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VOLATILE ORGANIC COMPOUNDS (VOCs) IN SMALL COMMUNITY WASTEWATER DISPOSAL SYSTEMS USING SOIL ABSORPTION

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Bruce A. Greer

An Independent Study Report Submitted In
Partial Fulfillment of the Requirements
for the Degree of Master of Science
(Civil and Environmental Engineering)
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The University of Wisconsin-Madison

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INTRODUCTION

Individual residences, communities and small commercial establishments often dispose of wastewater through individual or community septic tank soil-absorption systems. It has been estimated that 18 million housing units, or 25% of all housing units, in the United States dispose of their wastewater using on-site wastewater treatment and disposal systems (USEPA,1980). The design goals of such systems include effective treatment of contaminants in the wastewater using the capabilities of the septic tank and soil, and discharge of treated effluent to groundwater.

Groundwater pollution is a major consideration when septic tank soil absorption systems are used. Numerous Federal and State programs for protecting groundwater quality have been established and expanded in recent years. These efforts have contributed to the identification and inventorying of sources of groundwater contamination. The Office of Technology Assessment (OTA) identified domestic wastewater subsurface percolation (e.g., septic tanks and cesspools) as the largest source of discharge to groundwater, approximately 820-1,460 billion gallons per year (OTA 1984). The report indicated the presence of organic chemicals, inorganic chemicals, and biological sources of contamination in the subsurface percolation systems.

In October of 1985 the Wisconsin Department of Natural Resources promulgated Wisconsin NR 140 for the protection of groundwater quality in the state of Wisconsin. This statute set standards for both inorganic and organic contaminants. The use of and array of commercial products such as disinfectants, solvents, and cleaners is increasing. Organic compounds, specifically volatile organic compounds (VOCs), that maybe present in these products are of concern with respect to septic tank effluent and the receiving groundwater. The presence of priority pollutants in septic tank soil absorption systems has only recently been investigated with respect to groundwater pollution (Tomson 1984). Organic compounds specifically VOCs present in septic tank effluent (STE) are of concern. This concern arises because of their persistence in the environment and evidence of carcinogenicity to humans.

This paper presents a summary of the results of a field study of six subsurface soil absorption systems with respect to VOCs present in effluents and adjacent groundwaters. The results of monitoring septic tank effluent for VOCs at six septic tank soil absorption systems (STSAS) are presented. The results of groundwater monitoring for VOCs at four STSAS are also presented.

The objectives of this study were:

1. To complete a literature review of the potential sources and presence of VOCs in on-site wastewater disposal,

2. To identify VOCs in the septic tank effluent, septage and the groundwater at sites using septic tank soil absorption systems,

3. To estimate potential loadings of VOCs to the environment from small community septic tank soil absorption systems.

In the first phase of this study, the concentrations of VOCs were quantified for effluent from six septic tanks from septic tank soil absorption systems (STSAS). Five of the systems investigated were small community STSAS ranging in age up to eight years. The sixth system analyzed was a mobile home park. Three samples were collected over a four month period from the dosing chamber or siphon chamber at each site during phase 1.

The second phase of the investigation involved the installation of groundwater monitoring wells at four of the small community sites. The assumption was that if VOCs were present in the septic tank effluent as had been demonstrated, VOCs could migrate and be discharged to groundwater. In addition, four STE samples were collected at the six sites from phase 1. During phase 2 , four groundwater samples were also collected from four of the sites. Septage samples were also collected at two of the small community sites which used a central septic tank.

LITERATURE REVIEW

Potential Sources of VOCs in Household Wastewater

Wastewater disposed of using septic tank soil absorption systems comes primarily from residential sources. The major portion of this waste stream originates from the bathroom, kitchen or laundry (Kanter and Knox 1985). The disposal and use of household products results in a waste water that is chemically complex. The wastewater coming from the home may contain organic compounds from an array of products such as disinfectants, cleaning materials, paints and solvents.

Several investigators have identified household products which contain chemicals listed as priority pollutants by the United States Environmental Protection Agency (USEPA). MacKay (1979) conducted a consumer survey in Nassau county, New York to identify sources of harmful organic compounds discharged to the groundwater of Nassau County, New York. Investigators examined nearly 1000 products and recorded information found on labels regarding ingredients, the use , method of use and manufacturer. The product evaluation system resulted in the identification of 12 categories of concern, comprised of 232 separate products (see Table 1).

Table 1

Breakdown of Consumer Products Identified as
Potentially Contributing to Groundwater Contamination
(MacKay 1979)

Product Category	Number of Products
1) Organic Solvent Cesspool Cleaners	12
2) Paint and Varnish Removers	39
3) Household Cleansers , Disinfectants and Oven Cleaners	40
4) Laundry Degreasers	6
5) Driveway and Garage Degreasers	12
6) Solvents and Cleaning Fluids	47
7) Engine and Metal Degreasers	16
8) Solid Toilet Bowl Deodorizers	14
9) Floor Strippers, Cleaners and Dressings	12
10) Radiator Flushes	10
11) Car Waxes and Cleaners	17
12) Miscellaneous	7

Of the twelve categories of products surveyed , priority was given to organic solvent cesspool cleaners and drain openers because of their almost direct discharge into groundwater. The survey estimated yearly sales of 76,500 gallons of organic solvent cesspool cleaners and drain opening products. The study indicated the following chemicals were present in cesspool cleaners, methylene chloride, 1,1,1-trichlororethane, orthodichlorbenzene, and petroleum distillates. Estimates of the volumes of other household products used in Nassau County were as follows:

1) Solvents and cleaning fluids 346,950 gal./yr.
2) Paint and varnish removers 93,050 gal./yr.
3) Household cleaners 55,650 gal./yr.

A summary of the quantities of harmful organic chemicals found in products indicated that a minimum of

93,000 gallons of organic chemicals listed as carcinogens or suspected carcinogens were being sold yearly in Nassau County. The study recommended to the New York State Attorney General that control measures regulating the manufacture, sale and use of organic solvent cesspool cleaners be implemented by the state.

Hathaway (1980) investigated the types of products used by the typical U.S. household that contained toxic compounds listed as priority pollutants by the USEPA. Consumer products commonly used in the household where grouped into general categories. Thirteen major categories were identified as potential sources of priority pollutants in domestic wastewater. Table 2 lists the major categories identified by Hathaway.

Table 2. Major Categories of Consumer Products (Hathaway 1980)

1) cleaners
2) cosmetics
3) deodorizers
4) disinfectants
5) house and garden pesticides
6) laundry products
7) ointments
8) paint and paint products
9) photographic products
10) polish
11) preservatives
12) soaps
13) medicines

Major categories were assigned several types of consumer products listed as potential contributors of priority pollutants to a wastewater stream. Hathaway also listed in a qualitative manner specific types of compounds present in each of the individual consumer products examined. In this effort each of the 129 priority pollutants listed by the USEPA was identified with respect to its use in household products.

