

Commodore Semiconductor Group

Pump and Treat—Soil Vapor Extraction—In Situ Chemical Oxidation—BiRD

Site Name: Commodore Semiconductor Group

Site Location: Norristown, Pennsylvania

Technology Used:

- Pump and Treat (P&T)
- Soil Vapor Extraction (SVE)
- In Situ Chemical Oxidation (ISCO) (Sodium Permanganate)
- Biogeochemical Reductive Dechlorination (BiRD)

Regulatory Program: Superfund NPL

Remediation Scale: Full

Project Duration: 1993 to present

Site Information: The Commodore Semiconductor Group site was operated as a computer chip facility by Commodore Business Machines from 1970 to 1993. In 1994, GMT Microelectronics, Inc. acquired the site to produce integrated microelectronic circuits. In 2000, GMT Microelectronics discontinued operations and abandoned all of its assets, including the site. Currently, the property is owned by a developer who is marketing it for reuse as office space.

Contaminants: Leaking underground storage tanks that contained waste solvents contaminated the groundwater and vadose zone. Table 1 presents the initial maximum detected contaminant concentrations in groundwater in 1990. Contaminants were found in both the perched water and regional aquifer. Nearby residential wells contained elevated levels of contaminants as did two of the public water authority's deep wells. The extent of the plume in 1990 is shown in Figure 1. An upgradient offsite source of volatile organic compounds (VOCs) mingles with the site plume. This plume contains several of the same contaminants as the onsite source, except that it also has relatively high concentrations of Freon 113, which is not a Commodore contaminant. Hence, the presence of Freon in a downgradient Commodore monitoring well would indicate a commingled plume.

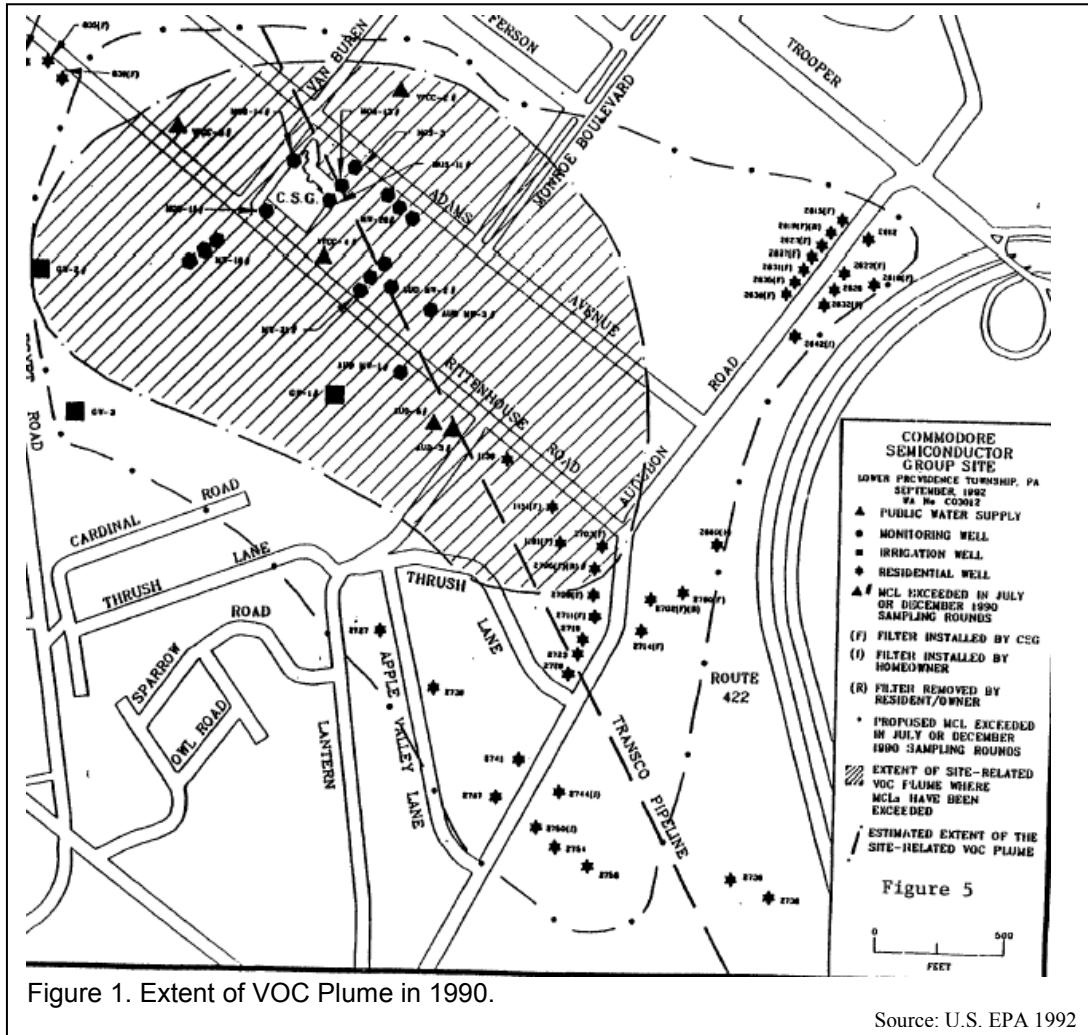
Table 1. Initial Groundwater Contaminant Concentrations

