Chapter 1

PCBs AND GENERAL ELECTRIC IN OAKLAND

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Introduction

Ground water contamination is an emerging public health threat. Deadly industrial chemicals are being found in ground water, contaminating a major source of the nation's water supply. An unforeseen contributor is the industrial chemicals which were once thought harmless and are now found to be responsible for chronic illnesses which are sometimes fatal. This is the situation involving polychlorinated biphenyls (PCBs).

Prior to the 1960s spills and disposal practices involving PCBs were no cause for concern since they were thought harmless. On-site waste burials and spills of PCBs went unrecorded until evidence showed PCBs to be one of the most toxic chemicals used today. Because of their toxicity to man and their persistence in the environment, clean-up efforts are necessary.

This report is about one such clean-up effort presently going on in the Bay Area. General Electric operates a transformer and repair plant in Oakland where an estimated 20,000 gallons of oil containing PCBs were spilled. My report gives a brief case history of the site and the clean-up effort being made. The Regional Water Quality Control Board (San Francisco Bay Region) has a detailed study on the General Electric Oakland Site on which much of this report is based.

An Introduction to PCBs

The term polychlorinated biphenyls (PCBs) refers to a family of organic chemicals which can be altered in a series of chemical reactions. The result is a mixture of complex molecules that have properties advantageous to many industrial applications. The chlorinated biphenyl isomers can be rearranged to have a higher ratio of chlorine per biphenyl molecule, usually resulting in a greater resistance to chemical and biochemical degradation, making PCBs one of the most stable compounds known (Kopp, 1976). (An isomer refers to any two or more chemical compounds that contain the same number of atoms of the same elements but differ in structural arrangement and properties.) Other properties, such as low electrical conductivity, low solubility in water, low vapor pressure and low flammability, make PCBs extremely advantageous for use as dielectric (an electrically non-conducting material) and heat transfer fluids (Kopp, 1976).

In the late 1960s it became apparent that although PCBs exhibit little acute toxicity (toxic effects from high level, short-term exposure), they are accumulated in the tissues of many biological species and do exhibit chronic (long-term) toxicity to many organisms even when the exposure is to very low concentrations (Kopp, 1976). PCBs are poorly metabolized and tend to accumulate in fatty animal tissues and organs. Therefore, as the PCBs are passed from trophic level to trophic level, the concentration of the PCBs can increase from 10-100 times the initial concentration. Humans, at the highest trophic level, ultimately receive the highest PCB concentrations. Animal studies have revealed that PCBs can cause adverse effects in numerous organ systems including the liver, kidney, adrenal gland, spleen and skin (IIEQ, 1976). The most tragic case of human PCB exposure is the "Yusho" incident in which over 2,000 Japanese people became intoxicated by consuming PCB contaminated rice oil. They experienced a wide range of effects such as skin lesions, facial swelling and neurological disorders (IIEQ, 1976).

History of the Oakland Site

General Electric Company owns and operates a transformer production and repair shop at 5441 East 14th Street, in Oakland, California. This 24 acre site, located approximately 1 and 1/2 miles east of San Francisco Bay, is surrounded by commercial, industrial and residential development. The Oakland plant was used for transformer assembly from 1923-1975. Insulating fluids containing PCBs produced by the Monsanto Chemical Company under the trade name Pyranol were used in the manufacturing process (RWQCB-A). In 1968 all new transformer production was discontinued, but warranty replacement of the transformers with Pyranol continued until 1975. In 1975 the facility converted to a repair shop for large industrial and utility equipment such as transformers, traction motors and small gas turbines. Transformer repairs now incolve 10-C oil, a non-PCB insulating fluid which can be removed, filtered and replaced in the transformer (RWQCB-B). In the repair of older transformers that contain Pyranol or Pyranol-contaminated replacement 10-C oil, the fluid is removed and stored in a covered cement-floor warehouse. The facility stores the waste for up to 90 days, then transfers it to a Class-I dump site.

Problem Identification

In July of 1979, a GE employee concerned about improper handling of PCBs on the site, contacted the California Department of Health Services (DOHS). On July 20, 1979, a DOHS representative investigated the site and found no evidence of PCBs being mishandled. The GE employee, dissatisfied with this conclusion, requested a second inspection. A second visit was made 10 days later and soil samples were obtained from the site. Tests made on these samples revealed high amounts of PCBs in the soil. Because of these findings DOHS directed GE on November 29, 1979 to remove all PCB-contaminated soil to a Class-I disposal site (RWQCB-C).

