SITE NO. 8
3M COMPANY
WOODBURY, MINNESOTA

INTRODUCTION

From 1960 until 1966, spent solvents and acids from 3M's Chemolite and St. Paul scotch tape and sandpaper operations were disposed in pits at a site in Woodbury Township, Minnesota. In May 1966, a private well near the disposal site was found to be contaminated by one of the solvents, isopropyl ether. Dumping was immediately discontinued and a sampling program of the area ground water wells was initiated. Although many of the well water samples tested contained elevated concentrations of nitrates, only the one originally affected well was found to be contaminated with organic solvents. Analysis of water from a test well drilled at the disposal site indicated isopropyl ether concentrations of 4 to 5 mg/l occurred in the shallow drift and decreased to 0.1 mg/l at a depth of 61 m (200 ft).

During late winter 1968, the pits were excavated and the waste removed and burned on-site in open cells. Between 1966 and 1971, solvent waste produced by 3M was sent to off-site incinerator facilities. Additionally, in-house operations were tightened to reduce the amount of waste that would require disposal. In 1971, an incinerator was constructed by 3M to destroy ? decompose their solvent wastes.

Four barrier wells were installed at the Woodbury site to halt the spread of ground water pollutants. These barrier wells continuously pump and discharge approximately 0.16 m^3/sec (3.6 mgd) with a daily maximum discharge of 0.19 m^3/sec (4.3 mgd). A portion, approximately 60 percent, of the barrier well water is presently used as non-contact cooling water for the Chemolite plant operations. As a result of withdrawing ground water using barrier wells, the top shallow aquifer, which provided well water

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for the isopropyl ether contaminated well, has gone dry. The barrier wells are presently withdrawing water from the Shakopee Aquifer and will continue to do so indefinitely. The water is discharged to the Mississippi River at Milepoint 817. Based upon analytical results, both 3M and the Minnesota Pollution Control Agency appear to be satisfied that the barrier wells have effectively prevented migration of the contaminants from the Woodbury site.

SITE DESCRIPTION

Site Layout

Figure 8-1 shows the directional relationship of Minnesota Mining and Manufacturing's (hereafter called 3M) Woodbury disposal site to Chemolite, the Twin Cities, and to the Mississippi River. The 3M Woodbury disposal facility is located on the eastern side of the Twin Cities (Minneapolis-St. Paul) metropolitan area. The Chemolite Manufacturing facility of 3M, which provided a major portion of the waste disposed at the Woodbury site, is located about 5.6 km (3.5 mi) south of the Woodbury disposal facility.

Environmental Setting

The geology in the area consists of Paleozoic bedrock overlain by glacial drift averaging 15.2 to 30.5 m (50 to 100 ft) thick. The site appears to lie in a buried glacial valley. During an earlier time period, the valley (channel) apparently was cut by a tributary which fed into the nearby Mississippi River. The channel was subsequently filled with sand and gravel from more recent glaciation. The buried bedrock channel trends toward a northwest to southeast direction and was carved out of the Prairie du Chien-Jordan Aquifer.

Beneath the glacial outwash, Platteville limestone, a medium dense gray shaley limestone, overlays the St. Peter Sandstone. The St. Peter Sandstone in turn overlays the Shakopee-Oneota dolomite, which overlies the Jordan Sandstone. The Shakopee

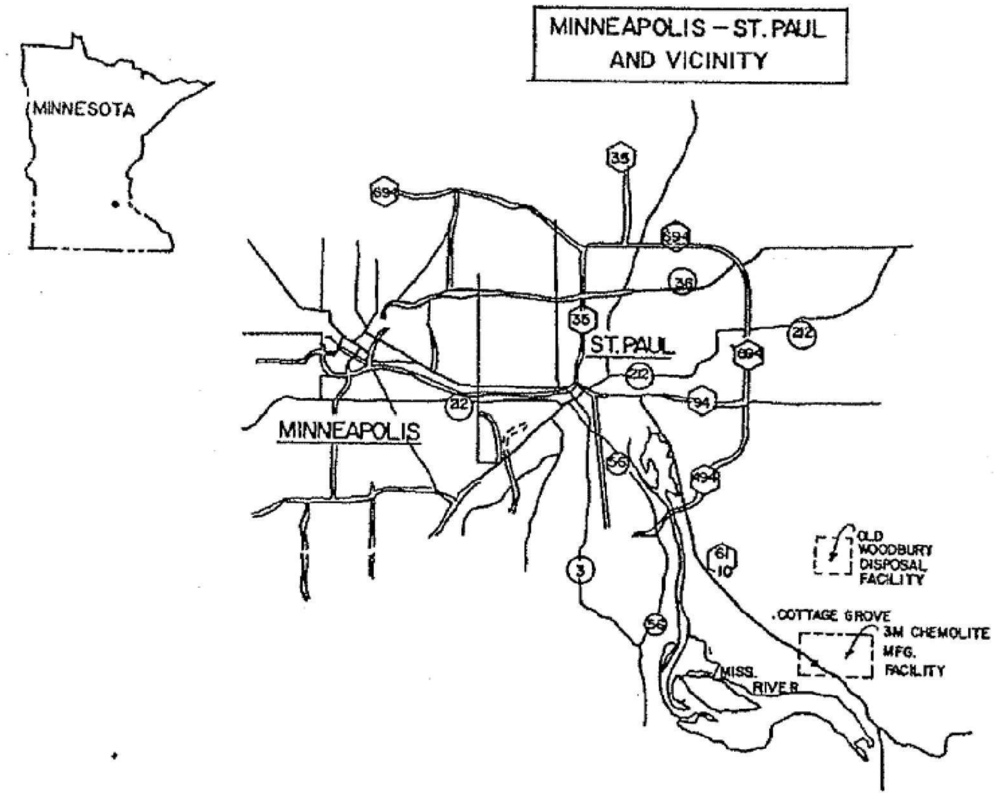

Figure 8-1. Location of 3M Woodbury Disposal Site
Woodbury, Minnesota.

