gas at a profit. These processes are treated in the historic-summary literature in a rather less complicated manner than what truly was the case. Economics did lurk behind every gas-making venture, and bankruptcy was the bane of the incompetents and an often uncaring public typically wanted the “best for the least.” Behind these conditions stood the Euro-American system of patents as a reward for invention. Probably more effort was spent on circumvention of gas-making patents than on their discoveries. Hence, there are some subtleties to keep in mind when we read of a gas “undertaking” of dozens of decades (or more) ago.

From earliest to generally latest, here are the gas-making processes that were employed in historic Californian undertakings.

Coal Gas. Coal is a remarkable host for easily extracted mineral wealth, and just as complicated in its formulation. It is a fact that the manufactured gas industry never truly solved

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the exact chemistry of the gas-formulating compounds or of their residuals and wastes. The gas was made in cast iron, wrought iron, and clay "retorts" of various forms and dimensions, and the product was tar-laden illuminating gas, ammoniacal liquors, cyanides, and such other impurities as sulphur and trace-element metals originating in the coal feedstock.

Wood Gas. Coincidentally with the introduction of coal-gas plants, other small gas manufacturing plants initiated with "fatwood," the resinous variety of pine and other soft woods, along with the pomice of wine vinting. These local fuels were free for the cutting, but they cost dearly in terms of finding reliable wood cutters to fend off the gold fever and deliver cords and cords of feedstock over rough trails and an ever-expanding radius of harvesting. The gas plant at Nevada City began in 1859 with the use of fatwood. The writer believes that wood-stock gas making was over with in California by about 1890 and would, by then, have been found only at smaller and more remote plants.

Organic Waste Gas. Right at the very beginning of gas manufacturing, it was commonly known that flammable gas could be made by pyrolytic roasting of literally any organic matter. In California, this prominently meant the pomice of wine vinting, which is known to have been utilized at one of the Napa gas plants.

Illuminating Oil Gas. Oils of all types were early discovered to yield combustible gas with sufficient illuminants to serve as street light and residential and commercial lamp gas. At the beginning of statehood, gas oils were nonexistent in California, but then petroleum seeps were discovered with natural fractionation of the light ends that began to serve for gas generation. This was believed first at the Maxim Gas Works, erected in San Rafael in 1871 and Eureka in 1878, and by the Garden City Gas Company, at San Jose, about 1878.

Illuminating Water Gas. This inappropriately named gas manufacturing technology came from basic discoveries in Britain by J. H. Ibbetson, about 1824, who disintegrated steam on a bed of glowing coke, thus forming a mix of carbon monoxide and hydrogen gas, considerable in heat provision but poor in illuminating quality. The technology is more properly known as "blue gas," for its flame, but the doctrine of historic usage constrains our options today. Patents on water-gas technology were loose, and many techniques emerged, many of which employed pyrolyzed gas oil for sufficient enrichment to boost the candle power to an acceptable range of 18–22.

Of and by itself, water gas (aka "blue gas") does not carry the candle power for use in illumination. At 150 to 300 Btu, it did serve as fuel gas, but where used for illumination, the candle power was enhanced by addition of vaporized oils of almost any available variety. The variety of vaporization and melding schemes were highly variable and there was no single simplicity that was captured by patents, such as those of T. S. C. Lowe in developing the strikingly different carburetted water gas. The gas plant researcher is constantly plagued by indiscriminate references to "water gas" when, indeed, the reference may mean the blue fuel gas, an enhanced blue gas, or the Lowe carburetted water gas patents, but without proper name.

Carburetted Water Gas. Carburetted water gas was the patented invention of Thaddeus Sobieski Constantine Lowe, a Scotch-Irish son of Burlington, Vermont, and the intrepid Civil War balloonist founder of the U.S. Army Corps of Astronauts, now known as the U.S. Air Force. Lowe perfected his technology, from 1872 through 1874, by adding a thin, atomized spray of gas oil to a second water-gas generator shell and a fixation chamber, forming a heat-adjusted manufactured gas of significant illumination candle power. Lowe sold his patents to the first American utility holding company, the United Gas Improvement Company, of Philadelphia, in its founding year

of 1882, and served for several years as an officer of the firm and as its chief engineer, before migrating to Pasadena, California, in 1887 to further affect the gas industry of the West Coast.

Lowe's Oil Gas. Even though oil gas had been manufactured since its discovery in Scotland (Edinburgh) in 1823, its success in America was never achieved until Leon Percival Lowe, eldest of the T. S. C. Lowe boys, followed in the footsteps of his father and developed Lowe's patented Oil Gas in Lowell, Massachusetts, in 1889. The same year, the younger Lowe moved west, stopping long enough at Colorado Springs, Colorado, to construct his first full-scale oil gas plant there, and reached Pasadena, California, that same year. At Pasadena, he immediately immersed himself in the construction of the first oil gas plant on the West Coast, as the California Light & Fuel Company. This plant was the world's first crude-oil gas plant.

Pacific Coast Oil Gas. The only truly distinctive West Coast gas manufacturing technology developed because of the shortage of Pacific Coast coal, the distinct nature of California crude oil, and the growing post-1890 propensity of the new petroleum refiners to strip off the most valuable light ends as solvents and, later, with the advent of the motor car, as motor spirit (gasoline). By 1900, the handwriting on the wall was clear to the manufactured gas industry: development of a successful oil-gas manufacturing technology would have to be based on California's particular crude oil, and time was of the essence. Pacific Coast oil gas technology became so distinct that in 1926, when J. J. Morgan (Columbia University, New York City) released his highly regarded two-volume technical treatment of manufactured gas, the Pacific Coast Oil Gas chapter was prepared by Willis S. Yard, the newly appointed (1921) vice president and *de facto* chief engineer of the Pacific Gas & Electric Company. Yard, however, was only imparting the knowledge developed by recently retired Chief Engineer E. C. Jones. For full development of the technology see Table 1.

CHRONOLOGY OF GENERIC GAS DEVELOPMENT IN CALIFORNIA

In nearly all technological aspects of manufactured gas, California led the way, with the possible exception of the briquetting of oil-gas lampblack residue into solid fuel. This advancement was made mainly by the Portland Gas Light & Coke Company, of Oregon.

California's contributions were driven by the oil-supply equation, but there is a fascinating step-like progression of that development. Here is that aspect of California's manufactured gas history.

1852–1884: Coal Gas Dominates

At \$36 (gold dollars) per ton on the Donahue dock, Australian coal pushed the price of coal gas to \$15 per thousand cubic feet ("feet")—to the writer's knowledge, the world's most costly illuminating gas, then or since. Inferior-quality west coal began to appear in the 1850s, mainly from Nanaimo, on Vancouver Island, and the mines around Centrailia, Washington. Supply of coal to California gas works settled into a routing of return ballast of Australian coal in English ships supplying California wheat to Australia.

There were frantic local efforts to make gas from other organic materials and to use small gas machines, mainly of the institutional variety and many of which operated on semirefined light ends of petroleum crude, imported from the eastern U.S. or from Scotland. The general composition was that of kerosene, made from oil shale and identical to the lamp oil that was being widely marketed after Abraham Gessner's discovery of the technology, in Nova Scotia in 1846.