GE began its own site study in order to determine the extent of soil contamination and the most effective means of disposal. It hired the consulting firm of Brown and Caldwell to write an investigative Phase I report. Included in the report was a description of the site, its operational history, an evaluation of the contamination problem and alternative correction programs (RWQCB-C).

Upon completion of this Phase I report in 1980 it became apparent to both GE and DOHS that the PCB contamination was more extensive than previously believed, and would require more serious mitigation methods than soil removal. The Regional Water Quality Control Board (RWQCB) was alerted by DOHS to the site contamination problem because of possible ground water contamination. On October 1, 1980, the RWQCB, accompanied by representatives of the DOHS, inspected the site. Initial observations revealed shallow drainage courses, discolored soils, sumps, oily material in surface soils, and porcelain fragments in soils not identified in the Phase I report. Samples of standing liquid collected by RWQCB from an unlined drainage course on-site ranged from 0.52 ppb to 6.6 ppb concentrations of PCBs. A dry soil sample from another on-site drainage ditch contained 100 ppm PCB (RWQCB-A). Those findings resulted in a RWQCB Clean-up and Abatement Order to GE on December 1, 1980. The order consisted of the following requirements: (2) By January 20, 1980, a plan for immediate mitigation measures that would stop all discharge of PCBs, oils, oily materials and other waste constituents originating from the on-site industrial processes and removal of any waste stored on-site to the proper disposal facility (b) By May 1, 1980, a plan that described long-term mitigation measures necessary to remove and/or treat contaminated soils and ground water to obtain acceptable levels and to maintain long-term control of storm water run-off; and (c) By March 1, 1981, a more extensive and complete report of the contamination (RWQCB-A). GE submitted plans to cooperate fully with the order and agreed to pay for the entire clean-up costs.

History of On-Site PCB Dumping

The RWQCB report (RWQCB-C) describes GE's disposal practices in great detail. The following is a brief summary of GE's past disposal practices as reported by RWQCB.

Accidental spills, leaks and negligent disposal practices of PCB-contaminated material occurred throughout the 50 year period of Pyranol use at the Oakland GE site. A frequent mishap, which resulted in Pyranol spills, was the "blowing" or overflow of a mobile PCB filtering unit caused by the application of too much pressure. But the amount of resulting contamination was relatively small compared to negligent on-site disposal practices.

The plant operators stored Pyranol, 10-C and other waste oils in tanks on site. The storage tanks were scattered over the entire site. Poor maintenance of these tanks resulted in an excessive number of leaks. The tank farm was a major contributor to the subsurface contamination described later in this report.

The primary means of disposal for waste oils was on-site burial. A trench was excavated in the late 1940s for burial of liquid waste after attempts to burn waste in oils proved unsuccessful. This practice continued for approximately 10 years. During this time no effort was made to separate the 10-C and Pyranol oils. When leaking occurred, a Pyranol 10-C oil mixture resulted, enabling the PCBs to spread further. It was not until the mid-1950s, when trench burial was no longer practiced, that the 10-C and Pyranol oils were separated. There was also a significant amount of solid waste generated from the plant's production process which was eventually buried on-site at some distance from the oil trench. It is possible that the solid waste came in contact with Pyranol before burial, causing further contamination of the soil.

The quality of the 10-C and Pyranol oils was tested in laboratory facilities on-site. Laboratory personnel poured oil samples down the drain which emptied into a septic tank. Eventually this septic tank collapsed and the samples drained directly underground. Any waste oil from the laboratory either infiltrated the subsurface soils or combined with rainfall run-off. It is unknown how long direct contamination occurred before test samples were disposed of properly in the mid-1960s.

Evaluation of Site Contamination as Reported by GE

The site was divided into three areas of varying degrees of contamination. In Area I soil surface concentrations ranged from 0.1-220 ppm. The higher concentrations were located nearer to the surface. GE hypothesized that the suspended solids were contaminating the ground water and began to separate the solids from the ground water through filtration process. After the process, the PCB level in the ground water was undetectable. (The EPA-recommended ambient water concentration is 1 ppt for PCBs.) The PCB concentration in the solids was 31 ppm. There was some concern that the contaminated sediment in Area I would flow with ground water towards San Francisco Bay, but soil profile tests showed the area to be surrounded by impermeable fine-grained clay soils (RWQCB-D).