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dolomite is not a tight formation and contains fractures created by previous glacial loadings. The pits at the Woodbury disposal site are located in the glacial outwash over the Shakopee dolomite. Therefore, it is speculated that if any contaminants reached the Shakopee, easy access would be provided to the underlying Jordon aquifer.

The outwash glacial material in the area is typically clay and gravel. The soil is a sandy loam provided by the glacial material and is reasonably fertile. The limestone provides an alkaline pH to the soil. The soil lends itself to drought conditions due to its sandy nature. The topography of the area is also influenced by previous glacial movements. The land is slightly rolling to flat with only minor ravine systems.

There are no drainage creeks or rivers in the immediate site area since the glacial till acts as a sponge. Therefore, there was never a concern with runoff into creeks or streams. The disposal pits provided a basin of their own. The surface drainage of the Twin Cities area consists of potholes, swamps, lakes, and only a few small river valleys. Due to the nature of glacial drift, a drainage river valley appears for only about a kilometer or so before terminating in a marsh area. The only significant drainage river in the area is the Mississippi River. The Mississippi River breaches a major underground water source, the Jordon aquifer.

The commercial and residential water supply for the area primarily comes from ground water wells. Industries in the surrounding area depend upon the Jordon for their supply of water. The Jordon is a high quality aquifer and provides a controlled temperature water. However, it is hard due to the presence of dissolved solids.

Prior to installation of barrier wells, two ground water bodies were located beneath the pits in Woodbury: a perched water table and the Jordon aquifer. Figure 8-2 displays a generalized geological cross section of the area beneath the site.

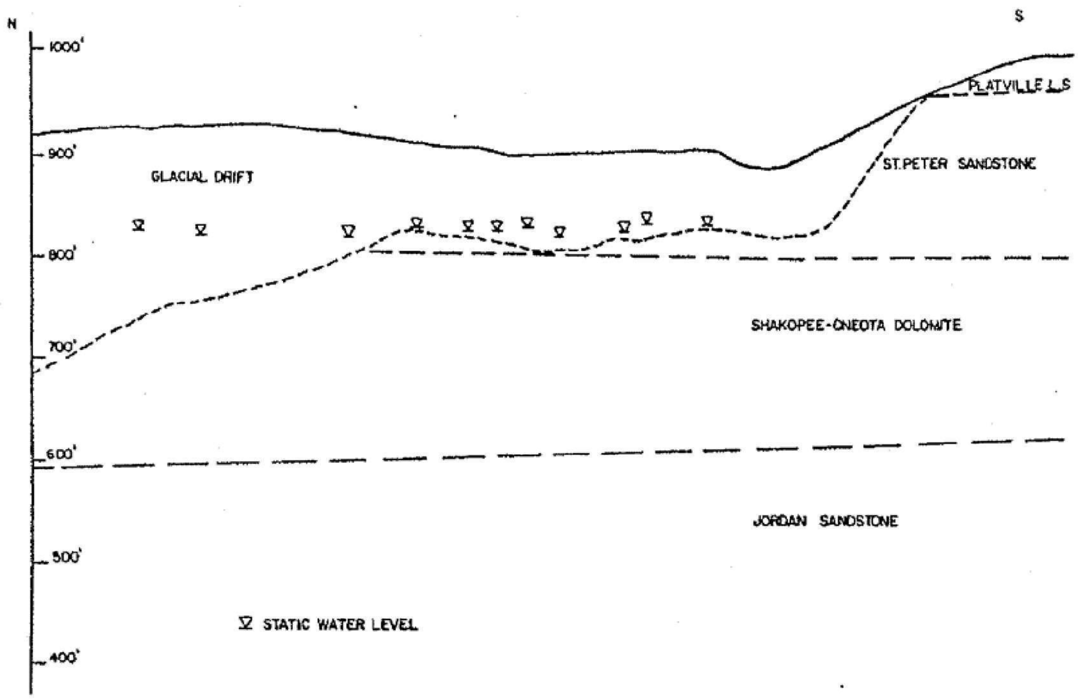

Figure 8-2. Geological cross section of area beneath Woodbury site.[1]

The perched water table which was located in the glacial drift material immediately below the pits supplied water to shallow wells in the immediate vicinity. Three years after 3M's installation of barrier wells, the perched ground water in the glacial till had dissipated. Therefore, presently the only ground water body located beneath the old pit area is the Jordon aquifer. The glacial drift ground water tended to flow southwestward to south toward the Mississippi River. The Jordon aquifer flows generally northwestward from the site area toward Minneapolis and St. Paul.

The normal annual precipitation for the area is 66 cm (26 in.) and the normal annual snowfall is 117 cm (46 in.). The average wind speed is 16.9 kph (10.5 mph) with the maximum having occurred during a 40 year time period at 148 kph (92 mph) from the west. The normal daily maximum temperature is approximately 12°C (54°F) with the highest temperature occurring in July at 28°C (82.4°F) and the lowest in January at -6°C (21.2°F). The average annual evaporation is approximately 102 cm/yr (40 in./yr). There are approximately 160 freezing days per year in the Twin Cities area.