The total wastewater stream from a household was also divided by Hathaway into eight separate events (see Table 3).

Table 3. Household Wastewater Events (Hathaway 1980)

1) toilet flush
2) garbage disposal
3) kitchen sink
4) automatic dishwasher
5) laundry wash
6) bath and shower
7) utility sink waste
8) bathroom sink

Each household wastewater event was identified by the types of consumer products which could enter the wastewater stream through the event. This result was listed in tabular form itemizing specific compounds likely to be found in each household event.

Hathaway also predicted which priority pollutants would have the greatest likelihood of occurring in the wastewater stream. Compounds were identified using an arbitrary selection method. Those compounds designated were listed in at least three household wastewater events and were predicted to be present in measurable quantities. The following compounds were predicted to be present in measurable quantities from household wastewater (see Table 4).

TABLE 4.
Predicted Priority Pollutants in Household Wastewater
(Hathaway 1980)

Organics	Inorganics
benzene	arsenic
phenol	cadmium
2,4,6,-trichlorophenol	chromium
2-chlorophenol	copper
1,2-dichlorobenzene (ortho)	lead
1,4-dichlorobenzene (para)	mercury
1,1,1-trichloroethane	zinc
naphthalene	antimony
toluene	silver
diethylphthalate	
dimethylphthalate	
trichloroethylene	
aldrin	
dieldrin	

The compounds listed in Table 4 were those predicted to be used and wasted into domestic wastewater of small community or individual wastewater treatment systems. It was noted by Hathaway that not all of these compounds would be detected in household wastewater streams. A number of factors would affect their presence, such as changes in product usage within individual homes or communities, and changes in product ingredients. Sampling techniques employed to sample waste flows may miss low concentration peak flows of certain chemicals wasted only periodically.

Hathaway's work examined priority pollutants in household wastewater in a strictly qualitative manner. The author did not attempt to quantify the amount of toxic wastes in domestic wastewater.

In another study, Ridgley et al. (1982) conducted a Toxicant Pretreatment Planning Study for the Municipality of

Metropolitan Seattle (METRO). The study included a Toxicant Inventory Study and other related projects as part of an effort to assess the presence, sources, fates and effects of toxic substances. The study was designed to help Metro identify problems and formulate effective control programs for point and nonpoint sources of toxicants.

Research involved selecting consumer products that posed the greatest concern for environmental harm. The study looked at the following four classes of products: (1) automotive products, (2) pesticides, (3) paints, solvents and preservatives and (4) household cleaners. The classes of products that were chosen for review were selected because the authors perceived them to have been commonly used in large volumes in the home.

Background information, usage figures and environmental impacts were presented on the four classes of compounds. Technical data, such as sources, toxicities and health hazards on specific chemicals of concern were reviewed for each class of products.

A few findings were common to all four classes of toxic consumer products. In general , while toxic substances were widespread in consumer products, information on the specific constituent chemicals was often difficult if not impossible to obtain. Determining the contents of familiar products was a challenge because of trade secret restrictions and because it was common for ingredients or proportions of ingredients to vary over time or geographical area. The labeling of products, whether of contents, directions for use, or recommendations for safe disposal was often inadequate and sometimes non-existent. Even when specific chemical constituents were known, information on chronic toxicities and environmental effects was limited.

Another important gap in the data concerned information on quantities of products sold, used and discarded by consumers. In order to estimate the cumulative effect of numerous small, dispersed sources, knowledge of quantities was necessary. Such estimates were difficult to determine for most product classes.

The results of the study indicated that in general, household products contain less toxic or hazardous substances than those chemicals used in commercial or industrial processes. It was also noted that consumer products had shown a tendency toward safer chemicals, or contained smaller quantities of toxic chemicals. Researchers were unsure if this was in response to regulation, economics, the market place or liability concerns. It was noted however that toxic or hazardous constituents were common in household products and warranted concern when considering their disposal.

Household pesticides were found to come in a wide variety of classes, including chlorinated hydrocarbons, carbamates, organophosphates and natural product extracts.

Conflicting and inadequate test data and a limited amount of information on chronic effects make any ranking of pesticides by disposal hazard very difficult. However, it appeared that certain classes such as the natural extracts, botanicals or synergists had much less potential for environmental damage than some of the more powerful or persistent synthetic products.

Paint products as a class posed a relatively minimal potential for environmental harm through proper disposal methods for two reasons:

1.) paints usually do not contain chemicals with long-term effects.

2.) irresponsible use or disposal practices are probably rare.

Solvents were used both as components of paints and as separate products for thinning or cleaning painting materials, furniture stripping and surface refinishing. The solvents in oil based paints and in separate solvent products were materials of concern. Many of them were acutely toxic to the user while some are suspected to pose chronic hazards such as liver and kidney damage (toluene, 1,1,1-trichloroethane) or cancer. The alcohols, ketones, esters and distillates tended to be less hazardous than the aromatic and chlorinated hydrocarbons.

Household cleaners comprised a range of cleaning and disinfecting products, such as disinfectants, bathroom cleaners, drain cleaners, furniture polish, dry cleaning fluid, bleach, oven cleaners, abrasive powder, air fresheners, floor cleaners and waxes, rug cleaners, upholstery and window cleaners, as well as laundry products such as detergents, fabric softeners and additives. Within each type of product, there are tens and sometimes hundreds of different formulations for specific uses and brands. These formulations change over time and over geographical area. Organic solvent constituents seem to be of greatest concern, especially such disinfectants as chlorinated phenolics, and dry cleaning or septic tank/drainfield degreasing solvents such as 1,1,1-trichloroethane. Other specific household cleaning chemicals predicted to affect the environment through their disposal were:

* chlorinated phenolics
* detergents
* aerosol propellants

While presenting very high hazard to the user, once diluted in wastewater or the environment these constituents were thought to be harmless and degrade rapidly.

Motor vehicle products included such diverse items as gasoline, oil, cooling system additives, cleaners and polishes, paints, brake and transmission fluids and battery acid. Many of these products, specifically the fuel and lubricants, are fractions distilled from crude petroleum and chemically treated with additives. Petroleum products are primarily hazardous as environmental pollutants, causing problems with their physical effects (coating surfaces, odor) as well as toxicological effects. Gasoline was an extremely dangerous substance commonly found in households; it was seldom disposed of, but when dumped presents acute toxicity problems as well as acute flammability concerns (Ridgley et al.).