TABLE 1. Sequential Development of Pacific Coast Oil Gas Technology

Date & Inventor	Features	Environmental Implication
1889: L.P. Lowe arrives in California	Tests his east-coast light-medium oil generator	Finds difficulty in securing ideal light-weight gas oil; Begins to modify system for prevalent high-weight California crude oils.
1890-1901: L.P. Lowe modifies his east-coast oil-gas generator	Finds optimal gas oil to be in very short supply in California	Installs modified Lowe oil gas generators at various points in northern and southern California; Particularly at Sacramento.
1902: Lowe sets up crude-oil gas generator at Oakland Station B	Perfects basic straight-shot, single shell device for West Coast oil gas	Lowe becomes partner in de Sabla & Martin's California Gas & Electric Co., by purchase of rights to his oil-gas process, covered by patents of 1889, for 16 northern California counties for 95,000 of stock.
1904: E.C. Jones becomes Chief Engineer of Calif. Gas & Electric Company	Immediately sought to increase the production capacity of Lowe's basic oil-gas generator	L.P. Lowe had again modified his design now to produce all gas sufficient for Oakland, from one oil-gas generator set, of enlarged dimensions.
1905: Pacific Gas & Electric Company is formed	Operating on basic premise of conversion to oil gas as soon as possible	Looking to economize at large scale and to use oil-gas as the basis to convert larger stations to central stations and to close and/or convert small stations to district stations for transmission of gas.
1906-1918	E.C. Jones increases capacity of Pacific Coast oil-gas generators	Diameter and heights scaled up so that maximum capacity reaches 5,000,000 cf/day per generator set; Lampblack production minimized for West Coast process.
About 1918	Lowe and E.C. Jones and son Leon B. Jones, begin formal cooperative relationship	Create stand-alone company, the Oil Gas Process Company of San Francisco, of which they are officers. One of these advanced generators is installed at New Bedford, MA, in 1924.
15 February 1920	Edward C. Jones retires from PG&E	Known "as probably the best known gas engineer on the Coast, if not in the United States." <i>Pacific Service Magazine</i> , Feb 1920, p. 289
1920-1924	L.P. Lowe sues PG&E for infringements of 1905-1906 patents; \$1,000,000 claimed	Lowe's influence and participation in PG&E had gone to naught prior to 1912. Special Master rules against Lowe in September 1924.
1930	Manufactured gas is replaced by natural gas throughout California	Consolidated utility companies have garnered the California gas market and have essentially replaced manufactured gas with natural gas. Oil-gas generators go on standby status.
1931	L.P. Lowe dies	At Los Angeles, California.
1937	Last known Pacific Coast oil gas plant	Seattle, WA; Constructed at what is now known as Gas Works Park on grounds of the old Seattle Gas Company Lake Station.

Compiled by the author, from various sources.

Among the attempts to make gas with various forms of petroleum products, the dominance seems to have been the Aubin process, tried at one location in San Francisco (1857), and Hiram Maxim's (inventor of the machine gun) oil gas process, in some use north of San Francisco.

1884-1889: Coal Gas Dominates, Carburetted Water Gas Appears

As in all other locations, carburetted water gas offered the strong incentive for use of coal-gas coke as its preferred feedstock, and it was on this premise that T. S. C. Lowe had produced a revolutionary concept. Lowe patented CWG from his workshops at Norristown, Pennsylvania, in 1875. Early in his development of carburetted water gas (CWG), T. S. C. Lowe was approached by itinerant entrepreneur "Colonel" Zachur Boyer, who became the western sales representative. Boyer was successful in 1872 by selling one of Lowe's new generators to the Nevada City Gas Company, located in the Mother Lode County.

In his reflections on the development of West Coast manufactured gas, E. C. Jones (1910) cites 1884 as the beginning of serious process departures from coal-gas generation. Cali-

fornia petroleum, in that year, began to meet the carbureting needs of water gas machines from statewide supplies.

1889-1902: Coal Gas Holds, Carburetted Water Gas Enjoys Modest Success, Oil Gas Appears and Rises

Key to this period was the personage of Edward Campbell Jones, later to become one of the very most competent manufactured-gas engineers, worldwide. Jones was self-educated and the son of a career gas manager of Boston, Massachusetts. He was imported to San Francisco in 1891 by the San Francisco Gas Light Company for the purpose of taking charge of the new North Beach gas plant. Jones's interest and knowledge extended to and covered all aspects of gas manufacture and its chemistry, and he was a tireless experimenter, writer, and commentator on gas industry affairs. With the formation of the California Gas & Electric Company in 1901, Jones was acquired with the San Francisco Gas & Electric Company and in a short time rose to be the chief engineer of the next level of Central California gas utility consolidation, the Pacific Gas & Electric Company, in October of 1905.

Jones's count of California gas works in 1899 had 18 coal-gas plants, 10 of T. S. C. Lowe's carburetted water gas plants (likely manufactured by UGI and marketed through Pacific

Gas Improvement Company), 1 crude-oil water-gas plant, and 5 oil and air gas works (probably the original Maxim machines). The Jones total was 34 gas plants in 1899.

1902–1912: Concept of Central Station is Developed at Oakland

Driven by successes in transmission of D. C. hydroelectric power, John Martin and Eugene A. deSabra Jr. move into the concept of high-pressure distribution of manufactured gas, thereby closing out older and smaller manufactured gas plants (mainly coal gas) and replacing them with District gas holders located radially outward from the new and expanded central stations.

Central stations were a natural progression of the finding that Pacific Oil Gas generators knew almost no bound in size and resulting economy gained by operating at truly large capacities (up to a few million cubic feet per generating unit per day) under the control of master gas makers. John A. Britton was responsible for this innovation at the Oakland Gas Light & Heat Company, of which he was president. Beginning in 1902, operating with the L. P. Lowe single-shot crude-oil machine, and from this point on, the idea of supplanting smaller MGPs at further distances went on almost unhindered. There were two implied considerations, both of which truly were not real limitations: (1) The use of slightly higher pipeline pressures (then considered high pressure at the modest range of about 10–20 psi) available by use of the emerging acetylene welding technology, and (2) district gas holders located at the far end of each pressure-distribution push. Central station companies also had the option of adding additional far-side compression from the district holder for another extension radially outward from the central station. An added feature to central station distribution was the introduction of loop-type (as opposed to dead-end), ensuring even-pressure gas distribution throughout the outlying service districts.

By their very nature, the central stations were owned and operated by holding companies, which themselves appeared in California originally in the form of the San Francisco Gas & Electric Company, established in 1896, in the early-growth stage of Pacific Coast Oil gas technology. Coincidental with proven “high pressure” gas distribution, smaller manufactured gas plants were converted to service centers and their gas-making machines often sent to World War I scrap drives.

1902–1930: Pacific Coast Oil Gas Dominates, Water Gas Diminishes, Coal-Gas Fades

Between 1906 (in the recovery actions related to the great San Francisco earthquake) and about 1912, Pacific Coast Oil Gas is established as a progression of technical improvements by Leon P. Lowe and E. C. Jones. By 1912, the original PG&E seed founders, John Martin and Eugene de Sabla Jr., are replaced in the management; Lowe falls away from the firm (acrimoniously); Jones is elevated; and Pacific Coast Oil Gas begins a sequence of rapid increases in generator size and efficiency.

E. C. Jones tallied the 1908 (Jones 1910) gas-generation status of California; one small coal-gas plant remaining, one oil and air-gas plant, and a burgeoned oil-gas production base of 56 plants, of which three yet had kept their carburetted water gas installations. Here is a strong departure from the eastern States, which in the interim had strongly converted from coal-gas to carburetted water gas. To support the gas oil appetite of the Pacific Coast Oil Gas technology, California now was producing oil at 48,306,910 barrels for the year. This was about the last year in which gas oil was available without encumbrance, as the rising diversions of the light-oil (benzol/motor spirit) to motor vehicles had not yet struck the gas industry.

Jones also reminds us that by 1909, “these doubts and fears (of gas quality) have all been allayed and oil gas as now made in California has the same stability as well made coal gas, with the further advantage that any desired candle power may be maintained and naphthalene stoppage can be practically controlled from the station.” (Jones quoted in Lindsay and Pease 1925, p. 116).

1913–1927: Natural Gas Appears in Southern California and Eventually Replaces Manufactured Gas

Natural gas was present in California nearly from the 1854 beginnings of the manufactured gas industry. As with elsewhere in the United States, the technology of gathering, processing, and distributing the gas was insufficient to capture and make use of a reliable supply. For the record, however (Table 2), waterwell drillers brought in natural gas at Stockton in 1864, from 1,800 ft of depth and sufficient to first light the Court House and to warm the water of the Weber Swimming baths. The Stockton Natural Gas Company was organized (Coleman 1952, p. 38) in 1888, and some near-novelty use of natural gas continued in California up to its then high-technology discovery in 1911. By 1900, the national transmission capacity for gas in the U.S. was about 75 miles, considering pipeline leakage and gas compression equipment.

By 1911, seemingly reliable supplies of natural gas had been discovered at Fullerton, near Santa Ana, and at Midway, near Taft (Bakersfield), and on this occasion some of the power figures in the southern California manufactured gas industry took actions to capture this supply. In November, the Midway Gas Company was organized in San Francisco, with Los Angeles gas notables A. C. Balch, A. B. McBeth, and W. G. Kerckhoff allied with S. Waldo Coleman, behind-the-scenes gas financier, of San Francisco. Through natural development, the company brought natural gas to Los Angeles in sufficient quantities to affect general operations by 1913, at which time it was being mixed with manufactured gas for distribution. By 1917, the company had been piping for nearly four years and was now supplying 24,000,000 cfd to Los Angeles via its 124-mi pipeline from its Midway Field wells, near Taft, and an additional 8,000,000 cfd from wells of others, at Fullerton.