SITE OPERATION AND HISTORY

In 1960, Terminal Warehouse purchased 12 to 16 ha (30 to 40 ac) of land in Woodbury, Minnesota for use as a waste disposal site. Prior to 1960 the land was farmland. Even today, the land surrounding the site is used to grow grain crops such as corn. After the property was purchased by Terminal Warehouse, 3M commissioned Terminal Warehouse to haul and dispose their waste at the site in unlined lagoons (pits). In August 1961, 3M purchased the land from Terminal Warehouse and continued to use it for disposal of waste from their Chemolite plant (located in Cottage Grove Cove, Minnesota) and downtown St. Paul facility. Unlined pits were used by 3M as a permanent containment for liquid wastes such as spent solvents and sludges and solid wastes such as scrap plastic. 3M also allowed Woodbury Township to dispose their municipal waste in the southeast corner of the property. Figure 8-3 shows the location of the pits at the Woodbury site. The municipal waste was segregated and kept outside the pit areas used for solvent, acid, and facility waste of 3M. Only a minor amount of Woodbury municipal waste was disposed at the site in relationship to the 3M waste. This was one of the factors which prompted 3M to purchase the property in 1961 and to haul their own wastes to the site. Presently 3M owns some 101 to 113 ha (250 to 280 ac) in the immediate vicinity of the disposal area.

Little is known about actual operations at the disposal site. No records were kept as to type and quantity of wastes disposed. It has been estimated that 153,000 m^3 (200,000 yd^3) of wastes were disposed in the area. The waste consisted of solvent contaminated material, adhesive, rolls of film, rags, resins, and off-specification materials. Approximately 50 percent of the waste was in a liquid form, and consisted of an estimated 760 m^3 (200,000 gal) of isopropyl ether. It was also estimated that 23,000 m^3 (6,000,000 gal) of wet scrap was disposed at the site.

The solvents which were deposited at the site had been used as carrier agents to maintain a fluid condition of the adhesives applied on scotch tape and sandpaper. Scotch tape and sandpaper are the principal products of the 3M Chemolite and St. Paul facilities. The chief solvent used as a carrier agent was heptane. Other solvents used were acetone, isopropyl ether, and toluene. The wet scrap which resulted from the manufacturing processes for scotch tape and sandpaper consisted of wash water, filter trappings, discarded rolls of tape, general residue of manufacturing processes, and general housekeeping equipment wastes. Wet scrap was categorized as non-pumpable and pumpable. The highly flammable liquid waste was sent to Newport, Minnesota and burned on a contract basis. The waste which was considered at the time to not be a desirable wet combustible material was placed in pits at the Woodbury site.