In summary the research indicated that each class of products had its particular areas of concern; this could be labeling deficiencies, the toxicity or persistence of the contents, the disposal route, volumes used, etc. Three kinds of products were identified as being of special interest in that they all have the potential to harm the environment, they are used in significant quantities, and they may be disposed of in harmful ways. These are:

* Pesticides
* Solvents, especially the chlorinated organics
* Motor oil

Solvents pose the greatest potential input of toxic organic compounds to septic tank soil absorption systems.

Studies of Organic Compounds in On Site Wastewater Treatment Systems

Andreoli (1980) conducted a field study to determine the effect of leaching pool cleaners on groundwater. Two leaching pool systems, one experimental (pool 1) and one control (pool 2), were constructed. Raw domestic wastewater was fed to both pools. The pools were allowed to clog and leaching pool cleaner was added to the experimental pool, the control was not unclogged. Leachate quality and leaching rates were monitored for approximately one year. At the end of that period additional solvent was added and monitoring was continued.

In the first experiment it was found that pool 1 failed to leach satisfactorily following solvent addition. A conservative amount of solvent had been used in experiment 1. Halogenated hydrocarbons were found 1 month after addition in the leachate collected below the cesspool. The solvents had not rapidly migrated through the system as had been anticipated, but had remained in a slug of contaminated leachate above the leachate collection system. The halogenated hydrocarbons tended to move through the leaching pool system as a slug with a maximum concentration of over thirteen hundred parts per billion (1,300 ppb). The two predominant compounds detected in the leachate were methylene chloride at a maximum concentration of 1,282 ppb and 1,1,1-trichloroethane at a maximum of 38 ppb. The concentrations of total halogenated hydrocarbons decreased rapidly after the maximums were observed.

Potable water was added to both pools six months after the initial failure in order to flush any retained solvent through the system. A second slug of hydrocarbons (> 500 ppb) was detected under the treated pool. Pool 2 which did not have the cleaner added had a higher leaching rate than pool 1 which had cleaner. A second flush of the two pools with potable water produced a third slug of hydrocarbons from pool 1 exceeding a concentration of 200 ppb.

In experiment 2, the solvent dosage of pool 1 was increased, in accordance with the solvent manufacturer's recommendations, to see if the leaching rate would improve and what the effect would be on groundwater. The results indicated that halogenated hydrocarbons had leached through the soil below the leaching pool treated with the cesspool cleaner product. The maximum concentration was again seen approximately one month later and moved by the leachate collection system in a slug. The two predominant compounds were methylene chloride (38,310 ppb) and 1,1,1-trichloroethane (2,360 ppb). Total hydrocarbons were detected in concentrations over 40,000 ppb. Compared to experiment 1 an increased dosage (three times) of the product resulted in disproportionately higher concentrations of solvent in the leachate. A comparison of data indicated that peak solvent concentrations in the leachate during experiment 2 were 30 times higher for methylene chloride and 163 times higher for 1,1,1-trichloroethane. It was also determined that the cleaner product when added to pool 1 did not increase the leaching rate as was expected.

The trace organic removal efficiency for a rapid infiltration system treating 13 mgd secondary effluent was investigated by Tomson et al. (1981). A total of sixtyseven refractory organic compounds were detected in sampling of both effluent and groundwater samples. Nine VOCs were identified in the wastewater including: trichloroethylene, toluene, tetrachloroethylene, xylene, m-dichlorobenzene, p-dichlorobenzene, o-dichlorobenzene. The VOCs detected were found at concentrations of >1 ppb. Overall removal efficiency was about 92% for trace organics. A chemical class breakdown of the organics yielded removal efficiencies of most compounds that were from 90 to 100%. Noted exceptions were the removal efficiency of chloroalkanes, alkylphenols, alkanes, phthalates and amides with removals of approximately 70%.

Trace volatile organic removals in a community septic tank were investigated by DeWalle et al. (1982). The study evaluated the presence of volatile organics in raw domestic sewage generated in a subdivision serving 91 homes located south of Tacoma, Pierce County, Washington. The wastewater was treated by a two compartment 64,908 gallon septic tank. The septic tank was cleaned prior to the study by having the solids removed by pumping. The organics were measured during a week long monitoring followed by six additional samplings. The results for all samples taken indicated that dichloromethane was found in all samples, followed by toluene in frequency of detection. Toluene was the most prevalent among the priority pollutants, at an average concentration of 34.6 ppb in the raw wastewater, and 38.8

ppb in the effluent. These two compounds were also found in the water collected from a 125-foot deep monitoring well located adjacent to the drainfield.

Analysis of the volatile organic fraction typically contained 40 to 50 compounds at a concentration > 1 ppb. However, only 5 were identified as priority pollutants in the wastewater. These compounds showed essentially no removal during the 2-day detention in the septic tank. Table 5 lists the volatile organics detected in the septic tank influent and effluent averaged over the 7 day 24 hour composites.

TABLE 5
Volatile Organics in Septic Tank Influent and Effluent
(averaged over 7 d 24 h composites)
(DeWalle et al., 1980)

Organics	Concentration (ug L -1)			
	Influent	Effluent	Scum	Solids Accum.
Toluene	34.6	38.8	0.7	0.02
Dichloromethane	3.6	3.4	0.9	0.25
Chloroform	1.7	0.76	0.1	0.06
Tetrachloroethane	0.76	0.28	5.8	7.6
Ethylbenzene	0.1	0.1	6.9	6.

The priority pollutants generally showed higher levels during the weekend. It was concluded this trend probably reflected increased leisure activities and use of related chemicals (paint thinners, grease removers, toilet bowl cleaners, etc.) during the weekend. The majority of other volatile compounds were hydrocarbons. Their removal by the septic tank generally decreased with increasing molecular weight. Several compounds reflected the presence of anaerobic degradation processes occurring in the septic tank. The largest increase was noted for methanethiol, with small increases noted with larger molecular weight compounds probably reflecting the greater difficulty for bacteria to generate these large compounds. Organosulfur compounds showed substantial increases as a result of anaerobic degradation processes in the septic tank.

Trace organics in septic tank effluent were investigated by Viraraghavan et al. (1986). A study was undertaken to detect the presence and level of certain trace organics in wastewater samples collected from a septic tank in an individual household, from a lift station, and from a waste treatment lagoon near Regina, Canada. Eleven priority pollutants were analyzed. Six priority pollutants- chloroform, bromodichloromethane, toluene, benzene, methylene chloride and tetrachloroethylene - were detected in the samples. Benzene and bromodichloromethane were dominant in the samples analyzed. Benzene concentrations in septic tank effluent (max. value 450 ppb), lift station wastewater (max. 240 ppb), and in lagoon effluent (max. 120 ppb) were much higher than in raw wastewater (max. 15 ppb). The author gave no explanation of this occurrence of benzene. Bromodichloromethane concentrations in raw wastewater and septic tank effluent were 0.03 ppb and 0.46 ppb respectively, showing no removal through the septic tank. The average concentrations in lift station wastewater and lagoon effluent were 0.62 ppb and 0.16 ppb respectively, showing approximately 74% removal. Toluene occurred at an average concentration of 225 ppb in the household wastewater while none was detected in the septic tank effluent , sludge or scum. Chloroform was present in the lagoon effluent sample once at a concentration of 0.03 ppb. Methylene chloride and tetrachloroethylene could not be quantified at the low concentrations present.