In Los Angeles, the sheer magnitude of gas consolidation could be seen by 1916, in which the leading manufactured gas holding company, now mixing with natural gas, the Los Angeles Gas & Electric Corporation, had sold 4,331,911,400 cu ft of gas (*Walker's* 1917, p. 202). In June 1917, the corporation had consolidated to one central station manufactured gas plant, with 23 generator sets rated at daily capacity of 31,140,000 cu ft, gas holders of combined capacity of 14,950,377 cu ft, 1,370 mi of gas distribution mains, and 139,143 gas meters in service.

Pacific Gas & Electric Company took notice of the Los Angeles activity in natural gas development and earnestly tried to duplicate the effort, making modest discoveries in 1921.

According to the January 1935 issue of *Western Gas*, Los Angeles switched entirely to total natural gas in 1924. Santa Barbara and San Francisco Bay gas distribution went to mixed manufactured and natural gas in 1927. The entire PG&E switchover, marked by a five-month gas burner conversion program, took five months of 1930. The relief associated with completion of the conversion was interrupted for northern California in December 1932, with seasonally atypical cold weather in Oakland, San Francisco, San Rafael, and Vallejo, wherein oil-gas generators were sent through the tedious re-activation process of sequential heating (Willien 1934).

TABLE 2. Sequence of Natural Gas Exploration and Development in California

Date & Location	Developer	Extent of Development
1901: Santa Maria	Undetermined	Discovered with oil strike.
1907: Santa Maria	Santa Maria Gas & Electric Company	First domestic supply of natural gas to customers of manufactured gas.
1909: Buena Vista Hills, Kern County	Unknown	Unknown
1910: San Joaquin Valley	Formation of West Side Gas Company	To serve natural gas to oilfield cities of Fellows, Maricopa and Taft.
1913: San Joaquin Valley to Los Angeles	Midway Oil Company	Completion of 124-mile Midway gas pipeline across Tehachapi Mountains.
1921; Montezuma Hills, Solano County	PG&E	Its first attempt, a dry hole.
1924: Southern California	Midway Oil Company	Served exclusively with natural gas from San Joaquin Valley and the Fullerton fields
1926: Elk Hills, near Bakersfield, San Joaquin Valley	PG&E	250-mile pipeline reaches San Francisco Bay area with 1000-1100 Btu natural gas of about two times the existing manufactured gas. Bay area converted to natural gas service in 1927.
Oct 1928: Kettleman Hills natural gas strike	Undetermined	Even closer to San Francisco Bay area.
Aug 1929: Unlimited natural gas to San Francisco	PG&E	PG&E executes contracts with Milham Exploration Co., Texas Company and Standard Oil Company (CA) for 100,000,000 cf/day.
1935: Federal Public Utility Holding Act	PG&E	Federal government, for ten years, tries to treat PG&E as subsidiary of North American Company (Samuel Insull Industries) of Chicago

Compiled by the author, largely from Coleman, 1952).

1920–1929: Pacific Coast Oil Gas Suffers Decreasing Quality and Quantity of Feedstock Oils

Successes of the petroleum refineries and products distributors kept pace only with the development of the west coast as a land of the automobile. Supplies of motor fuel universally claimed most of the available crude oil, for refining and the manufactured gas industry, at best, never managed to take ownership of its critical oil supplies. The industry was adept at making investment inroads into the native natural gas industry, which was confined to southern California throughout the period. Southern California received substantial supplies of its own natural gas beginning in 1913, and the three larger holding companies—Pacific Lighting Corporation (through its Los Angeles Gas & Electric Company), the Southern California Gas Company, and the Southern Counties Gas Company—took actions to insure distribution of the supplies as they developed. As the pressure-integrity of transmission pipelines increased in both pressure and distance, the percentage of mix of natural with manufactured gas increased until final conversion occurred in the Los Angeles basin in 1927.

Northern California, however, seemed nearly isolated. Even though natural gas had been discovered at Stockton and Sacramento as early as 1888, supplies were unreliable in terms of quantity and distribution capacity was yet a hindrance. Stockton Natural Gas Company was founded in 1888, and the original gas company—then the Stockton Gas & Electric Company—did manage to produce 500,000 cfd in 1899 to supplement its manufactured gas production. The Sacramento Natural Gas Company was established with a soon-to-fail natural gas well on December 4, 1895. Reacting to the dwindling supplies of even crude oil, Pacific Gas & Electric Company began to feel, in the immediate years following the retirement of Chief Engineer E. C. Jones, a coming peril of the time when the petroleum producing firms would sever its supply of any form of oil for gas generation.

In about 1922, Willis S. Yard, the corporate successor to gas genius Jones, committed the firm to testing of Utah bituminous coal as a planned return to coal gas generation, in what was thought to represent a sure end to the crude oil necessary to

sustain PG&E's control of the supply of gas to northern California. Utah coal supplies were arranged by the company as a natural extension of its having been courted by Utah development interests as well as its 1924 investment in the construction and operation of the new Geneva Steel Company mill and coke ovens at Provo. At the same time, Yard saw to the rebuilding and conversion of the gas plant at Marysville, California, as the test bed for the Utah coal, which was to stave off the coming crude-oil famine. Yard's fears never materialized, however, because of the 1929 arrival of San Joaquin Valley natural gas via the new long-distance pipeline welding technologies of 1928. The crisis was over and the demise of manufactured gas was certain and swift.

Municipal Movements

It is a given fact that public ownership of utilities, with a few notable exceptions such as in Philadelphia, was never successful or popular in the history of the United States. California was no exception. However, there was in Los Angeles a form of municipal control in the Los Angeles Board of Public Utilities. For years a movement to carry the utilities to a city agency was waged in political warfare, finally ending in 1937 with establishment of the Bureau of Water and Power (now the Department of Water and Power). The gas industry never suffered that fate.

The Lampblack Issue

Along with oil gas comes lampblack, the fine, particulate carbon formed as a consequence of the generating process and largely collected at the wash box and scrubbers. At first there was no conceivable market, as the carbon powder was collected in wash water and, at best, could be somewhat dewatered by gravity and then dried to about 30% moisture content to serve as boiler fuel or even as feedstock to manufacture forms of blue gas. Industry—mainly in the east—used lampblack, in appropriate dryness and purity of carbon, for a variety of uses, including dye, ink, automobile tires, bowling balls, phonograph records, and stove polish. On the west coast, the supply outdistanced even the imagination.

A key legal case over lampblack developed in 1906 when the Portland (Oregon) District Engineer of the U.S. Army Corps of Engineers charged the Portland Gas Light & Coke Company with pollution of the Willamette River by its discharges of lampblack as a wastewater slurry. This was, to the writer's knowledge, the first use of the Refuse Act provision of the Rivers and Harbors Act of 1899, which, by the way, was the only federal law on the books in 1965 when the Department of Justice began prosecuting environmental polluters.

Needless to say, the Portland company found means of drying out the lampblack and of first disposing of such other than in the river. Ongoing research developed a means of compressing dried lampblack, with suitable oil-gas tar binder, into two sizes of fuel briquettes, walnut size and brick size. The former approximated the shape of your own barbecue briquettes, which the writer believes follow the original form and machinery developed at Portland. The bane became another source of innovation for GASCO, as the company and its by-product label were known and were shipped to the National Army Camp at Fort Lewis, Washington, to feed the cook stoves and barracks furnaces of World War I. The briquettes went out by the train load in gondolas.

In California, W. S. Yard points out (J. J. Morgan 1926, p. 343) that the general production relationship was that the lampblack was generated at greater quantities in the straight-shot (single shell) process (typical of southern California and Portland, Ore.). Relatively lesser amounts of lampblack were produced in the heat-and-make-down single shell or double shell processes (used in northern California). Lindsay and Pease (1925) offer more of the arguments facing selection of processes yielding more or less lampblack.

Southern California gas companies had no problem following the example of GASCO, wherein the Los Angeles Gas & Electric Company, in particular, operated a large briquette plant at its Aliso Street station and supplied the briquettes by sack or bulk, as delivered to the customer.

Today we are concerned about caches of lampblack as potential toxic substances, for its behavior is analogous to that of granular activated carbon, as a sorbant to toxic substances via both adsorption and absorption. The gas generation process itself made tar-residual compounds and placed them proximate to the lampblack, and it should be presumed to have been formed in a contaminated state, while its disposal on or off-site may have placed it in contact with other toxic plant residuals.