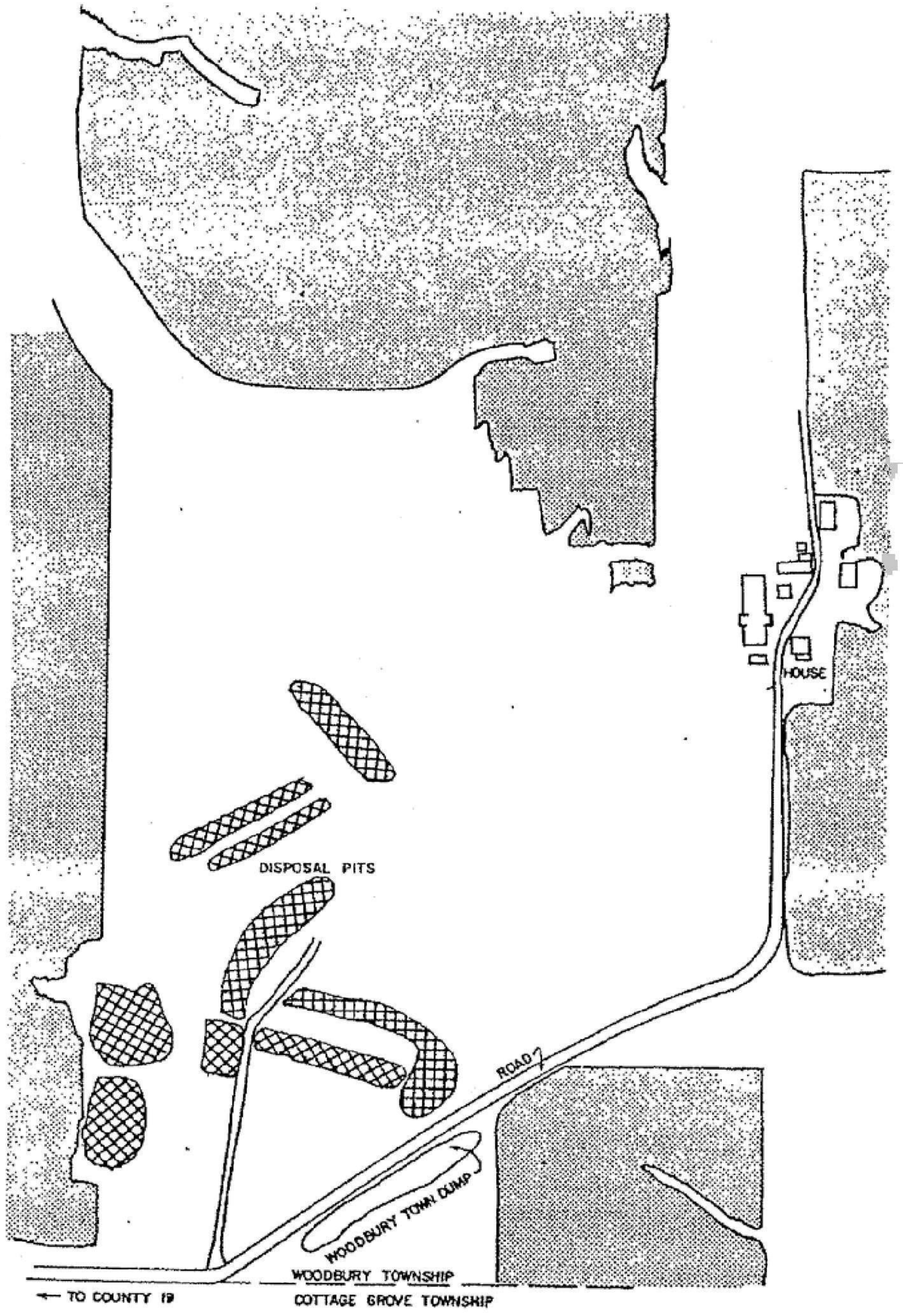

Figure 8-3. Pit location at 3M Woodbury disposal site.[2]

Prior to 1963, various acids, chiefly sulfuric, were dumped in limestone pits at the site. In late 1963, Minnesota Water Pollution Control Commission (MWPC) informed 3M that ground water contamination could occur as a result of their practices and recommended that the dumping of acids be discontinued and that all other wastes be placed in clay pits. These conditions were accepted and implemented by 3M. In 1962, the first clay lined pit was installed. In 1963 a limestone pit was constructed at the Chemolite plant and disposal of acid was discontinued at the Woodbury facility. Toward the end of use of the disposal pit facility, 3M had begun to make florocarbons. Concentrated wastes from the florocarbon production went into the Platefill limestone pits as well as the various acids. However, this practice was not long lasting.

When evidence of ground water contamination appeared in 1966, 3M stopped all disposal activities at the Woodbury site. General housekeeping practices were instituted to cut down on the amount of waste to be discarded. Wet scrap was sent to Shakopee, Minnesota for incineration from 1966 to 1971. In July 1971, an incinerator was put into operation at the Chemolite plant facility. When the Shakopee facility began experiencing problems with the regulatory agencies, 3M removed 25,000 drums in 1973. Most of the removed waste was burned at 3M's new incinerator at the Chemolite facility.

POLLUTION

One of the biggest problems associated with the disposal pits at the Woodbury site was that the Company had no idea as to the exact nature and quantity of wastes dumped into the pits. In May 1966, a private well near the site was found to be contaminated with one of the solvents (isopropyl ether) being disposed by 3M. The private resident noticed a peculiar chemical odor in the drinking water. The odor was particularily apparent during use of his automatic dishwasher.

Eighteen residential wells were sampled in Woodbury Township and Cottage Grove Village around the disposal area. Eleven of the eighteen well water samples had nitrate concentrations in excess of the maximum allowable concentrations recommended by the United States Public Health Service for use in feeding infants. However, the high nitrate concentrations were not the result of chemical contamination from the disposal site, but were rather due to barnyard runoff. Only the originally affected well, not included in the 18 well study, contained organic chemicals. A gas chromatograph was used in 1966 to determine the presence of trace organic chemicals by comparing control water samples from three wells located out of the influence of the disposal site to the 18 residential well water samples.

By August 1966, all the wells in the area had been sampled and use of the disposal site had been discontinued. Eugene A. Hickok and Associates was retained by 3M to determine the extent of the problem and to make recommendations regarding its solution. A 61 m (200 ft) 30 cm (12 in.) test well was drilled on the site on September 13, 1966. Resistivity test equipment was used to determine the best location of the test hole, and the resistivity of the glacial drift between the contaminated resident's (Schuessler's) well and the dumping area. Figure 8-4 exhibits the location of Schuessler's well in relationship to the disposal site and to the test hole (later called Observation Well A).

Drilling of the test well stopped at two levels in the glacial drift, three levels in the Shakopee-Oneota limestone, and one level in the Jordon Sandstone. Water samples were collected from each level for analysis. Additionally, water samples were collected from two 3M existing 5 cm (2 in.) observation wells and the caretaker's well located on the disposal site. One observation well is located in the northwest