In Area II the extent of contamination was much greater. PCB concentrations generally ranged from 0.33-1,900 ppm. However, in some spots concentration levels reached as high as 14,000 ppm (RWQCB-C). Subsurface soil contamination was detected down to 46 feet. All unpaved surfaces had PCB concentrations of greater than 5 ppm. Again, contaminated soil sediments were coming in contact with ground water. The greatest concentration of PCBs on the entire site was found in Area II. Within the layers of soil at a depth of 31-32 feet, a layer of free floating oil was found. This subsurface plume ranged from 0-8 inches thick (RWQCB-C). The PCB oil plume was thought to have the greatest potential for spreading off-site and for contaminating San Francisco Bay. There was also concern that the plume would sink, making efforts to control or recover the oil very difficult. To date, there is no evidence of horizontal movement and present mitigation measures are designed to control vertical movement of the plume.

The contamination in Area III was contained in approximately a quarter of the 7.1 acre section. The PCB concentrations ranged from 1-3,400 ppm (RWQCB-C). The concern with AREA III was that the ground water was at the shallowest depth on-site. Precipitation could percolate through the

PCB-laden soil and contaminated ground water. Ground water could then migrate towards San Francisco Bay where the PCBs could easily enter the food chain.

Immediate Mitigation Measures

The overall objectives in the immediate correction plan for the GE facility included prevention of contaminant movement off-site or into deeper soils, extraction or immobilization of free oil and associated PCBs, containment and extraction of oily ground water, and meeting all appropriate regulatory requirements (RWQCB-C).

The following is a brief summary of GE's Immediate Correction Plan submitted in 1981:

The greatest potentially harmful situation was the oil plume. There was concern that the oil plume would travel. Off-site migration of the oil would result in a greater area of contamination and would pose a public health threat. The system chosen to extract and immobilize the oil was the French-drain system (Figure 1). The French-drain contains three perforated pipes which empty into a central collection sump. The pipes are vertically separated from each other by about three feet, with the lowest pipes reaching a depth between 25-30 feet. Each pipe length varies from 60-80 feet

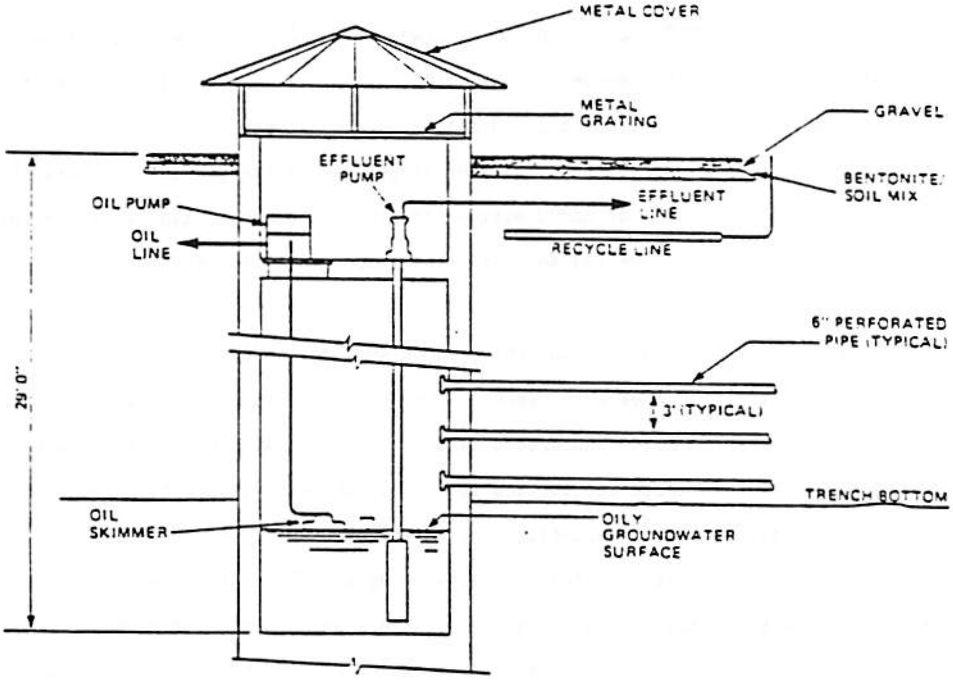

Figure 1. The French-Drain System
Source: RWQCB-C.

and has a diameter of 6 inches. Surrounding the pipes is drain rock which extends to about 1 foot of the soil surface. The drain rock is overlain by compacted fill and then covered with a surface seal so as not to permit infiltration into the drainage system. Water could not be allowed to infiltrate the subsurface soils in order to control the movement of the ground water and the oil plume. Three French-drains were used for this site.