Demise of Manufactured Gas in California

With natural gas present, near-universal plans were made in California to place gas generators on standby, first out of the potential unreliability of the new natural gas supplies, and secondly, from reluctance to take the generators off the rate-justification books until times of more favorable write-offs to the capitalization of the newer units. Oil gas plants were retained in working order at most California plants in response to corporate plans, for as long as possible, or at least until the war clouds of the late 1930s.

Former Manufactured Gas Plants of California

The writer has compiled an exhaustive list (see Appendix III) of former manufactured gas plants in California, as discovered through perusal of the literature, Sanborn Fire Insurance Maps, and records held by the State of California. Nearly all those sites currently listed are FMGPs, with only a few of the many alternative coal-tar sites yet discovered. The list contains 288 sites, of which all but a few are FMGPs. A 1997 technical paper (Hatheway 1997) contains a listing of the many types of associated sites at which we may expect to

encounter polycyclic aromatic hydrocarbons and other FMGP-similar toxic wastes.

The table in Appendix I is compiled so that District Stations, with only a compressor house and one or more gas holders, are considered as separate sites of potential contamination, and hence bear distinct calling out as an individual "FMGP Site." Wherever there is an indication that two successor sites may be located even on contiguous parcels of land, they are counted and included as more than one separate site.

The Consolidating Companies

"Consolidation" was the term applied throughout the United States for the phenomenon of acquisition of companies operating in the same city. This trend apparently began at New York City, about 1884 and again in 1901. Most of the impetus behind the consolidations was aimed at the profit motive, strongly backed by the urge to survive. Consolidations offered chances at savings on the cost of manufacturing gas, but at the same time, the creation of monopolies that stifled the all-to-common threat of "gas wars" between the original franchise company and newly emerging "opposition firms." Most gas franchises were written in the American east for periods commonly as long as 50 years, by which franchises became open to reallocation beginning about 1870.

Holding companies began at Philadelphia, in August 1882, with incorporation of the United Gas Improvement Company (UGI) of Philadelphia (Hatheway 1999a). UGI was formed under the innovation of Thomas Dolan, a highly successful Philadelphia businessman of obscure Pennsylvania farm origin. Dolan's concept of organizing integrated business structure embodied several philosophies that became the backbone of American industry: integration of supplies, equipment, management, sales, and interwoven boards of directors. Dolan made several early moves to ensure the success of UGI as the single most powerful manufactured gas entity, at least until the arrival of such holding company giants as Samuel Insull, H. M. Byllesby, the Dawes Brothers, and Henry L. Doherty, to name a few of the most successful.

From its August 1882 origin, UGI moved quickly westward to San Francisco and Phoenix and made a strong undercover attempt to take over the manufactured gas business at St. Louis. None of these ventures was ultimately successful, and the action at St. Louis was a failure from the start. East of the Mississippi River was another story; one of strong success. UGI did, however, create the San Francisco seed of the Pacific Lighting Company, progenitor of Pacific Enterprises, the giant holding company of southern California.

When evaluating the effects of period financing, one should keep in mind the presence of external financiers serving in the management or on the Board of Directors. For instance, one Rufus C. Dawes served in 1917 (*Walker's*, p. 251) as 1st Vice President of the Southern Counties Gas Company of California, indicating a possible connection with the Dawes Brothers, major Chicago gas utility investors.

In the final sum, the writer has identified 24 separate holding company entities involved in the history of manufactured gas in California. Many of these companies are but limbs on just a few "trees," those representing the master financial bodies that brought about the final ownership of most of the manufactured gas plants in California—ultimately, Pacific Enterprises and the Southern California Edison Company in the south and the Pacific Gas & Electric Company in the north. Appendix II provides the writer's summary after years of research on the overall subject.

Key Technical Literature

From its 1852 beginnings and for the next 41 years, the West Coast gas industry relied entirely on eastern U.S. journals

and gas association proceedings and British journals for its technical advancement. Key among these was the highly valuable and successful *American Gas-Light Journal*, published in New York City, mainly as a weekly. Experienced gas engineers, both “practical men” and college graduates (the latter mainly after 1875) were regularly imported from the East Coast, with relatively lucrative offers (for the day) and chances for enhanced career opportunities.

In 1893, West Coast leaders, predominantly Edward C. Jones (an 1887 arrival from Boston), T. S. C. Lowe (arrived 1887), son Leon Percival Lowe (inventor of the modern oil gas process, 1889), and John A. Britton, organized the Pacific Coast Gas Association, in San Francisco. The PCGA never left its headquarters city, San Francisco, but did hold annual and semiannual meetings in alternate cities from San Diego to Seattle. Excellent and informative *Proceedings* were published for the Annual Meeting. These volumes surely are as interesting and useful to today’s gas plant remediation expert as they were to those who developed and operated the plants in their heydays. For most years, membership barely exceeded about 300 individuals, but the Association adopted an early resolution of supplying copies of the *Proceedings* to the libraries of

the leading technically oriented universities of the day. Even so, extant copies of these volumes are rather rare today, considering natural losses through attrition and the fact that microform copies never have been made. Often, the contents of PCGA *Proceedings* serve as “tie-breakers” on important facets of site and waste characterization for today’s FMGPs, in the absence of critical records that may not be present in the archives of the consolidated gas company successors of today.

1895 brought about a San Francisco monthly entitled *Journal of Electricity*, eventually becoming the *Journal of Electricity, Power, and Gas* (JEPG). The editors were Dr. F. A. C. Perrine (a Stanford University electrical engineering professor) and George P. Lowe (a “practical man” and later the official historian of the Pacific Coast Gas Association). The journal sparkles with fine technical and situational background information, though it, like the PCGA *Proceedings*, is rare and difficult to locate in libraries. JEPG had a life longer than manufactured gas in California, but seems to have neglected its gas coverage beginning with 1916.

Also useful are the several employee as well as consumer magazines of the large California holding companies, as listed in the references. And several of the holding companies have

TABLE 3. Key Events in History of Manufactured Gas in California

Date & Event	Location	Implication
1854: Australian coal	San Francisco; Sole port of import	Selling at \$36 per ton delivered to San Francisco; Makes for highest cost of manufactured gas in U.S.
1870: California Legislature allows multiple franchises	All locations in California	Ease of creation of opposition companies so that today we are faced with a larger-than once-optimal number of coal-tar sites.
1872: Gas war	San Francisco	Prices drop to unprofitable levels of \$1.60 per mcf.
1873: Financial panic	Worldwide	Forced some gas companies out of business.
1878: Price of Australian Cannel Coal	San Francisco; Add \$4.00 per ton for off-port transport to gas works	Still priced at a premium in terms of American coal.
1883: San Francisco gas war	San Francisco Gas Light Co. vs. Central Gas Co.	Leads to creation of first consolidated gas company in California.
1899: West coast gas producers and engines	Hercules Gas Engine Works, San Francisco	Creates strong and growing market for producer gas (usually water [blue] gas) as an industrial fuel.
1904: Lowe increases crude-oil gas usage	Oakland, Station B	Capacity increased to supply entire output of Oakland gas plant to supply entire city.
1904: Consolidation	Consolidation effort begins at Los Angeles	Gas production being gathered under aegis of Los Angeles Gas & Electric Company.
1905: Rate regulation	San Francisco Board of Supervisors	Gas rates fixed at \$1.00/1000 cf; Strong incentive for economizing and move to large-capacity oil-gas machines at central stations.
1906: Earthquake	Epicenter near San Francisco	Newly-formed (1905) Pacific Gas & Electric Co. nearly fails; Admit eastern financiers.
1906	Struggle for municipal ownership utilities begins at Los Angeles	Never successful, except at Long Beach; Established in 1924.
1911: Public utility regulation act passed	Public Utilities Act of 1911	Formation of the Public Utilities Commission of the existing Railroad Commission of California.
1911: Natural gas at Midway Field	Around Taft, California	Los Angeles gas financiers were able to capture this investment and support a 124-mile pipeline to Los Angeles.
1910-1911: Consolidation	Major consolidation effort at Los Angeles	Creation (1910) of Southern California Gas Co. Creation (1911) of Southern Counties Gas Co.
1913: Natural gas at Fullerton and Midway fields	Near Santa Ana, and also lower San Joaquin Valley, California	Los Angeles gas financiers utilize this gas to mix with the basic manufactured gas production.
1924	Public Utility Board of California Railroad Commission cooperative optimization tests	E.C. Jones one of two official PG&E representatives; Acting in retirement to the California Railroad Commission industry-cooperative oil-gas optimization tests at several central stations.
26 Jan 1927: Los Angeles	Straight natural gas	End of production of manufactured gas.
1929: San Francisco Bay	Natural gas arrives at San Francisco	PG&E spearheads conversion in northern California.
1930	PG&E completes change to natural gas	At all locations.