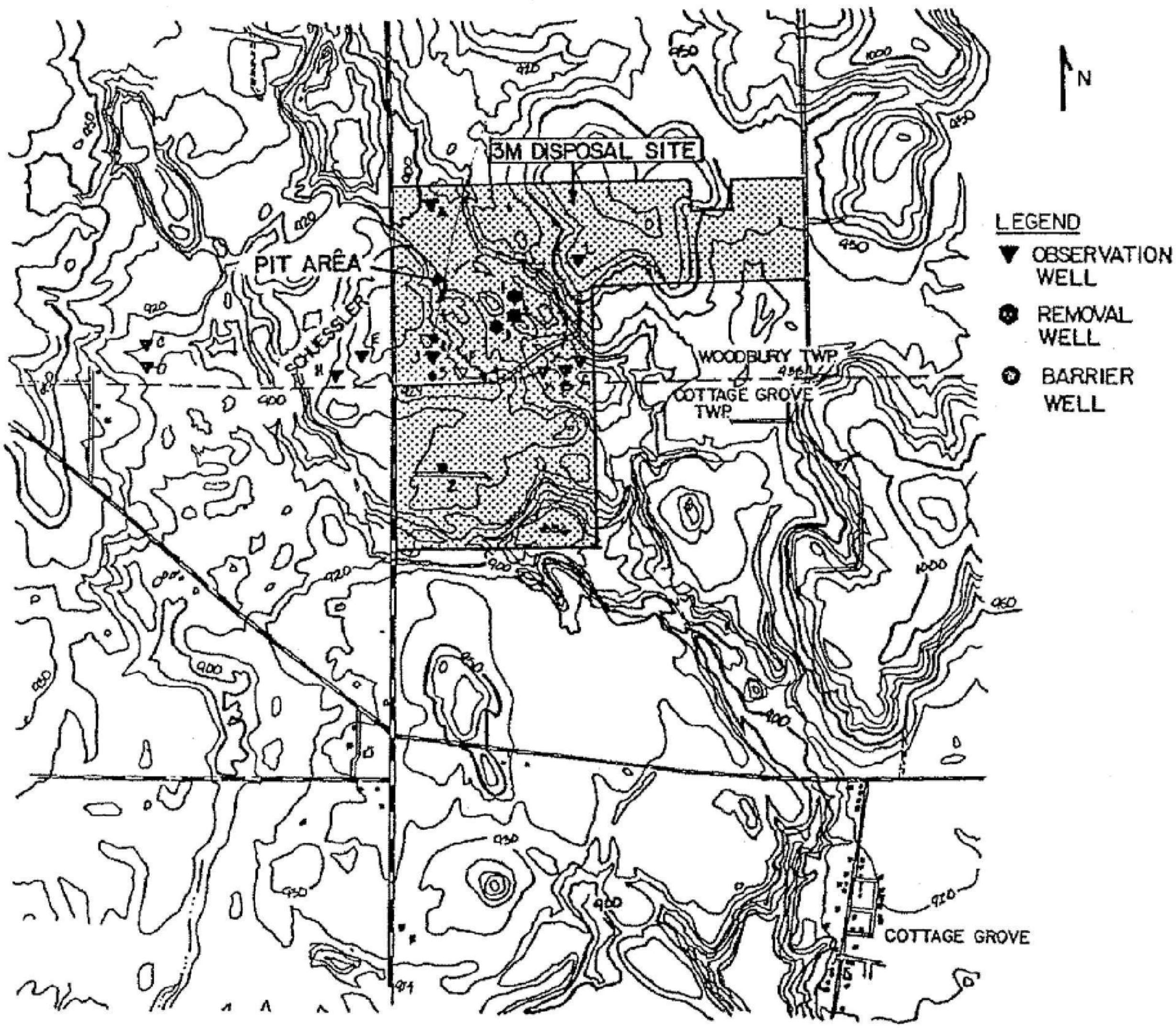

Figure 8-4. Location of contaminated well (Schuessler well) and barrier wells.[1,3]

corner of the site, one in the southwest corner, and the caretaker's well is located east of the disposal area equi-distant between the two observation wells. The observation wells finish in the St. Peter sandstone and are open to both glacial drift and sandstone.

Analysis on the above wells showed that the glacial drift and upper levels of the Shakopee-Oneota limestone at a depth of about 61 m (200 ft) were chemically contaminated. The concentration decreased substantially with an increase in depth. Only insignificant trace concentrations of chemicals were detected in the Jordan sandstone. Isopropyl ether was the dominant pollutant with concentrations varying from 4 to 5 ppm in the shallow drift to less than 0.1 ppm at 47.5 to 61 m (156 to 200 ft). Isopropyl ether was identified as being the contaminant causing the odor problem at the Schuessler's residence. Isopropyl ether is very mobile and has a low odor threshold in the ppm range.

Since confirmation of contamination of upper ground water aquifer, regular monitoring has been conducted at the nearby residential wells. Ten area wells are now sampled bi-monthly by the Department of Health and by 3M. Previously, 3M had sampled 52 wells in the surrounding neighborhood on a bi-monthly schedule. The 10 wells presently sampled are located in glacial material and have shown no chemical contamination except for barnyard runoff. Schuessler's well was the only well ever found to be contaminated with organics. As a result of barrier well water withdrawal, the glacial perched water table was dissipated and Schuessler's well went dry around 1970. A new well was installed for Schuessler which retrieves ground water from the Jordon aquifer. The Jordon was never found to be contaminated with isopropyl ether. Figure 8-5 exhibits the combined concentration of isopropyl ether and other compounds at the Schuessler well. The new well installed for Schuessler in 1970 was never found to be contaminated with isopropyl ether.