Researchers concluded that trace organics in the septic tank effluent and lagoon effluent, at the low concentrations detected, may not pose any significant risk either to aquatic life or to public health. This conclusion considered the attenuation capacity of the soil and the dilution available.

Several researchers have analyzed septage samples from septic tanks. MacKay (1979) reported a sample representing domestic wastes collected from four separate residences. The sample was taken from a cesspool waste hauler after collection. The sample had high levels of 1,1,1-trichloroethane (630 ppb) and lesser amount of chloroform (80 ppb).

Ridgley (1982) investigated the sources of toxic pollutants to the Seattle Metro Treatment system. As part of the project three samples were taken from septic tank septage. These samples consisted of composites from 11 to 16 individual septic tank cleaning trucks, primarily from residential sources, although other inputs such as bilge water and chemical toilet pumping were present as well. Table 6 lists the organic pollutants found in concentrations greater than 100 ppb in septic tank septage samples.

Table 6.

Organic Pollutants Found in Concentrations Greater than 100 Parts Per Billion in Septic Tank Septage Samples. (Values are Concentrations in ppb) (Ridgley 1982)

Compound	Sample #1	Sample #2	Sample #3
1,3 dichlorobenzene (meta)			290
1,2 dichlorobenzene (ortho)			5600
1,4 dichlorobenzene (para)	400	270	800
1,2,4,-trichlorobenzene			760
Fluorene		120	
Phenanthrene		580	120
Fluoranthene		1480	130
Pyrene		1710	110
Di-octyl phthalate	4600	6500	130
Di-n-butyl phthalate		740	130
Butyl benzyl phthalate		740	130
Phenol		410	340
2 methyl phenol		210	
4 methyl phenol		1300	2400
Benzene			160
Methylene chloride	600	520	
Toluene	600	1200	150

Only three compounds were found in all three samples at concentrations of greater than 100 ppb.: 1,4 dichlorobenzene, di-octyl phthalate, and toluene. In addition to these three compounds, four other compounds were found in all three samples but in concentrations of less than 100 ppb.: tetrachloroethylene (range:<5-60) and trichloroethylene (<5-50), both of which are commonly used solvents. 4,4-DDE (range: 1.6-19), a persistent pesticide; and various PCBs (range: 3.5-54) were also detected in the three samples.

Koleaga et al. (1982) examined five septage disposal facilities in Connecticut. The facilities consisted of two lagoons placed in series. The primary lagoon received wastes and allowed solids to settle and undergo further biological degradation. The secondary lagoon allowed the liquid portion to infiltrate and percolate through the soil to the groundwater below.

Samples were taken from trucks hauling septage to five sites over three different periods in 1979 and 1980. Toluene was found in nineteen of twenty-one septage samples. Toluene concentrations ranged from 100 to 8500 ppb, with three of the samples exceeding 1000 ppb. Approximately 75 percent of the septage came from residences with the remainder being from business or commercial establishments.

Toluene (range: 0.01-1100 ppb), 1,1,1-trichloroethane (range: <0.5-480 ppb), and methylene chloride (range: 65-85 ppb) were detected in groundwater samples taken from three of the sites. Other trace organic compounds detected in groundwater included: 1,1,2-trichloroethane, chloroform, acetone, trichlorethylene, chlorobenzene, and butane.

Tomson et al. (1983) studied groundwater pollution from a total of eight septic tank systems around the country. The distribution box at each site was sampled and taken as input to the soil adsorption field. The primary emphasis of the work was monitoring of chromatographable trace level organics (C-TLOs). From preliminary studies, twenty-two C-TLOs were targeted for quantification. The input of targeted C-TLOs was predicted from the use of pesticides, plasticizers, organic solvents, and neutral chlorinated hydrocarbons. Concentrations of the 22 target compounds varied from a high of approximately 300 ppb in the distribution boxes to a high of approximately 15 ppb in groundwater wells. Typical concentrations in the distribution boxes and groundwater samples were <1 ppb and <0.1 ppb respectively , indicating generally >90% removal of C-TLOs within a few tens of feet from the soil adsorption systems. In sandy soils significant C-TLOs compounds were detected up to 200 ft away from the leach field. The compounds at this distance were removed at greater than 90% removal. It was concluded that a few tens of feet (approximately 50 ft) is probably not sufficient for significant C-TLO removal in sandy soil. However, in heavy clay soils C-TLOs may only travel a few feet. Several classes of C-TLOs were identified which together accounted for most C-TLOs which persist in groundwater. The classes included chlorinated hydrocarbons, plasticizers, antioxidants, aromatic solvents, and bicyclo compounds.

The fate and transport of organic contaminants in the subsurface environment is a relatively new area of concern. A variety of possibilities exist for the movement of organics, including transport with the water phase (Roberts 1986), transformation of halogenated aliphatic compounds (Vogel et al. 1987), volatilization and loss from the soil system, retention on the soil due to adsorption (Morrill 1982, Curtis et al. 1986, Karickhoff et al. 1979), incorporation into microbial or plant biomass, and bacterial degradation (McCarty 1986, Macalady et al. 1986). The relative importance of these possibilities in a given situation is dependent upon the characteristics, and the subsurface environmental conditions (Canter and Knox 1985). The physical, chemical and biological processes which affect priority pollutants' fate in wastewater treated by septic tank soil-absorption systems has not been addressed in the research. Because of the vast array of chemical and biological transformation pathways available it is beyond the scope of this review to examine the potential fates of all organic compounds present in wastewater.

Summarized Findings of Prior Research

The potential sources of toxic organic compounds related to domestic wastewater have been examined by several authors (MacKay 1979, Hathaway 1980, Ridgley 1982). Those studies indicated that septic tank cleaners tend to present the greatest potential for groundwater pollution because of their direct input to the septic tank. The compounds that appeared in these products included: methylene chloride, 1,1,1-trichloroethane, orthodichlorobenzene, and petroleum distillates (Andreoli 1980, Hathaway 1980, Ridgley 1982). Organic solvent constituents in consumer products were also identified as significant sources of organic compounds in domestic wastewater. Solvents were found as components of paints, thinners, oven cleaners, dry cleaning fluids and a host of other cleaning products. The compounds that were estimated to be present in the greatest quantities included: toluene, benzene, chloroform, 1,2-dichlorobenzene, 1,4-dichlorobenzene, and trichloroethylene (Hathaway 1980). The results of such studies indicated that in general, household products contain less toxic or hazardous substances than chemicals used in commercial or industrial processes. It was also found that in recent years consumer products have shown a tendency toward the use of smaller quantities and fewer kinds of toxic chemicals. As changes occur it would be expected that the organic compounds present in domestic wastewater will change in concentration and vary over time (Ridgley 1982).