Compiled by the author, from various sources.

TABLE 4. Manufactured Gas Holding Companies of California

Date	Name & City of Origin	Remarks
1884	Pacific Gas Improvement Company, San Francisco	Formed at San Francisco by Albert Miller, with strong, but presently unknown ties with United Gas Improvement ; Eventually bought by San Francisco Gas & Electric Company and descended to PG&E. 1903: PGI sells to San Francisco Gas & Electric Company.
1886	Pacific Lighting Company, San Francisco	Formed from PGI by C.O.G. Miller and W.B. Cline, each barely 20 years of age and Miller son of President Miller of Pacific Gas; Acquire (<1889) MGPs at San Bernardino, Santa Rosa, Eureka; Eventually becomes today's Pacific Enterprises. 1961: PLC claims to be "... the largest single gas distribution network in the world." (<i>Pipes of Prometheus</i> , 1961, p. 10). 1937: PLC merges gas properties of Los Angeles G&E into its Southern California Gas Company. 1967: PLC moves headquarters to Los Angeles. 1970: PLC merges Southern Counties Gas Company into its Southern California Gas Company.
1889	California Light & Fuel Company, San Francisco	Founded by Leon P. Lowe, on arrival from Lynn, MA, with father, T.S.C. Lowe, for purpose of designing, building and operating oil-gas plants. Controlled San Francisco Coke & Gas Company, selling merchant gas to San Francisco Gas & Electric Co.
1896	San Francisco Gas & Electric Company San Francisco	Established as a holding company to consolidate gas and electricity manufacturing at San Francisco. Merged into California Gas & Electric Company (holding) in 1901 and thence (1905) into Pacific Gas & Electric Company.
1896	Southern California Edison Company, Los Angeles	Organized as a California corporation by John B. Miller; 1902, miller recapitalizes with eastern money; Operates 12 isolated manufactured gas plants; 1907-1919: SCE disposes of its manufactured gas plants, either to Southern Counties Gas Company or to Southern California Gas Company.
1899	Midland Counties Gas & Electric Company, Los Angeles	1899: Established at Los Angeles and developed holdings at San Luis Obispo, Santa Maria and Paso Robles. Overfolded (1913) by creation of Midland Counties Public Service Corporation, and sold in 1920 to Southern Counties Gas Company.
1901 1903 1905	California Central Gas & Electric Company, San Francisco	Established as a holding company by Eugene de Sabla and John Martin. Merged into California Gas & Electric Company. Descends to PG&E through California Gas & Electric Company (Coleman, 1952, p. 346).
1903	Monterey County Gas & Electric Company, San Francisco	Post-1903: Acquired by Central Valley Gas & Electric Company and subsequently sold to Central Valley Gas & Electric Company, which was acquired by PG&E.
1905	San Diego Consolidated Gas & Electric Company, San Diego	Organized under laws of California; To serve San Diego and vicinity; Controlled by Standard Gas & Electric Company, Chicago, itself owned by H.M. Byllesby & Company, Chicago.
1905	San Joaquin Light & Power Company, San Francisco	Formed by Wm. G. Kerckhoff (Pres.), Allan C. Balch (VP); and concurrently General Manager of Pacific Light & Power Co. of Los Angeles in 1912) and A.G. Wishon (Genl. Mgr.). Reorganized and refinanced as a Corporation in 1910. Final dissolution in 1938, much or all of its assets going to PG&E, including gas plant properties at Fresno, Bakersfield, Selma, Fowler, Sanger, Easton, Madera, Chowchilla, Merced, Atwater and Livingston.
1905	Pacific Gas & Electric Company, San Francisco	Formed as the third step of consolidation of gas and electric holdings at San Francisco; Destined (by 1930) to control all gas undertakings north of Bakersfield, California, to Oregon.
1908	Northern Calif. Power Company Consolidated, San Francisco	Organized by J.G. White Engineering Corporation, San Francisco. System extends from Arbuckle (south) to Copper City, ca. 15 mi. north of Redding; Gas plants shown at Red Bluff, Redding and willows.
1909	Orange County Gas Company, Los Angeles	Organized to produce and distribute gas in Santa Ana and other points in the county.
1910	Western States Gas & Electric Company; owned by H.M. Byllesby & Company, Chicago	Firm organized at Chicago, IL and moves into various States. Eventually has offices at Chicago, New York City and Tacoma, WA.
1910	Southern California Gas Company, Los Angeles	Organized at Los Angeles, to succeed Domestic Gas Company of Los Angeles; Key officers are W.G. Kerckhoff, Pres., A.C. Balch, VP, A.B. McBeth, VP; All three also serve as Directors. 1929: Pacific Lighting Company buys Southern California Gas Company coming to control all the major gas companies of southern California, save that of San Diego. 1937: Merge Los Angeles Gas & Electric Company and has been bought by Pacific Lighting Company by 1952.

TABLE 4. (Continued)

1911	Southern Counties Gas Company, Los Angeles	Company organized to manage isolated manufactured gas plants serving more than 40 cities in Los Angeles, Orange and San Bernardino Counties of southern California. 1925: Pacific Lighting Company buys Southern Counties Gas Co.
ca. 1912	California Gas & Coke Company, Los Angeles	Present in CA PUB Annual Report; May had a plant in San Fernando Valley; California Coke & Gas Corporation was partial owner of the plant.
1912	Central California Gas Company, San Francisco	Commonly known as California Central Gas Company.
1912	Citrus Belt Gas Company, San Bernardino	1913: CA PUC approves purchase of "a system of gas plants from P.J. Dubbell" by Citrus Belt Gas Company as successor to San Bernardino Valley Gas Company (JEP&G, 01Feb 1913).
1912	Coast Counties Gas & Electric Company, San Francisco	Organized by S. Waldo Coleman, R.M. Hotaling, L.W. Pryor, and John C. Coleman; Offices at 454 California Street, San Francisco; Controlled in 1927 by Samuel Insull interests of Chicago.
1912	Coast Valleys Gas & Electric Company, San Francisco	Organized under the laws of California to acquire Monterey County Gas & Electric Co.; Formed by Western States Gas & Electric Company, a H.M. Bylesby holding.
1912	Consolidated Heat, Light & Power Company; Unknown Location	1912-1916: Central California Gas & Electric Co. was qualifying with CA PUC to purchase the company.
1914	Contra Costa Gas Company, San Francisco	Incorporated by S. Waldo Coleman and John C. Coleman, to operate a central station gas plant adjoining Pittsburg, Contra Costa County, and to serve Antioch, Concord, Martinez and Crockett.

Compiled by the author, from various publicly-available sources.

TABLE 5. Known Former Manufactured Gas Plants of California

Location	Origin	First Owner	Features
Agnews	Unknown	Pacific Gas & Electric Company	No details.
Alameda	pre-1899	Alameda County Gas Company	No details
Alhambra	pre-1912	Lowe Gas Works of S. Pasadena	Probably oil gas plant
Anaheim 1	pre-1887	City Gas Works	Possibly gasoline gas
Anaheim 2	1912	Unknown; Later So. Cal. Gas Co.	Possibly gas distribution
Arcadia 1	pre-1912	Southern Counties Gas Co.	Possibly gas distribution
Arcadia 2	1917	U.S. Army Air Service, Ross Field Balloon School	May have had gas generators
Arcata 1	1900	Several small gasoline gas sets	Institutional machines?
Arcata 2	pre-1900	Union Steam Laundry	Acetylene gas
Arroyo Grande	1912	R.E. Easton applies for franchise	No details
Attwater	Unknown; post-1900	San Joaquin Light & Power Company, San Francisco	Listed as gas plant at its 1938 corporate dissolution
Avalon, Santa Catalina	pre-1920	Municipal Gas Works	No details
Azusa	Unknown	Southern Counties Gas Co.	Possibly gas distribution
Bakersfield 1	1887	Bakersfield Electric Light & Gas Company	No further details
Bakersfield 2	pre-1906	Bakersfield Transit & Gas Co.	
Bakersfield 3	pre-1912	San Joaquin Light & Power Co.	
Balboa	pre-1913	West Coast Gas Company	No details
Banning	1907	Banning Gas & Lighting Co.	Water gas
Beaumont 1	1909	Beaumont Gas & Power Co.	No details
Beaumont 2	1895	Beaumont Hotel.	No details
Bellflower 1	Unknown	West Coast Light & Fuel Co.	No details
Bellflower 2	1918	Consumers Gas System	No details
Benecia 1	1881	Benecia Gas Company	No further details
Benecia 2	1896	Solano Electric Light & Gas Co.	
Berkeley 1	1878	Berkeley Gas Light Company	No further details
Berkeley 2	1895	University of California	
Chico 1	1874	Chico Gas, Electric, Power & Lighting Company	Maxim and/or wood gas plant
Chico 2	1901	California Central Gas & Electric Company	Modernizes Chico Gas & Electric Co. plant with L.P. Lowe oil gas sets
Chowchilla	Unknown; post-1900	San Joaquin Light & Power Company, San Francisco	Listed as gas plant at its 1938 corporate dissolution
Coalinga	1909	Coalinga Gas & Power Co.	Later municipal gas plant