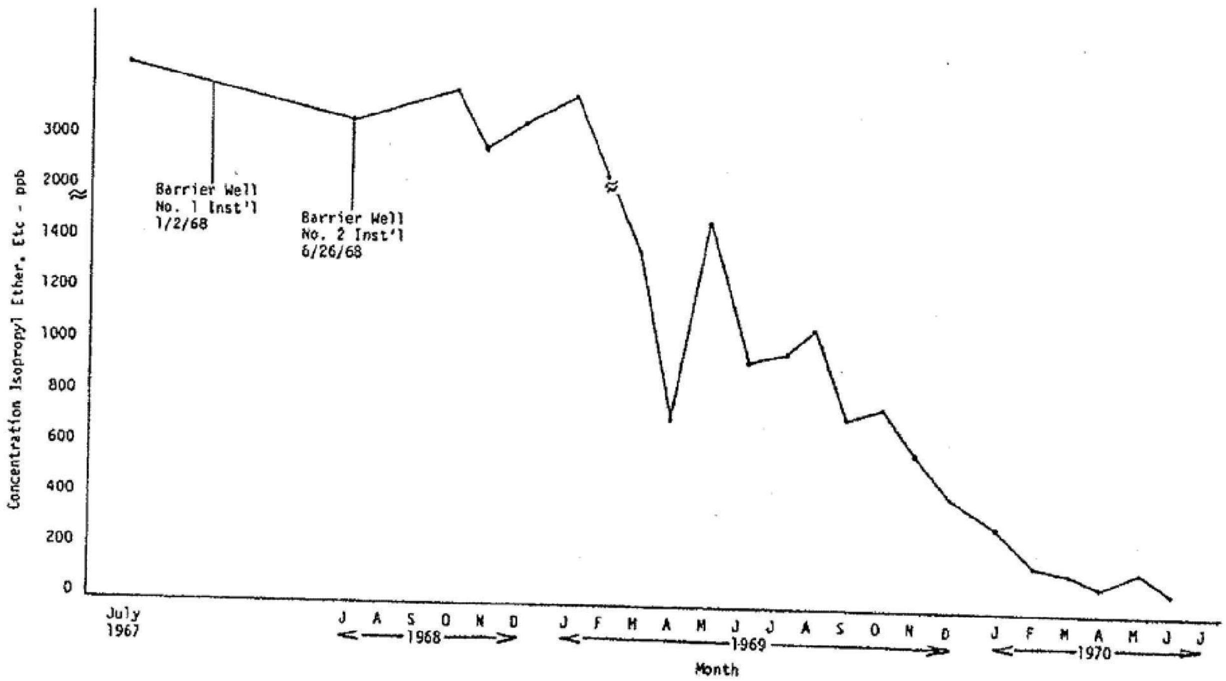

Figure 8-5. Sum of the Concentration of isopropyl ether, isopropanol, and dichloromethane for Schussler well Woodsbury Township

REMEDIAL ACTION

Based upon determinations that the contaminants were located chiefly in the upper ground water table and had not migrated extensively, the following remedial actions were initiated:

- All disposal activities at the site were discontinued.
- General housekeeping practices were tightened to reduce waste. The waste which was produced and which required disposal was sent to an outside incinerator/disposal facility. In 1971, an incinerator was built on plant property at the Chemolite facility to burn acceptable wet scrap.
- Waste within the pits was removed and burned.
- Barrier wells (a total of four) were installed to stop the possible spread of contaminants and to remove the dissolved contaminants by removing contaminated ground water. These wells were installed down gradient from the site to reverse the direction of ground water flow. The water removed from the barrier wells is discharged to the Mississippi River in an approved manner and is monitored regularly.
- A regular monitoring program of residential wells in the immediate vicinity of the disposal site was instituted to ensure that these wells remained free from any chemical contamination.

Several alternatives were considered for reducing and disposing the solvent/wet scrap waste located in the pits. For lack of other viable alternatives it was decided that the waste would be excavated from the pits and open burned. It was postulated that a time limited, large-scale burning project would rid the pits of solvents judged to be the source of ground water contamination and would shorten the time necessary to bring the ground water back to an acceptable quality. Alternate solutions would take longer. A trial test was required to determine possible problems encountered with burning the waste.

The trial open cell burning test was conducted in August 1967. A drag line was used to excavate the waste from the pits and to pile it beside the pits in 0.3 to 0.6 m (1 to 2 ft) layers. During the burning process, the drag line was used to mix the burning mass and to accelerate the burning efficiency. Following the test, samples of the remaining residue were collected for analysis. The overall waste volume had been reduced about 95 percent and the contamination in the waste had been reduced by more than 99 percent. The residue was soaked with water and no contamination was found in the water. Based on their results, it was decided that the residue could be placed into the ground without further seepage. It was decided that as an extra precaution, the burned residue should be placed above ground, diked, and observed over a period of time before burying it.

The burn test was considered to be successful, therefore, 3M obtained approval for open burning from the Woodbury and Cottage Grove villages. Burning was conducted during the winter (January) of 1968 to avoid adverse weather conditions, and to take advantage of high temperature differential and low vapor pressure. Burning was conducted on a 24 hour day, 7 day week basis until all waste had been burned. It is estimated that 153,000 m^3 (200,000 yd^3) of waste was burned during this period.

On January 2, 1968, one cell 15 m x 30 m (50 ft x 100 ft) and two cells 15 m x 15 m (50 ft x 50 ft) were filled to a depth of about 0.6 m (2 ft) with excavated waste and burned. As soon as these cells were burned, two more cells 15 m x 30 m (50 ft x 100 ft) each were filled and subsequently burned. During the burning the air was monitored with a network of check stations. The monitoring network consisted of five stationary sampling stations located at residences on each side of the property and one in the concentrated population of Cottage Grove Village. In addition to the stationary sampling stations, a mobile unit was provided by the City of St. Paul to sample various points for contaminants in the burning area. Carbon dioxide, sulfur dioxide, suspended particulate matter, and settleable particulates were monitored. A weather station located near the burning area provided data on wind direction, wind speed, and ambient temperatures.

After the burning was underway in the open cell pits, it was determined that the disposal pit itself could be burned and mixed more effectively and efficiently once its capacity was reduced by one-half to two-thirds than by removing the waste and burning it in cells on the ground. Only stirring to reintroduce oxygen was required to keep the fire going. When unfavorable weather conditions existed, burning was reduced. A significant amount of smoke was generated during the burning. However, no excessive concentration of any of the products of combustion were found at any of the sampling stations during the burning period. Occassionally a slight odor was noticed at one or more of the sampling stations. When intensity of the odor increased, the burning was reduced. The air monitoring program carried out during the burning period by 3M did not indicate any potential health or vegetation damage. Growth tests were conducted on collected ash in the air sampling network to determine the composition and effect of the ash fallout on future vegetation. The ash was basically carbonaceous. It was determined that the carbonaceous ash would not effect the growth of vegetation.