The results of studies of on-site wastewater treatment systems indicated that organic compounds are present in such systems. The highest concentration of chlorinated organic compounds was found as a result of septic tank cleaning compounds (Androeli 1980). The monitoring of raw wastewater streams indicated the presence of a large number of organic compounds at concentrations from <1 ppb to 320 ppb. Toluene was present in the highest concentration in raw wastewater (range: 0.7 ppb-320 ppb) (Tomson 1984, Dewalle 1982).

Analysis indicated that priority pollutants in raw wastewater showed essentially no removal during detention in the septic tank. The removal of hydrocarbons varied considerably and their removal by the septic tank generally decreased with increasing molecular weight.

Although removal efficiencies in the septic tank were shown to be low, analysis of septage samples have shown elevated concentrations of organic compounds. With some compounds one or two orders of magnitude were seen between the raw wastewater and septage concentrations (Dewalle 1982).

The efficiency of on-site treatment systems for removal of various organic compounds varied from 74 to 100% (Tomson 1981). The analysis of groundwater samples below different types of sites indicates that there is removal of organic compounds in the subsurface environment (Andreoli 1980 , Koilega 1981). It was also shown that as the concentration of certain organics increases their removal efficiency decreases (Andreoli 1980). It appears that there is sufficient removal of organic compounds in domestic wastewater from on-site wastewater treatment systems to meet state groundwater regulations. It has not been demonstrated however, that small communities with commercial establishments using STSAS have similar concentrations and types of organic compounds in their waste flow. If concentrations from commercial STSAS are significantly more than domestic systems the STSAS may not be adequate to meet state groundwater regulations.

EXPERIMENTAL METHODS

Experimental Design

Given the on-going concern over the potential of groundwater pollution from priority pollutants in septic tank soil absorption systems, a field study was developed to assess the presence of VOCs in small community STSAS. Six small community systems were selected as part of an experimental design aimed at investigating the presence of VOCs in septic tank effluent, septage, and groundwater at each site. The small community sites were of particular interest because of the input of wastewater flow from commercial establishments (i.e. grocery stores, taverns, restaurants, etc.).

The present investigation was designed around five general ideas. The first assumption was that priority pollutants and more specifically, VOCs were present in household products used by residences at each community. Because it was not feasible to survey individual residence about their patterns of use with respect to types and quantities of household products, it was assumed that household products were used and VOCs were present in such products.

The second assumption was that household products containing VOCs were disposed through some household waste event to the community wastewater flow. It was assumed therefore that VOCs would be present in the raw wastewater flow.

The third assumption was that VOCs were not effectively removed in the septic tank or tanks of the small community sites. If the VOCs where not removed then they should be present in septic tank effluent.

The fourth assumption was that a grab sample from the dosing chamber was representative of the wastewater flow. It was assumed that the effects of mixing and detention in the septic tank and dosing chamber would provide a grab sample of effluent which was representative of a composite from the wastewater flow.

The fifth assumption was that if VOCs were detected in the septic tank effluent, these VOCs could contribute to groundwater contamination via the subsurface disposal of wastewater.

The first phase of the project involved the sampling of six STSAS over a five month period. Septic tank effluent was collected at each site three times during this phase. Each septic tank effluent was analyzed for 45 VOCs and several standard parameters (BOD, TOC, TSS, TVSS, etc.). The results of phase one indicated that VOCs were in fact present in septic tank effluent.

In the second phase of the project, monitoring of septic tank effluent was continued over a seven month period. The original six sites were sampled four times during this period. In this phase of the experiment installation and monitoring of groundwater wells at four of the small community sites was also undertaken. Four groundwater wells were installed at three of the sites, and at the fourth, three wells were installed to monitor groundwater contamination adjacent to the soil absorption beds. The samples were analyzed for 45 VOCs and several other standard groundwater parameters. Three septage samples from two of the small community sites using a central septic tank were also collected during this phase of the project. The septage samples were analyzed for 45 VOCs and several other standard parameters.

The following is a summary of samples taken during the investigation:

Site	STE Samples	Groundwater Wells Installed	Groundwater Samples	Septage Samples
Kingston	7	3	12	3
Town of Scott	7	4	16	0
Maplewood	7	4	16	0
Wyeville	7	4	16	3
Westboro	7	0	0	0
Don's Mobile	7	0	0	0

<u>System Descriptions</u>

Site #1 Village of Kingston, Green Lake County, Wisconsin

The need for centralized wastewater facilities in the village of Kingston arose out of public health concerns over failing private septic systems. In 1979 a wastewater facilities plan was developed outlining alternative collection and treatment technologies. In 1980, plans and specifications for the selected option of a community septic tank soil absorption field were submitted to and approved by the Wisconsin Department of Industry, Labor and Human Relations. The system went into service during December of 1981 and first exhibited permanent ponding in the soil absorption beds during the summer of 1983. The village is currently deciding on wastewater alternatives to replace the failed system.

The design service population was approximately 400 persons at 70 gpd for a design flow of 32,800 gpd. The design flow includes an assumed inflow of clearwater of 4800 gpd. The actual population during the study was 346 persons. Table 7 gives a breakdown of the users of the system.

Table 7.
Wastewater Sources Village of Kingston

TYPE OF USER	# OF UNITS
Single Family Homes	152
Automotive Garage	1
Bank	1
Tavern	1
Church	3
Grocery Store	1
Feed Mill	1
Restaurant	2
Woodworking shop	1
Metal Fabricator	1
Total	164

The village was served by approximately 11,390 ft. of 8 in. diameter gravity sewers, 2 submersible pump stations with approximately 1,016 ft. of 4 inch force main, plus 10 grinder pump installations with a totoal of about 1,755 ft. of 2-1/2 in. force main. The collection system fed a central three compartment 47,175 gal. septic tank. It was sized to provide 24 hours of hydraulic detention time and 1 year sludge accumulation. Effluent from the septic tank collected in a 8200 gal. pump chamber (dosing chamber) equipped with two 750 gpm submersible centrifugal pumps. The pumps were float actuated and employed digital time recorders from which the volume of STE pumped to the absorption beds could be back calculated.

Effluent was pumped from the pumping chamber through 4000 ft. of 8 in. force main to the absorption beds. In-situ soils at the depth of construction were loamy sand to sandy loam. Deeper underlying soils were predominantly fine to medium sands.