Contaminant	Maximum Detected Concentration ($\mu\text{g/L}$)
Chloroform	24
1,2-Dichlorobenzene	1400
1,4-Dichlorobenzene	17
1,1-Dichloroethane	12
1,2-Dichloroethane	110
1,1-Dichloroethene	122
1,2-Dichloroethene	4100
1,1,1-Trichloroethane	99
Trichloroethene	1800
Tetrachloroethene	280
Vinyl Chloride	24

Source: U.S. EPA 1992

Hydrogeology: The site is underlain by interbedded siltstone, fine-grained and medium-grained arkosic sandstone, red shale, very fine-grained red arkosic sandstone, and a few beds of coarse-grained sandstone and conglomerate. Groundwater movement through the bedrock aquifer occurs mainly through bedding-plane and high-angle fractures. Minor amounts of groundwater flow in the bedrock may occur through the primary porosity (unfractured matrix). The aquifer system was divided into two units based on depth. The shallow transition zone, which defines the upper 100-150 ft of the subsurface, consists of overburden and bedrock and is underlain by the deep bedrock aquifer. Very shallow perched water exists in the transition zone, which is hydraulically connected to the deep bedrock aquifer.

Project Goals: The initial remedies selected in the Records of Decision (RODs) were to connect residences on well water to the municipal system, prevent further migration of contaminants from the site, and eventually restore the site's groundwater quality to maximum contaminant levels or background levels, whichever is lower. Background at the site would include the contaminant concentrations of the offsite plume.



Cleanup Approach: The supply wells with their air stripping system, which was in place at the time of the ROD and maintained by the municipal water company, contained the deep aquifer contamination. In 1999, an onsite system of five extraction wells for shallow contaminant collection was constructed and began operation in August 2000. In addition, a French drain system that included one deep well (VFCC-4—a former municipal supply well) collected shallow water to prevent basement flooding at the main plant building. The onsite groundwater recovery and equalization system initially consisted of the following treatment processes:

- Weak acid cation exchange (WAC) to remove metals and minimize the potential for fouling subsequent process equipment.
- Air stripping to remove contaminants of concern (COCs) from the water.

- Vapor-phase carbon adsorption to capture COCs from the air.
- Nanofiltration to reduce total dissolved solids (TDS) and sulfates.
- Liquid-phase carbon adsorption as a final polishing step.
- Neutralization of process water to raise the pH prior to discharge.

Well VFCC-4 was reconfigured in September 2003 to include an inflatable packer at a depth of approximately 315 ft. Pumps were installed above and below the packer. This modification was made because water entering the well below 315 ft contained low concentrations of COCs and high concentrations of TDS and sulfate, while water entering the upper part of the well contained higher COC concentrations and low TDS and sulfate. The packer, which separated the well into two zones, allowed the proportion

of water pumped from the deeper zone to decrease, thereby reducing the TDS and sulfate concentrations in the overall well discharge. As a result, the WAC and nanofilter treatment processes were no longer necessary and were bypassed. The reconfiguration of well VFCC-4 increased drawdown in the more impacted portion of the aquifer, increased mass removal of COCs, decreased the COC concentrations in the lower zone of VFCC-4, improved treatment system efficiency, and reduced waste to the sanitary sewer. It also reduced operation and maintenance costs from \$418,000 to \$273,000. In January 2007, the municipal water company stopped accepting water from the treatment system. Treated water was then disposed of by pumping it to the sanitary sewer system. Attempts to find a more beneficial disposal method such as using the water for irrigation or disposal to a nearby surface water body have not been successful. The water company also reclaimed VFCC-4 and took it offline. The site has converted a deep monitoring well to replace it.