Once the burning had been completed, the remaining residue (metal, ceramic scrap, etc.) and ashwall was piled above ground, diked, and observed for a period of time, and then buried in the pits. The waste had been reduced more than 99 percent. The area was then allowed to reclaim itself naturally. Native grasses and trees have reclaimed most of the land and only minor areas of erosion are noticable. It was believed by 3M personnel that encapsulation would encourage migration of ground water from the site. It is believed that allowing the excavated pits to form a precipitation collection basin would encourage faster infiltration of contaminated soil and thereby enhance release of the contaminants! These released contaminants could then be collected and withdrawn with the installed barrier wells. At one time the possibility of placing a sprinkler in the pit area to enhance penetration of contaminants into the aquifer was considered. However, by that time, 3M was using most of the withdrawn water and did not wish to deflect that much water to a sprinkling system.

Based upon a hydrological study by a consultant, it was determined that contamination had not gone very deep and had only migrated in one direction, with Schuessler being at the leading edge. Therefore, barrier wells designed to operate continuously were installed in an effort to prevent further migration of contaminants and to remove the contaminants from the ground water. The first barrier well went into operation on January 2, 1968. In 1974, the last barrier well, Barrier Well No. 4, was installed. Barrier Wells 1 and 3 withdraw water from the Jordon. The Jordon ground water is not contaminated and is used to dilute the contaminated water withdrawn by Barrier Wells 2 and 4 which withdraw from the Shakopee dolomite. The four wells withdraw a monthly average of 0.16 m^3/sec (3.6 mgd). Originally water from Barrier Well No. 1 was recycled back to the excavated disposal pits to dislodge and dissolve chemicals absorbed to the soil and to flush the aquifer. This practice has since stopped.

Presently, approximately 60 percent of the withdrawn water from the Woodbury site is used at the Chemolite plant as a non-contact cooling water. The remainder of the withdrawn water is discharged to the Mississippi River.

Table 8-1 shows the horsepower of the barrier well motors and the average discharge quantity per barrier well. Figure 8-4 exhibits the location of the barrier wells. Figure 8-6 shows that a decrease in concentration of isopropyl ether has been experienced since the introduction of the barrier wells. Table 8-2 displays 19 priority pollutants which were found in the discharge water. The discharge system consists of a 9.7 to 10 km (6 to 7 mi) discharge underground forcemain privately owned by

TABLE 8-1. HORSEPOWER AND DISCHARGE OF BARRIER WELLS

Well No.	Motor Horsepower	Average Discharge m^3/min	Average Discharge gal/min
1	75	0.38	100
2	40	2.65	700
3	50	1.89	500
4	125	4.54	1200

TABLE 8-2. 3M WOODBURY WELLS PRIORITY POLLUTANT SAMPLING RESULTS

Name	Concentration (ug/1)
Benzene	1
1,2-Dichloroethene	3
1,1,1-Trichloroethane	1
1,1-Dichloroethane	3
1,1,2-Trichloroethane	4
2,4,6-Trichlorophenol	1
Parachlorometa cresol	1
Chloroform	5
Ethylbenzene	4
Methylene Chloride	8
Phenol	<1
Bis (2-ethylhexyl) Phthalate	9
Diethyl Phthalate	2
Toluene	2
Trichloroethylene	1
Endosulfan-Alpha	<0.01
Endrin Aldehyde	0.14
Heptachlor Epoxide	<0.01
BHC-Alpha	<0.01

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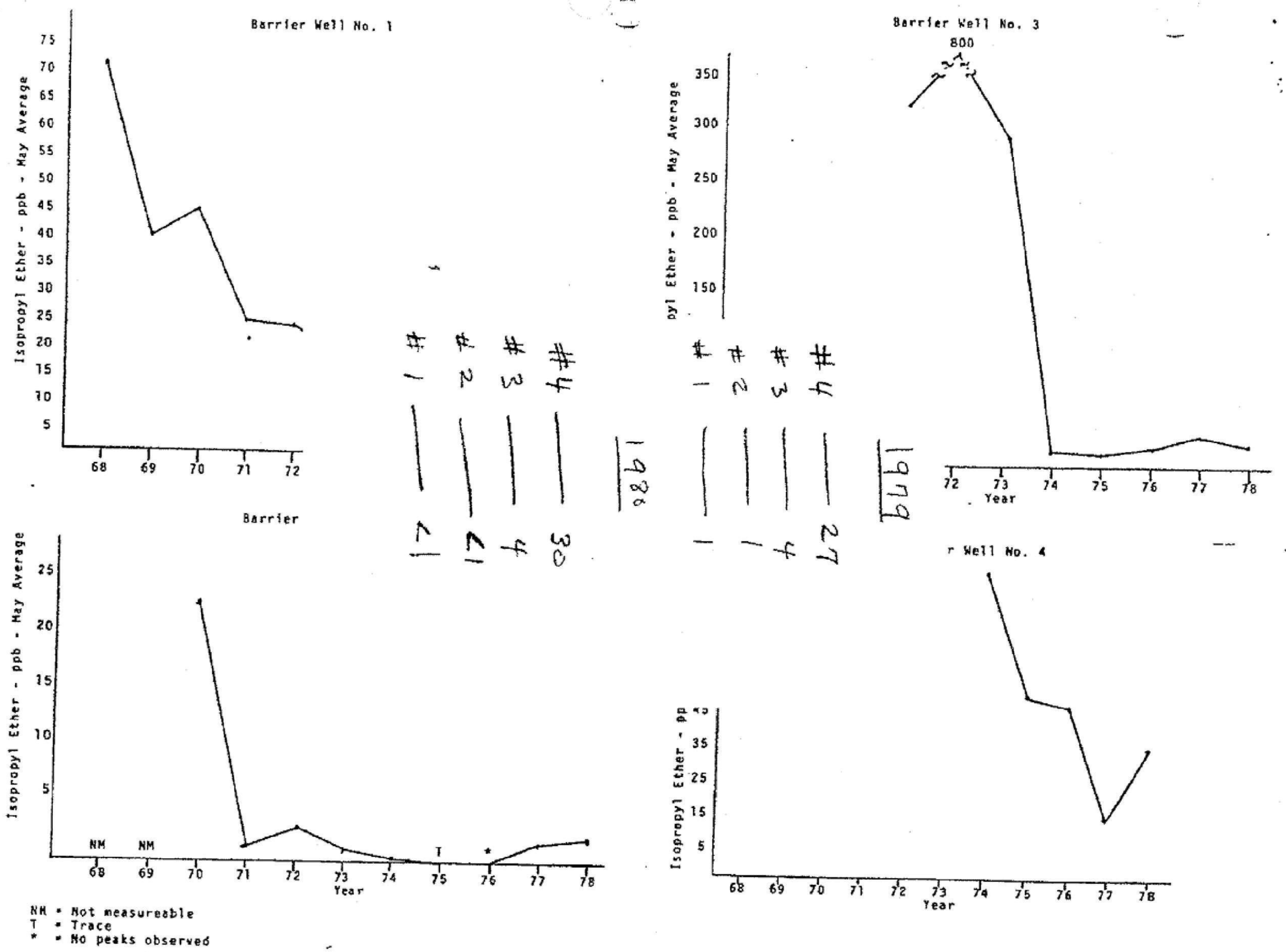