The distribution network was comprised of an 8 in. header running down both sides of each bed connecting to 1-1/2 in. laterals located 5 ft. on centers running the width of each bed. The network was installed in 15 in. thick washed gravel beds overlain by protective filter fabric. The required infiltrative area for the design flow rate of 32,800 gpd. was 36,000 square feet. Fifty percent excess infiltrative area was provided by designing 3 beds at 18,000 square feet each (180 ft. x 100 ft.)(see Figure 1). The system was operated such that two beds received alternating doses of effluent for a three month period while the third was being rested. In this manner no single bed was in service more than 6 months.

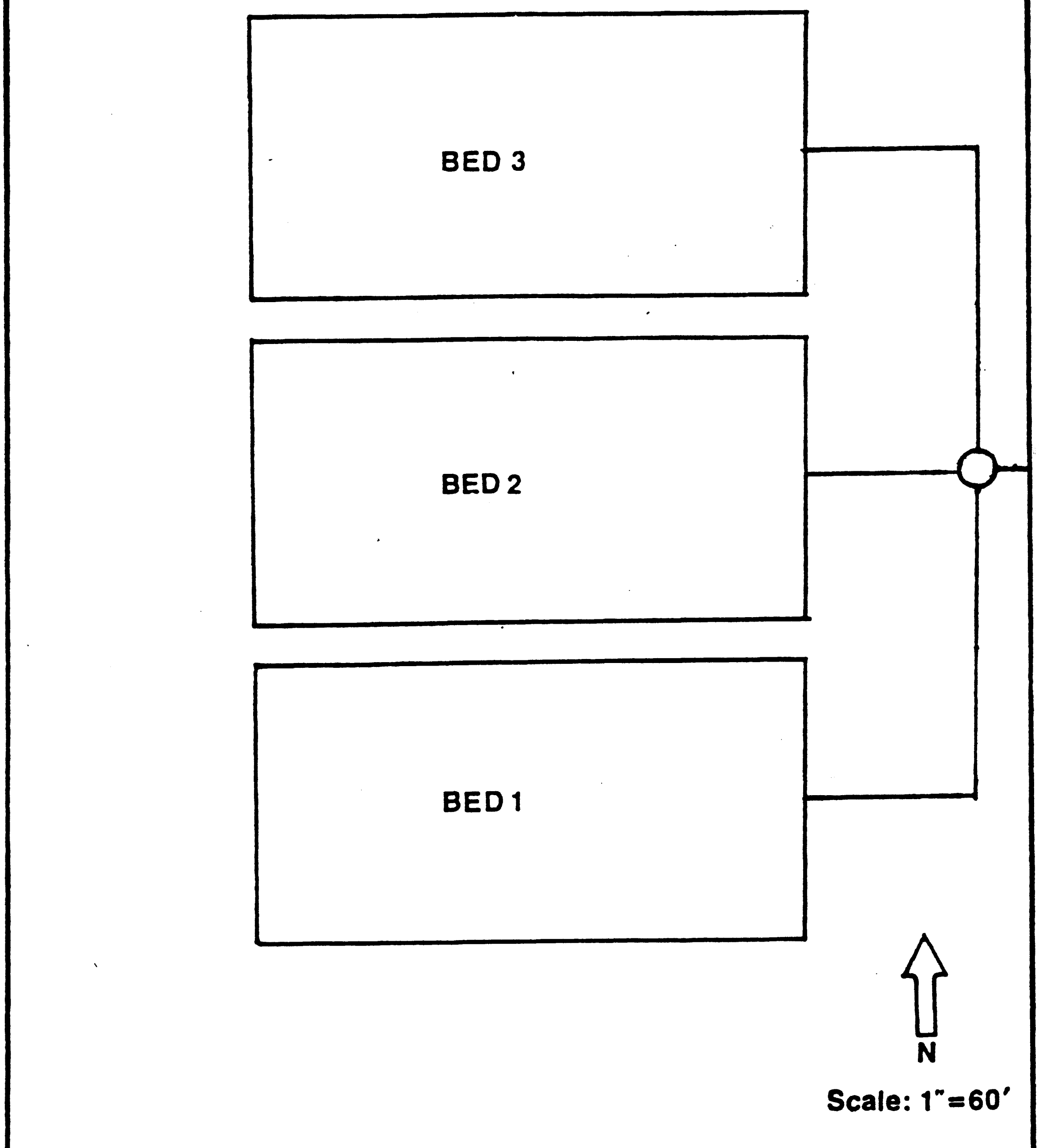


FIGURE 1
SITE MAP OF SOIL ABSORPTION BEDS
AT THE VILLAGE OF KINGSTON, WISCONSIN

Site # 2 Town of Scott Sanitary District, Sheboygan County, Wisconsin

The Town of Scott Sanitary District serves the unincorporated Village of Batavia. The need for centralized wastewater facilities in the Village of Batavia arose out of public health concerns over failing private septic systems. A sanitary survey in Batavia indicated that individual private sewage systems in Batavia were restricted by unsatisfactory types of soils, small lot sizes, high groundwater and shallow bedrock. In 1984, plans and specifications for the selected option of a community septic tank soil absorption field were submitted to and approved by the Wisconsin Department of Industry, Labor, and Human Relations. The system went into service during September of 1985.

The design service population was approximately 215 persons at 120 gpcd, with an estimated 3700 gpd commercial flow. The design flow rate for the system was 29,500 gpd. The actual population during this study was approximately 170 persons. Table 8 details a breakdown of the users of the system.

Table 8.
Wastewater Sources Town of Scott
Sanitary District

TYPE OF USER	# OF UNITS
Single Family Homes	55
Duplexes	10
Elementary School	1
Hardware Store	1
Restaurant	1
Bar and Restaurant	1
Church	1
Legion Hall	1
Fire Station	1
	Total 72

The population equivalent of the inventoried units was 240 persons at 120 gpcd. The village was served by approximately 5,977 ft. of six in. gravity sewers and two septic tank effluent pump stations. During construction of the system all individual septic tanks were inspected and either replaced or rehabilitated. Each residence was served by a individual septic tank during the study. Two existing septic tanks located below grade were served by septic tank effluent pumps to discharge their effluent to the gravity sewer. The septic tank effluent collection system discharged to a central lift station.

The effluent was collected at a central lift station with a capacity of 140 gallons. The lift station was equipped with two submersible, non-clog sewage pumps, each rated at 125 gallons per minute. The pumps were float actuated and employed time recorders from which the volume of STE pumped to the absorption fields could be calculated. The lift station pumps discharged through two 10 ft.