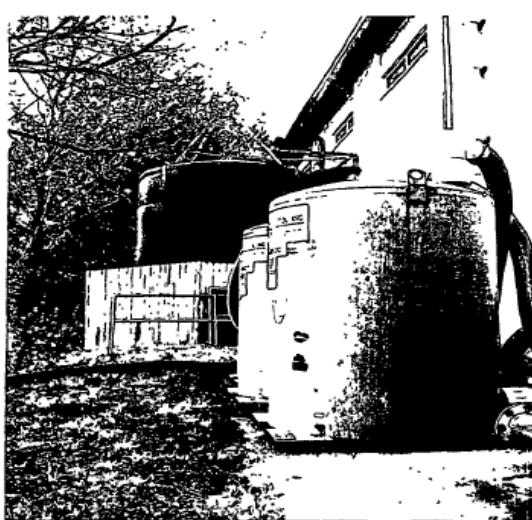


Figure 2. SVE Carbon Units

Source: U.S. EPA 2005

Continued evaluation of contaminant concentrations in the groundwater led to the belief that residual contamination in the transition zone bedrock might be an ongoing source of groundwater contamination. Thus, an SVE system was installed in two phases to address this source. Phase 1, the pilot phase, operated from March 2002 to June 2003. Phase 2, the full-scale opera-

tion, started in August 2003 and continued through March 2005. The full-scale system used eight wells, the French drain laterals, and carbon sorption units.

ISCO with a sodium permanganate solution was applied successfully to the unconsolidated soil underlying a 5,000 ft² area near the loading dock at the main building. A total of 3,575 lbs (12,500 gallons by volume) of potassium permanganate was injected, and a total of 660 lbs (321 gallons by volume) of sodium permanganate were injected into each injection point (U.S. EPA 2005). Twenty-five injection points were used inside the building, and 10 points were used outside around the loading dock. Permanganate lasted for four weeks after injection, and the two vapor monitoring points showed a greater than 90% reduction from baseline vapor levels.

Performance monitoring examined both the distribution of permanganate in the subsurface and the efficacy of permanganate in reducing the COCs. Permanganate distribution was monitored using a combination of oxidation reduction potential probes placed in selected wells and spot sampling with colorimetric analysis. After all the injections were completed, selected wells in both the treatment and perimeter areas were used to monitor the reduction in COCs.

A second ISCO injection to address deeper contamination was planned. The municipal supply wells were fitted with activated carbon filters in November 2006 due to concerns that permanganate might reach the municipal well field. Part of this installation included flushing the carbon units with water and food-grade citric acid. At the same time, the water company was flushing the water distribution lines. The timing of the two typically routine activities caused copper to chelate in the water lines, and blue-green water was distributed to customers for less than one day in November 2007. As a result of this incident, the water company terminated their agreement with the site, causing ISCO activities to cease.

A pilot Biogeochemical Reductive Dechlorination (BiRD) injection to determine if it will speed up the groundwater cleanup process is being planned for the site (see CDM 2008 for

discussion of this process). As of 2012, discussions with the water company over how this would be done are ongoing.

Project Results: By March 2010, more than 657 million gallons of water had been treated and 481 lbs of COCs had been removed via the recovery wells and the French drain. Water pumped from production wells accounted for about 85% of the total volume treated and 59% of the COC mass removed. Pumping water with higher COC concentrations from VFCC-4 improved system efficiency, defined as the mass of COCs removed per volume of water treated. P&T performance and plume recovery analysis is reported semi-annually.

The SVE system recovered over 750 lbs of COCs (68% of the total for the site). About 250 lbs of the recovered COCs were removed during the 16-month pilot-scale operation, and about 500 lbs were recovered in the 17-month full-scale operation.

The permanganate injection into the shallow zone of the site resulted in a significant reduction of contaminants.

Table 2 presents data from the third quarter of 2000 and the first quarter of 2010. There is a general downward trend of contaminant concentrations, but not consistently. For example, during this 10-year period, COCs in well MW30-S were 1,100 µg/L in 2000, as low as 66 µg/L in 2007, and 760 µg/L in 2010.

Table 2. TCE Trend Data from Selected Monitoring Wells (µg/L)		
Well Number	Q3 2000	Q1 2010
EW-2	190	43
EW-3	65	1.6
MOS-11R	190	20
MOS-13	31	5.8
MW-20D	9.9	17
MW-21D	170	35
MW-21M	55	18
MW-30D	42	26
MW-30S	1,100	760
MW-31D	180	22

Source: ERM 2007 and EPA 2010

The offsite source plume, which contains site COCs above cleanup criteria, complicates measuring total success. The presence or absence of Freon 113, which is not a site contaminant but is in the offsite plume, can be used to determine the presence or absence of the offsite plume in a site's monitoring wells but not necessarily the actual contribution of the offsite plume to total contaminant concentrations.

Sources:

ERM. 2007. CSG Pump and Treat Performance and Plume Recovery Analysis, Second Quarter 2006 through First Quarter 2007.

CDM. 2008. Workshop on In Situ Biogeochemical Transformation of Chlorinated Solvents.

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