TABLE 5. (Continued)

Colton 1	pre-1887	Colton Gas Company	Later sold to Pacific Lighting Company
Colton 2	1912	Southern California Edison Co.	Central station oil gas
Columbia	1857	Columbia Gas Company	No details
Colusa	1886	Colusa Gas Company	Coal gas plant
Concord	1914	Contra Costa County Gas Light & Heat Company	Organized by gas pioneer S. Waldo Coleman
Corona	pre-1907	Corona Gas & Electric Company	Coal gas plant
Coronado	pre-1921	San Diego Consolidated Gas & Electric Company	May be only a district station; oil gas distribution
Covina 1	pre-1889	Covina Gas Company	Gasoline gas plant; Oil gas by 1906
Covina 2	pre-1912	Southern Counties Gas Co.	Oil gas plant
Daly City	1905	California Gas & Electric Co.	World's largest oil gas plant at that time
Denver City	pre-1881	Unknown	Undetermined gas process
Dinuba	pre-1913	A.W. Weber	Undetermined gas process
El Centro	1909	Imperial Gas Company	Undetermined gas process
Elsinore	Unknown	Elsinore Gas Works	Undetermined gas process
Escondido	pre-1919	San Diego Consolidated Gas & Electric Company	Undetermined gas process
Eureka 1	1878	Eureka Maxim Gas Company	Maxim gas machine
Eureka 2	1883	Eureka Gas Company	Coal gas; Oil gas in 1910
Eureka 3	1894	Eureka Lighting Company	Undetermined gas process
Fellows	1912	Westside Gas Company	Undetermined gas process
Fontana	1942	Kaiser Steel Company	90-oven Koppers-Becker by-product coke plant
Fowler	1912	Fowler Gas Company	Undetermined gas process
Fresno 1	1881	Fresno Gas Company	Coal gas
Fresno 2	1883	Fresno Gas & Electric Light Co.	Believed to be coal gas
Fresno 3	1918	Pacific Gas & Electric Company	Oil gas
Fresno 4	Unknown	Southern California Edison Co.	Wood treatment plant
Fruitvale	1900	Fruitvale Light, Power & Heating Company	Undetermined gas process
Fullerton	pre-1912	Southern Counties Gas Co.	Undetermined gas process
Gilroy	pre-1899	Gilroy Gas Company	Coal gas
Glen Ellen	1895	State Home for Feeble Minded	Undetermined gas process
Glendora	pre-1912	Southern Counties Gas Company	Unclear as to gas plant or to district gas distribution
Grass Valley 1	1862	Grass Valley Gas Company	Coal gas
Grass Valley 2	1885	Grass Valley Gas Company	Undetermined gas process
Grass Valley 3	1895	Grass Valley Gas & Electric Light Works	Undetermined gas process
Hanford	pre-1910	Hanford Gas & Power Company	Oil gas
Happy Valley (AKA San Mateo)	1905-	California Gas & Electric Co.	Oil gas
Healdsburg 1	pre-1890	Healdsburg Gas Light Company	Pitch pine retorts
Healdsburg 2	1907	Humboldt Gas & Electric Co. of Western States Gas & Elec. Co.	Undetermined gas process
Hemet	pre-1912	Hemet-San Jacinto Gas Co.	Undetermined gas process
Hollister	1886	Hollister Gas Company	Coal gas
Holtville	ca. 1905	Imperial Valley Gas Company	Undetermined gas process
Humboldt	1907	Humboldt Gas & Electric Company,	Undetermined gas process
Huntington Beach	1912	Henry Leukfield seeking manufactured gas franchise	Undetermined outcome or gas process
Huntington Park	pre-1910	Huntington Park Gas & Electric Company	Unidentified gas process
Imperial	1909	Imperial Valley Gas Company	Undetermined gas process
Inglewood (Centinella)	1912	Southern California Gas Co.	Oil gas plant
Jackson 1	1863	Jackson Gas Light Company;	Coal gas plant
Jackson 2	pre-1895	B.E. Letang, owner & operator	Coal gas plant
Lincoln	ca.1875	Gladding McBean & Co.; Terracotta factory	Producer gas plant
Lindsay	1901	California Central Gas Co.	Likely oil gas
Livermore	pre-1899	Livermore Gas Company	Coal gas plant
Livingston	Unknown; post-1900	San Joaquin Light & Power Company, San Francisco	Listed as gas plant at its 1938 corporate dissolution
Lodi 1	1891	Bay City Gas, Water & Electric Works	Undetermined gas process
Lodi 2	Post-1891	Unknown entity	Possible second plant

TABLE 5. (Continued)

Lompoc 1	pre-1912	Lompoc Gas & Electric Co. of Santa Barbara County	Undetermined gas process
Lompoc 2	1912	West Coast Light & Fuel Co.	Undetermined gas process
Long Beach 1	1895	United Gas Improvement Company (Philadelphia)	Undetermined gas process
Long Beach 2	Late 1890s-1907	Edison Electric Company (Gas Department)	Undetermined gas process
Long Beach 3	1906	Long Beach Gas Co.	Undetermined gas process
Long Beach 4	1910	Long Beach Consolidated Gas Company	Undetermined gas process
Long Beach 5	ca. 1912	Long Beach Inner Harbor Gas Company	Undetermined gas process
Long Beach 6	1914	Southern Counties Gas Co.	Undetermined gas process
Long Beach 7	1925	City of Long Beach	Undetermined gas process
Los Angeles 1	1866	Los Angeles Gass Co.	La Brea Tar Pits asphaltum;
Los Angeles 2	1868	Los Angeles Lighting Co.	Coal gas ca. 1870
Los Angeles 3	1875	Los Angeles Gas Company	Coal gas plant
Los Angeles 4	1889	California Light & Heat Co.	World's first crude-oil gas plant (L.P. Lowe)
Los Angeles 5	1893	Pacific Improvement Company	Coal gas plant
Los Angeles 6	1901	Equitable Gas & Electric Co.	Pintsch plant (?)
Los Angeles 7	1901	Los Angeles Suburban Gas Co.	Applies for gas franchise
Los Angeles 8	pre-1906	Edison Electric Co., Gas Dept.	Undetermined gas process
Los Angeles 9	1907	City Gas Company	Undetermined gas process
Los Angeles 10	1908	Los Angeles City Gas Co.	Oil gas plant
Los Angeles 11	1909	Economic Gas Company	Lowe family; Likely oil gas AKA Producers Gas Fuel Company
Los Angeles 12	1909	Pres-To-Lite Gas Co., Oakland	Acetylene gas plant
Los Angeles 13	1912	Southern Calif. Edison Co.	Wood treatment plant
Los Angeles 14	1912	Valley Gas & Fuel Co./ California Coke & Gas Corp.	Coke oven gas and by-product plant
Los Angeles 15	1914	Los Angeles Gas & Electric Corp.	Large district gas holder
Los Angeles 16	1914	Los Angeles Gas & Electric Co.	Large district gas holder
Los Angeles 17	1914	Los Angeles Gas & Electric Corp.	Lamp black briquette plant
Los Angeles 18	1915	Southern California Gas Co.	Central station oil gas plant
Los Angeles 19	1918	Pintsch Plant (?) @ SF Railyard	Expected at division yards
Los Angeles 20	1919	Producer's Fuel Co.; AKA Midway Gas Company	May be natural gas mixing/distribution plant
Los Angeles 21	1932	Southern California Gas Co.	District gas holder station
Los Gatos 1	1869	Los Gatos Gas Company; Los Gatos Light & Fuel Company	Likely was coal gas process
Los Gatos 2	1885	Los Gatos Gas Company	
Los Gatos 3	1886	Los Gatos Ice, Gas & Electric Co.	Not sure; Likely coal gas
Madera	1913	George W. Kitchen; Madera Gas Company	Undetermined gas process
Mare Island Naval Yard	1868	U.S. Navy	Likely oil gas
Martinez	Unknown	Unknown; Then PG&E	Undetermined gas process
Marysville 1	1857	Marysville Coal Gas Company	Coal gas plant
Marysville 2	1865	Marysville Gas Company	Coal, pitch wood & oil gas
Marysville 3	1895	Marysville Gas & Electric Co.	Single-shot Lowe crude oil
Marysville 4	1924	Pacific Gas & Electric Co.	Experimental coal gas plant
Mendocino	Unknown	Near Talmadge State Hospital	Undetermined gas process
Merced 1	1881	Walter E. Dean; Merced Gas Co.	Coal gas plant
Merced 3	1899	Merced Falls Gas & Electric Co.	Lowe single-shot oil gas
Modesto	1884	Modesto Gas Company	Coal gas plant
Monrovia	1905	Unknown	Undetermined gas process
Montebello	1952	Texas Company	Coal gasification pilot plant
Monterey 1	1902	Monterey Gas & Electric Co.	Undetermined gas process
Monterey 2	1909	Monterey County Gas & Electric Company	Oil gas plant
Napa 1	1867	Napa City Gas Light Company	Believed to be coal gas plant
Napa 2	1888	Napa City Gas Light & Heating Company	
Napa 3	1899	Napa Gas & Electric Company	Coal gas plant
Napa 4	1895	Napa State Asylum	Undetermined gas process
Needles	1912	Needles Gas & Electric Co.	Undetermined gas process