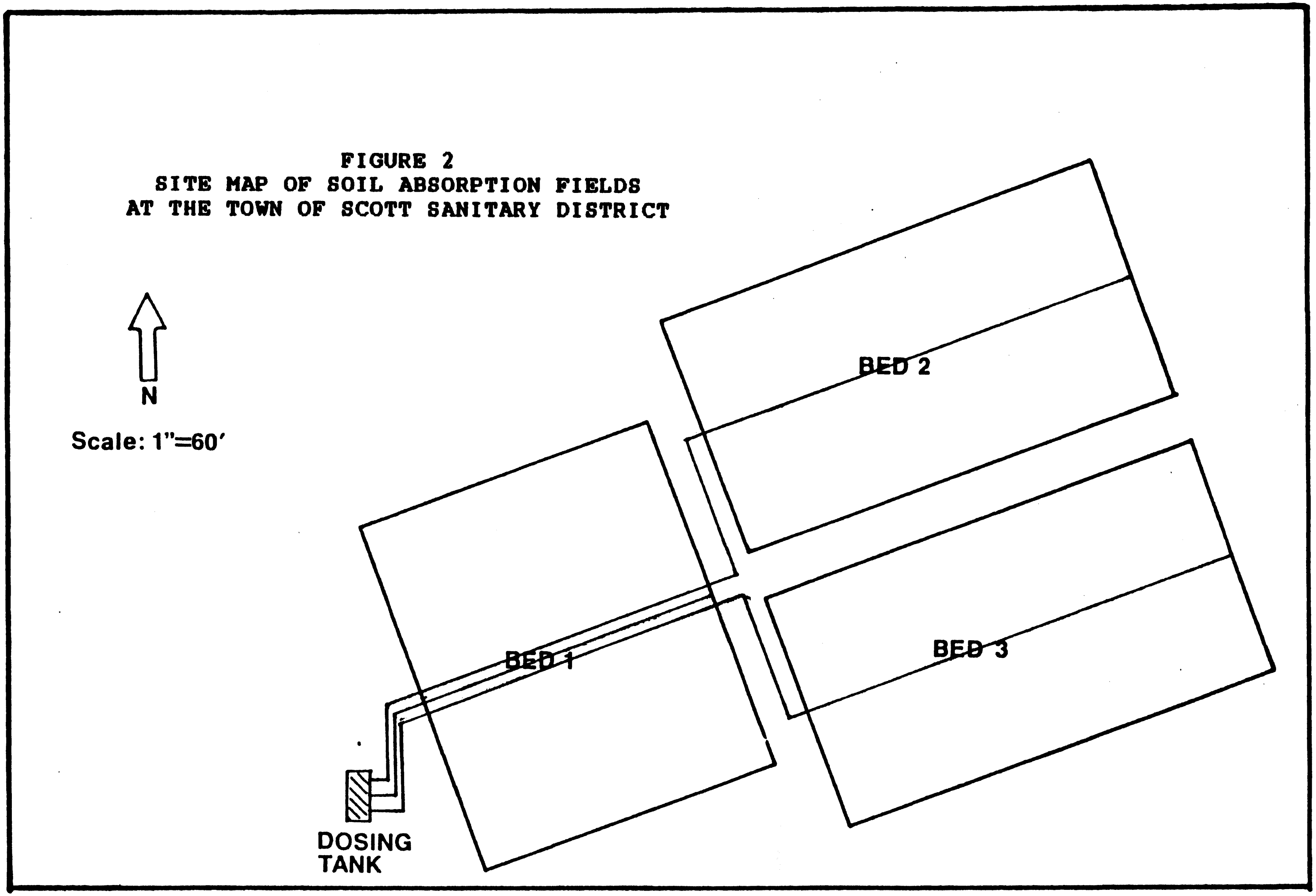
sections of 4 in. force main to a metering manhole.

The metering manhole discharged into approximately 4,333 feet of 6 in. force main. The force main terminated in a dosing chamber with a capacity of 5984 gallons. The septic tank effluent was automatically siphoned from the dosing chamber to two of three soil absorption fields.

Each soil absorption field was approximately 19,000 square feet in area. In-situ soils at the depth of construction were sand, medium dense, fine to medium grained, with trace to little silt. Deeper underlying soils were predominantly sand, medium dense to dense, fine to coarse grained, with a trace of silt. Cobbles were present in small lenses at varied depths below the site.

The distribution network was comprised of an 8 in. manifold running down the center of each of the beds and 1-1/2 in. laterals at 8 ft. on centers running the width of each bed. The laterals were perforated and were installed in 10 in. thick washed gravel beds overlain by protective filter fabric. The infiltrative area used for the average design flow rate of 29,500 gpd. was 57,344 square feet. There are three beds in the drainfield, two beds at 100 ft. x 192 ft. and the third at 128 ft. x 148 ft.(see Figure 2). The system was designed to operate such that two beds received alternating doses of effluent for a three month period while the third was rested. The system was initially operated with only one bed in service due to operator error.

FIGURE 2
SITE MAP OF SOIL ABSORPTION FIELDS
AT THE TOWN OF SCOTT SANITARY DISTRICT



Site # 3 Maplewood Sanitary District, Maplewood, Door County , Wisconsin

The Maplewood Sanitary District serves the unincorporated Village of Maplewood. The need for centralized wastewater facilities in the Village of Maplewood arose out of public concerns over failing private septic systems. In 1980, plans and specifications for the sanitary sewer, force mains, lift stations and soil absorption beds were submitted and approved by the Wisconsin Department of Industry, Labor and Human Relations. The system went into service in 1981.

The design service population was approximately 310 persons at 65 gpcd for a design flow rate of 20,150 gpd. The actual population during the study was approximately 130 persons. Table 9 details a break down of the users of the system.

Table 9.
Wastewater Sources Village of Maplewood Sanitary District

TYPE OF USERS	# OF UNITS
Single Family Homes	44
Multiple Family Dwellings	2
Service Station	2
Plumbing Supply	1
Auto Parts Supply	1
Welding Shop	1
Bar and Restaurant	1
Tavern	1
Church	1
Parsonage	1
Post Office and Implement Shop	1
Community Hall	1
Total	60

The population equivalent of the inventoried units was 193 persons at a 65 gpcd.

The village was served by approximately 5,975 ft. of six in. gravity sewers, 1,875 ft. of 2 in. force main, and 900 ft. of 2-1/2 in. force main. During construction of the system all individual septic tanks were inspected and either replaced or rehabilitated. Each residence was served by an individual septic tank during the study. The septic tank effluent was pumped to one of three lift stations.