The selection of the French-drains was based on conditions at the site. There was a shallow ground water table above the plume, and it was theorized that, initially, as the oil plume moved downward into the drains, the water table would drop (RWQCB-C). As the water level dropped, the vertical and lateral migration of ground water outside of the control area would be prevented and redirected towards the drains (RWQCB-F). Water flowing towards the drains would enhance the downward flow of the oil plume. The oil-water mixture would be collected by the pipes and drained into the central collection sump. Here an oil and water interface would be created which would enable one pump to remove the oil and another to pump the contaminated ground water to an on-site treatment facility. The oil would be stored on-site in 55-gallon drums for no more than 90 days, after which they would be taken to a Class-I landfill (RWQCB-C).

The concentration of PCBs in the collected ground water was still too high for the East Bay Municipal Utility District (EBMUD) to handle at its sewage treatment plant without exceeding its effluent standards. (EBMUD is the sewage disposal facility for the GE site.) In order for EBMUD to accept the effluent from the GE site it could not exceed an average concentration of 50 ppb and a maximum concentration of 150 ppb at any time. The theory behind the standard set was that after the GE effluent mixes with the rest of EBMUD wastewater, the PCB concentration would be less than 1 ppt. To meet this standard, GE created an on-site treatment facility for the extracted ground water.

Other immediate mitigation measures concentrated on surface run-off control. There were four specific areas where control measures were needed: unpaved areas with or without PCB contamination, building roofs, existing paved areas, and around-site perimeters. All unpaved areas were altered so that run-off would not infiltrate the surface soils. Slopes were graded to direct run-off towards a drain site, covered with a Bentonite-soil impermeable seal, then topped with a layer of gravel. Run-off from rooftops was directed to catch-basins and flowed through buried drain lines. Curbs and more drains were placed around the site perimeters and other existing paved areas to prevent surface run-off (Figure 2). Collected run-off was monitored before it left the site in order to make sure it did not exceed the PCB standard average of 50 ppb.

Results of Immediate Mitigation Plans (as of January 1983)

In general, the immediate mitigation measures taken at the GE facility are considered successful (RWQCB-C). The surface seal and drainage system does reduce infiltration of precipitation into the ground water system, thus enhancing the ability of the French-drains to control ground water movement. Also, all effluent leaving the GE site meets standards set by EBMUD. Data collected for the first 6 months of operation indicate that the average PCB effluent concentration in the treated ground water is 0.1 ppb, well below the EBMUD standard.

The French-drain system has been partially successful. The water table levels prior to the installation of the system showed a significant drop. The directional flow of the ground water was reversed towards the French-drains. However, the quantity of oil and ground water removed

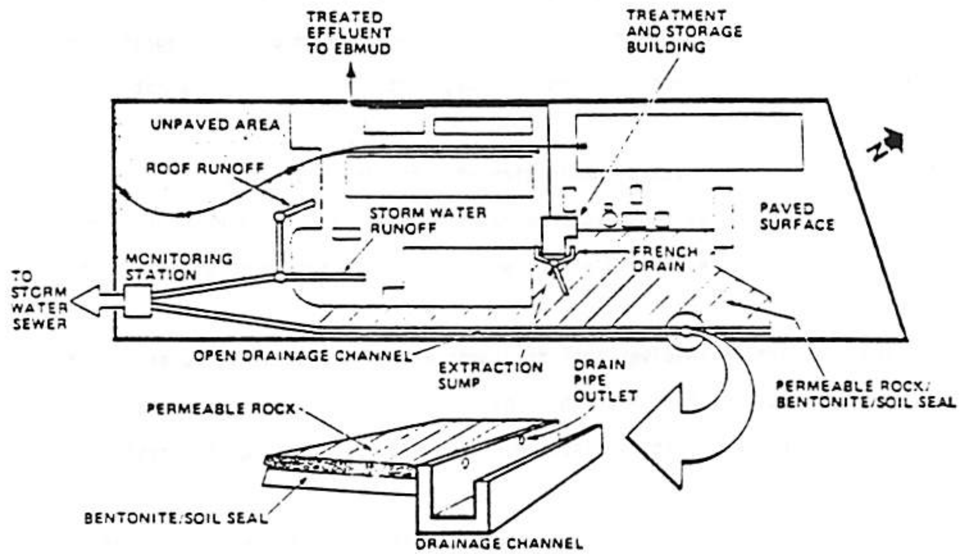

Figure 2. Drainage Control System - Oakland Site.
Source: RWQCB-C.