TABLE 5. (Continued)

Nevada City 1	1858	Nevada City Gas Light Co.	Coal gas plant
Nevada City 2	1885	Nevada City Gas Company	Oil shale and pitchwood
Nevada City 3	1901	Nevada County Gas & Elec. Co.	Undetermined gas process
Newport Beach	1898	Home Gas & Electric Co.	Undetermined gas process
Oakdale	1913	Oakdale Gas Company	Single-shot oil gas plant
Oakland 1	1866	Oakland Gas Light Company	Coal gas plant
Oakland 2	1884	Oakland Gas Light & Heat Co.	Undetermined gas process
Oakland 3	1899	Equitable Gas Company	Undetermined gas process
Oakland 4	1902	California Light & Fuel Co.	First oil-gas central station in California
Oakland 5	Post-1922	PG&E District Gas Holder	District holder station
Oakland 6	1925	PG&E District Station	Brought from former Independent Gas Co. site at San Francisco
Ocean Park	Late 1890s-1907	Southern California Edison Company Gas Department	Undetermined process; likely oil gas
Oceanside 1	1912	Oceanside Gas & Electric Co.	Undetermined gas process
Oceanside 2	1926	South Coast Gas Company	Undetermined gas process
Ontario	1912-1913	Ontario-Upland Gas Company	Questionable if artificial gas plant
Orange	1906-1911	Southern Counties Gas Co.	Short-lived oil-gas plant
Oroville 1	1881	Oroville Gas Works	Coal gas plant
Oroville 2	1895	Oroville Gas, Electric Light & Power Company	Coal gas plant
Oroville 3	1902	Butte County Infirmary	Institutional gas machine
Oroville 4	ca. 1915	Koppers Corporation	Merchant coke plant
Oxnard	ca. 1911	Unknown; Ventura County Power Company	Unknown gas process
Palo Alto	1897	Palo Alto Gas Company	Unknown gas process
Parlier (Fresno County)	1915-1919	River Bend Gas & Water Co.	Undetermined gas process
Pasadena 1	1886	California Light & Fuel Co.	Single-shot oil gas plant
Pasadena 2	1906	Valley Gas & Fuel Company	Undetermined gas process
Paso Robles	1912	Midland Counties Gas & Electric Company	Undetermined gas process
Petaluma 1	ca. 1867	Petaluma Gas Company	Coal gas plant
Petaluma 2	post-1867	Petaluma Gas Light Company	Van Syckle oil gas plant
Pittsburg	1912	Contra Costa County Gas Co.	Likely oil gas
Placerville	1890	Placerville Gas Light Co.	Undetermined gas process
Pomona	pre-1899	Pomona & Ontario Light & Fuel Company	Undetermined gas process
Porterville 1	ca. 1870s	Unknown	Probably coal gas plant
Porterville 2	pre-1912	Home Gas Co.	Likely an oil gas plant
Red Bluff	1872	Red Bluff Gas Company	Undetermined gas process
Redding	1886	Redding Gas Company	Undetermined gas process
Redlands 1	1900	Redlands Gas Company	Undetermined gas process
Redlands 2	1909	Home Gas Company	Likely an oil-gas plant
Redondo Beach	1912	Western Fuel & Gas Company	Undetermined gas process
Redwood City	1906	United Gas & Electric Co.	Undetermined gas process
Reedley	1912	San Joaquin Light & Power Co.	Undetermined gas process
Richmond 1	1905	Western States Gas & Electric Company	Undetermined gas process
Richmond 2	ca. 1895	Hercules Powder Company	Producer gas plant
Rio Vista	1914	Mr. A. Erwin, of Winters, CA	Undetermined gas process
Riverside 1	1886	Edison Electric Company	Undetermined gas process
Riverside 2	1899	Riverside Light & Fuel Co.	McCullum water-gas plant
Riverside 3	Late 1890s-1907	Southern California Edison Company	Likely an oil-gas plant
San Bernardino 1	1886	Pacific Lighting Company	Coal-gas plant
San Bernardino 2	1895	Southern California State Asylum	Undetermined gas process
San Bernardino 3	1901	San Bernardino Power Co.	Undetermined gas process
Sanger	Unknown; post-1900	San Joaquin Light & Power Company, San Francisco	Listed as gas plant at its 1938 corporate dissolution
South Pasadena	1912	Lowe Gas Works	Oil-gas plant
South Santa Ana	1912	Southern Counties Gas Co.	Oil gas plant or natural gas distribution center?
Sacramento 1	1854	Sacramento Gas Company	Coal-gas plant
Sacramento 2	1857	Citizens Gas Light Company	Never built a gas plant
Sacramento 3	1875	Capitol Gas Company	Coal-gas, then Lowe CWG then Pacific Coast oil gas
Sacramento 4	1889	Citizens Natural Gas Co.	Built an oil-gas plant
Sacramento 5	1895	Sacramento Natural Gas Co.	Active at Sacramento 4

TABLE 5. (Continued)