Figure 8-6. Graphs of isopropyl ether measurements for Barrier Well Nos. 1 to 4.

1979

#4 — 27
#3 — 4
#2 — 1
#1 — 1

1980

#4 — 30
#3 — 4
#2 — <1
#1 — <1

3M and which allows effluent discharge into the Mississippi River at Milepoint 817. The forcemain consists of 5,000 m (16,400 ft) of 46 cm (18 in.) diameter iron pipe and 3,286 m (10,782 ft) of 46 cm (18 in.) diameter asbestos cement pipe. After forcing the water uphill for about 2 m (7 ft), the water flows down gradient to the Chemolite facility prior to eventual discharge into a ravine which empties into the Mississippi River. The receiving water is classified for propagation and maintenance of rough fish, fish commonly inhabiting waters of the vicinity under natural conditions, and boating and other forms of aquatic recreation.

Presently these barrier wells are expected to operate indefinately since they now serve another function as a supply of cooling water. Pumping is continuous. When the wells were first installed, power failure due to electrical storms was not uncommon. Power interruptions would shut the pumps off. To correct the problem, the pumping system was automated and a telephone circuit installed to relay problem information to the Chemolite personnel. The systems are checked once each day.

Initial attempts to use the withdrawn water resulted in migration of iron oxides, manganese oxides, and iron bearing bacterial slimes. To correct this problem, chlorine is added initially to the well discharge to inhibit iron reducing bacteria and a stabilizing chemical (Nalco 345) is used to prevent precipitation of iron and manganese oxides. Nalco is a polyphosphate and an anticoagulation agent. To prevent discharge of chlorine into the Mississippi River, the withdrawn chlorinated well water is dechlorinated with sulfur dioxide prior to discharge.

In 1972, a $4.6 million incinerator was constructed at 3M Chemolite to burn industrial liquid and semi-liquid chemical wastes which had previously been placed in pits at Woodbury. The incineration system includes a large materials handling building, five 38,000 l (10,000 gal) tanks for liquid waste storage, a specially designed feed system for 208 l (55 gal) drums, a large rotary kiln with secondary combustion chamber, high energy venturi scrubber for air pollution control, wastewater treatment facility, and a 61 m (200 ft) discharge stack.

Not counting the amount spent on development and operation of the incinerator, 3M has spent over $7 million dollars at the present time to correct the environmental situation at Woodbury. Approximately $95,000 is annually spent on barrier well operating costs.

CONCLUSION

When the problem of ground water contamination first appeared in connection with the Woodbury 3M facility, 3M immediately took responsible actions to mitigate and correct the problem. Previous practices were stopped, an investigation was undertaken to determine the extent of the problem, and corrective actions were initiated.

Within one and a half years, the waste had been removed from the pits and burned. It is unlikely that open burning would be accepted under today's air quality standards. In early 1968, when the burning was underway, even the Minnesota Pollution Control Agency did not wish to condone the open pit burnings. At that time the Minnesota Pollution Control Agency had not yet formulated an air control policy and had not established a permit system nor promulgated any air pollution control rules or regulations. The burning operations were chosen as the best method of getting rid of a reservoir of solvents judged to be the source of ground water contamination.

The use of four barrier wells appear to have effectively reduced the migration of contaminants from the area. Presently 3M uses some of the withdrawn water as a non-contact coolant and, therefore, has opted to derive benefits from money spent on a system used to correct a pollutant problem.

In general, the Minnesota Pollution Control Agency has been pleased with the efforts and prompt action of 3M and believe that the barrier well system is an appropriate corrective action.

Likewise, good public relations exist between 3M and the town of Woodbury and Cottage Grove. Several village meetings have been held during the years about the problem. 3M's installation and operation of an effective incinerator demonstrates their foresight for the proper management of hazardous materials.

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3. Personal communication and file review with Gary Kimball, Minnesota Pollution Control Agency, Permits Section, Division of Water Quality, Roseville, Minnesota, June 25 and 27, 1980.