is much lower than anticipated. The system has the capability of recovering 14,000-15,000 gallons of water per month but is currently pumping 1,000-1,500 gallons of water per month and recovering 1 gallon of oil per month. GE claims that 20,000 gallons of PCB-contaminated oil has been spilled on-site, most of which is located in the subsurface oil plume. If the reported flow remains constant without any other type of mitigation, it would take approximately 20,000 months (= 1,667 years) to extract all the contaminated oil from the site.

Long-Term Mitigation Plans

The object of the long-term mitigation plan is to remove and/or treat contaminated soil and ground water to acceptable levels (RWQCB-G). The research for this plan, to be done at GE's

Schenectady, New York, Research and Development Laboratories, will concentrate on the problem of removal or destruction of residual PCBs in the soil. Most likely the PCBs will be in the presence of other organic material, such as 10-C transformer oil, which will be a factor in the removal or destruction of the PCBs. The research proposals are grouped into three areas - microbial degradation, chemical degradation and physical extraction.

Several research proposals are underway for the investigation and development of bacterial populations which can degrade PCB isomers (RWQCB-G). Various studies have already addressed this proposal, and species such as Nocardia and Pseudomonas have demonstrated the ability to degrade partially some of the lower chlorinated isomers (RWQCB-E). Unfortunately, the type of PCB at the Oakland site is one of the most stable and highly chlorinated. The microbial degradation research in progress explores the problems of increasing degradation rates and consumption of higher chlorinated isomers.

Chemical destruction of PCBs involves a combination of potassium hydroxide (KOH) and polyethylene glycol (PEG). The KOH/PEG reactant decontaminates transformer oil under certain conditions. The reaction product is throught to be PCB-PEG ether, which could biodegrade more rapidly than the PCB in its initial form (RWQCB-E).

The idea of physical extraction involves soil treatment using an aqueous surfactant to flush oil out of the soil pores towards the French-drain. The liquid used should not leave any harmful residue in the soil, or if extracted, must be disposed of so that no further contamination of the environment occurs.

The various lab studies and field trials are projected to take 6 years, ending by 1987. It is possible, though, that research would take longer, as proposed work is abandoned when found to be impractical and new approaches are developed as research proceeds. The experiments mentioned are proposals; the final long-term mitigation experiments, as well as their results, were not available to the author.

Discussion

GE implementation efforts include surface sealing, a French-drain system and additional proposals, including a form of chemical or microbial degradation and/or physical extraction. GE is trying to develop a systematic approach to control and/or extract PCB contaminated soils and ground water. Yet they seem to have neglected to address the completion time necessary to clean up the site, 1,667 years. Even 1/10 of that time seems like an exceptionally long time period. It is difficult to imagine any company remaining at that site for 100 years, let alone 1,000 years.

GE is making a considerable effort to clean up the site, yet why wasn't the effort made sooner? Such negligent disposal practices and spills of PCBs were known as early as the 1950s. Immediate clean-up efforts should have been made as soon as PCBs were known to exhibit effects toxic to man.

The GE site investigation was initiated by a GE employee. A concerned and informed individual was responsible for bringing attention to a severe environmental hazard. I feel this indicates the possibility for public or worker involvement in identifying potentially hazardous situations. To instigate citizen awareness, an environmental educational effort must be made.

Along with public awareness, industry should make an effort to develop environmentally protective measures. Adequate testing for long- and short-term effects should be made before a chemical is made available. Besides detailed safety testing, industry should prepare a systematic clean-up procedure when harmful chemicals escape into the environment. Adequate precautionary measures using the best available technology should be implemented. Many industries claim environmental regulation costs too much, yet such measures as mentioned above could avoid costly individual clean-up attempts, increased government regulation, bad publicity and subsequent lawsuits. It appears GE is making such an effort.

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