Sacramento 6	1896	Sacramento Gas & Fuel Co.	Not known to have built a gas plant
Sacramento 7	1903	Washington Electric Gas & Fuel Company	Not known to have built a gas plant
Sacramento 8	1909	Southern Pacific Railway Co.	Possible gas producer
Sacramento 9	1913	Sacramento Mutual Gas Co.	Undetermined gas process
Salinas 1	1875	Salinas City Gas & Water Co.	Coal-gas process
Salinas 2	1942	Kaiser Permanente Cement Co.	Girbotol water-gas plant to furnish hydrogen gas
San Diego	pre-1906	San Diego Gas Company	Undetermined gas process
San Francisco 1	1851	San Francisco Gas Company	Coal-gas plant
San Francisco 2	1857	Aubin Patent Gas Company	Aubin oil gas plant
San Francisco 3	1855	San Francisco Asphaltum Gas Company	May have been only an asphaltum paving firm
San Francisco 4	1863	Citizens Gas Company	Coal-gas plant
San Francisco 5	1863	Metropolitan Gas Company	Gale-Rand oil-gas plant
San Francisco 6	1870	City Gas Company; Potrero	Coal-gas plant
San Francisco 7	1871	Metropolitan Gas Company	New Gale-Rand plant
San Francisco 8	1873	San Francisco Gas Light Co.	Coal-gas and Springer water-gas
San Francisco 9			
San Francisco 10	1879	Consumers Mutual Gas Works	Lowe CWG plant
San Francisco 11	1880	Hotel Del Monte	Undetermined gas process
San Francisco 12	1881	Central Gas Company	Coal-gas plant
San Francisco 13	1882	Central Gas Light Company	Lowe CWG plant
San Francisco 14	1882	Baldwin Hotel & Theater	Institutional gas machine
San Francisco 15	1884	Pacific Gas Improvement Co.	Coal gas & Lowe CWG
San Francisco 16	1889	San Francisco Coke & Gas Co.	L.P. Lowe oil-gas plant
San Francisco 17	ca. 1889	Metropolitan Light & Power Co.	Lowe Merchant coke works
San Francisco 18	1896	San Francisco Gas & Electric Co.	Coal gas & Springer water gas
San Francisco 19	1897	Equitable Gas Company	Hall process water gas
San Francisco 20	1899	San Francisco Gas & Electric Co.	Undetermined gas process
San Francisco 21	1899	Pacific Ammonia & Chemical Company	Ammonia recovery plant from gas plant liquors
San Francisco 22	1900	Merchants Gas & Electric Company	Undetermined gas process
San Francisco 23	1901	Independent Gas & Power Co.	Likely Lowe oil-gas plant
San Francisco 24	1901	United Gas & Electric Co.	Undetermined gas process
San Francisco 25	1909	Economic Gas Company	Possibly holding company
San Francisco 26	1909	Municipal Light & Power Co.	Likely not a gas plant
San Francisco 27	1911	Metropolitan Gas Corporation	Undetermined gas process
San Francisco 28	1922	PG&E Army Street Station	District oil-gas holder
San Jose 1	1860	San Jose Gas Company	Coal-gas plant
San Jose 2	1877	Garden City Gas Company	Lowe CWG plant
San Jose 3	1877	Globe Gas Company	Undetermined gas process
San Jose 4	1895	Electric Improvement Co. Gas Department	Undetermined gas process
San Jose 5	1905	United Gas & Electric Co.	Undetermined gas process
SanLeandro	1889	San Leandro Gas Company	Naphtha oil gas plant
San Luis Obispo 1	1899	San Luis Obispo Gas Co.	Gas plant; No details
San Luis Obispo 2	1903	San Luis Obispo Gas & Elec. Co.	Gas plant; No details
San Mateo 1	1892	San Mateo Gas Light Co.	No details
San Mateo 2	1902	United Gas & Electric Co.	No details
San Pedro	Late 1890s	Unknown	Probably oil gas plant
San Rafael 1	1871	San Rafael Gas Company	Maxim gasoline gas plant
San Rafael 2	1883	San Rafael Gas & Elect. Light Co.	Coal gas, then oil gas plant
Santa Ana	pre-1895	Santa Ana Gas & Electric Co.	Holmes process oil gas
Santa Barbara 1	1871	Santa Barbara Gas Company	Probably oil gas plant
Santa Barbara 2	Late 1890s	Southern California Edison Co.	Oil gas plant
Santa Clara 1	1906	Municipal Gas Plant	No details
Santa Clara 2	1909	Economic Gas Co. of Santa Clara	Year of incorporation
Santa Cruz	pre-1899	Santa Cruz Electric Light & Power Company	Coal gas plant
Santa Maria 1	1907	Midland Counties Gas & Electric Company	No details
Santa Maria 2	1912	Santa Maria Gas & Power Co.	No details
Santa Monica	Late 1890s	Santa Monica Gas Company	No details
Santa Rosa 1	1872	Santa Rosa Gas Works	Maxim gasoline gas plant
Santa Rosa 2	ca. 1874	Santa Rosa Gas Light Company	New coal gas plant
Selma	1901	Selma Light & Water Co.	Oil gas plant
Sierra Madre	1912	Southern Counties Gas Co.	Not clear if plant or service
Solano	1896	Solano Electric Light & Gas Co.	

TABLE 5. (Continued)

Sonora	Unknown	Sonora Gas Company	No details
St. Helena	pre-1890	St. Helena Gas Company	Van Syckle oil gas plant
Stockton 1	1859	Stockton Gas Company	No details
Stockton 2	1884	Stockton Gas, Light & Heat Co.	1899; First CA gas company to mix with natural gas
Stockton 3	1894	Stockton Gas & Electric Co.	No details
Stockton 4	Unknown	McCormick & Baxter Co.	Wood treatment plant
Susanville	1915	H. Howard Dunbar	Receives franchise to build/operate MGP
Tracy	1926	Tracy Gas Company	Single-shot oil gas plant
Tulare	pre-1899	Tulare Gas Company	No details; Closed by 1899
Turlock	1912	Turlock Gas Company	Oil gas plant
Ukiah	post-1893	Ukiah Gas Works	Oil gas plant
Upland	1909	J.R. Anderson	Secures gas plant franchise
Vacaville	1914	A. Erwin, of Winters, CA	No details
Vallejo 1	1866	Ensley Gas Company	Coal gas plant
Vallejo 2	1904	Vallejo Gas Company	Probably oil gas plant
Venice 1	pre-1918	Southern Calif. Edison Co.	Oil gas plant
Venice 2	pre-1918	Southern Counties Gas Co.	Oil gas plant
Ventura	pre-1901	Unknown; then Ventura Water, Light & Power Co.	No details
Visalia 1	1875	Unknown	Crude-oil gas plant
Visalia 2	1887	Visalia Elec. Light & Gas Co.	Water gas fuel plant (?)
Visalia 3	1906	Consolidated Heat, Light & Power Company	Oil gas plant
Visalia 4	pre-1912	Home Gas Company	Oil-gas plant
Visalia 5	pre-1940	Central California Gas Co. Southern Calif. Edison Co.	New central-station oil gas Visalia Pole Yard
Watsonville 1	1871	Watsonville Maxim Gas Co.	Gasoline gas plant
Watsonville 2	1879	Watsonville Maxim Gas Co.	Coal gas plant
Whittier	Late 1890s-1907	Unknown; Then Southern California Edison Company	One of 12 such isolated manufactured gas plants
Willets	pre-1932	Pacific Gas & Electric Co.	Oil gas plant
Willows 1	1895	Court House & City Jail	Institutional gas machine
Willows 2	ca. 1908	Northern California Power Company Consolidated	Probably Lowe single-shot oil gas
Wilmington	pre-1918	Southern Counties Gas Co.	Oil gas plant
Winters (Yolo)	pre-1914	Winters Gas Company	No details
Woodland 1	1874	Woodland Gas Company	Coal gas; Then low-temp. Van Syckell oil gas
Woodland 2	1901	California Gas & Electric Co.	Reconditioned to oil gas
Yreka	1850s	Yreka Gas Company	Eventually the northernmost PG&E plant

Compiled by the author from an exhaustive search of relevant records.

very useful corporate histories. Many of the references that appear in Appendixes IV and V constitute basic sources for remedial studies of the former manufactured gas plants of California.

APPENDIX I

These appendixes contain three lists of data that pertain mainly to the existence of individual FMGP and related sites of California. Even in their abbreviated form, the data may be useful to others, after "digesting" the situational information contained in the body of the paper. It is the hope of the writer to offer a string of these State or Province-related tables in the bodies of future papers in the *Practice Periodical*.

Chronology of Major Events

Listed in Table 3 are those events encountered by the writer as seeming to represent various forms of milestones that may have affected the technology or operating manner of the California manufactured gas plants. Researchers would be well advised to keep such events in mind as they are formulating the history of an FMGP site, as they may have affected the nature and disposition of today's toxic wastes.

There were three major challenges associated with devel-

opment of the Pacific Coast Oil Gas process: (1) to understand the difference in crude-oil chemistry; (2) to accept that the gas-oil supply never would be optimal; and (3) to face the prospect that economies of scale were possible by increasing the size of the generating sets.

APPENDIX II. LIST OF CONSOLIDATED COMPANIES

Table 4 is the best-sense order of the existence and basic organizational facts representing the holding companies that rose to control or otherwise affect the manner in which California's FMGPs were operated, in the sense of effects on today's toxic FMGP wastes.

APPENDIX III. LIST OF FORMER MANUFACTURED GAS PLANTS

Table 5 constitutes the writer's sum total of years of patient research in identifying and recording separate gas manufacturing and related "coal-tar" sites of California. Embedded in the list has been a dedicated attempt to locate and record the founding and existence of all manner of former industrial sites related to the technology of manufactured gas and its volatile (VOC) and semivolatile (SVOC) toxic wastes. No claims are made as to the completeness of the list, for it seems as soon

as one of these lists is established, the writer makes more discoveries. This and similar state or national lists compiled by the writer have resulted from reading and scanning literature that now constitutes a personal bibliography on the subject, extending to 310 pages of ten-pitch entries. Some of the most useful information in the writer's master database (not shown here) have some from unindexed news items published in the technical journals—items of which the discovery is purely fortuitous.

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