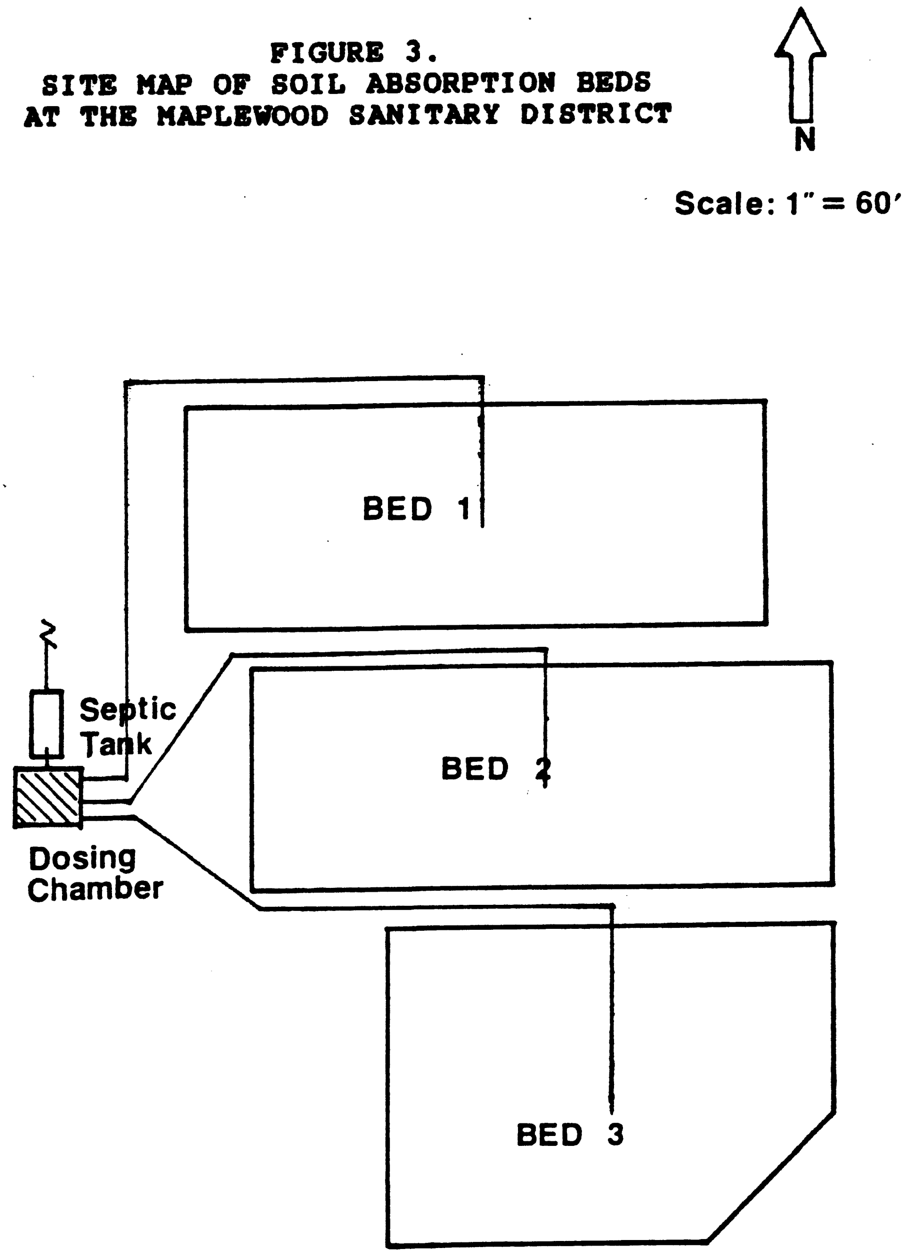
Effluent from the two outer lift stations was pumped to the central lift station. The central lift station was equipped with two submersible, non-clog sewage pumps, each rated at 80 gpm. The pumps were float actuated and employed time recorders from which the volume of STE pumped to the absorption fields could be calculated.

The central lift station discharged through 800 ft. of 4 in. force main. The force main terminated in a 2000 gal. septic tank, from the septic tank, effluent flowed through 6 ft. of 4 in. main to the 12,930 gallon dosing chamber. The septic tank effluent was automatically siphoned from the dosing chamber to two of the three soil absorption beds.

Each soil absorption field was approximately 12,600 square feet in area. In-situ soils at the depth of construction were sandy loam. Deeper underlying soils were predominantly loamy sand and sand. Stratified layers of silts, sands and clays were seen approximately 18 ft. below the depth of the beds.

The distribution network was comprised of a 10 in. main supply to a 6 in. distribution header running down the center of each bed. The distribution header connected to 2-1/2 in. laterals at 5 ft. on center running the width of each bed. The laterals were perforated and installed in 15 in. washed gravel beds overlain by protective filter fabric. The infiltrative area used for the design flow of 20,150 g.p.d. was 37,400 square feet. There were three beds in the drainfield, two beds at 180 ft. x 70 ft. and a third bed at 138 ft. by 100 ft. with an 800 square foot triangular area not used (see Figure 3). The system was designed to operate such that two beds received alternating doses of effluent for a three month period of time while the third was rested.

FIGURE 3.
SITE MAP OF SOIL ABSORPTION BEDS
AT THE MAPLEWOOD SANITARY DISTRICT



Site #4 Wyeville, Monroe County, Wisconsin

The need for centralized wastewater facilities in the Village of Wyeville arose out of public concerns over failing private septic systems. A sanitary survey in Wyeville indicated 57% of private sewage systems were failing and that these systems were discharging effluent to groundwater. In 1984, plans and specifications for the proposed low pressure sewer, community septic tank and mound soil absorption system were submitted and approved by the Wisconsin Department of Industry, Labor and Human Relations. The system went into service during September 1985.

The design service population was approximately 293 persons at 60 gpcd for a design flow rate of 17,600 g.p.d.. The actual population was approximately 163 at the time of the study. Table 10 details a break down of the users of the system.

Table 10.
Wastewater Sources
Village of Wyeville, Wisconsin

TYPE OF USER	# OF UNITS
Single Family Homes	58
Elementary School	1
Tavern	2
Retail Store	2
Motel	1
Village Hall	1
Gas station and Garage	1
Village Garage	1
Post Office	1
Total	68

The population equivalent of the inventoried units was

293 persons at 60.0 gpcd.

The village was served by approximately 9,900 ft. of 1-1/4 in., 1,700 ft. of 1-1/2 in., 2,200 ft. of 2 in., 1,200 ft. of 2-1/2 in., 4,600 ft. of 3 in., and 2300 ft. of 4 in. pressure sewers, 27 manholes and 7 air release manholes. During construction all individual septic tanks were replaced by grinder pump units. A total of 69 simplex and 3 duplex grinder pump systems were installed. Each simplex and duplex pump had a tank capacity of 60 gallons and 120 gallons respectively. Each pump was equipped with a, alarm light, buzzer and level detecting device for controlling pump operations. The pumps discharged wastewater to the low pressure sewers. The low pressure sewers discharged to a 3 chamber 25,200 gallon community septic tank.

The septic tank effluent discharged to a 4,100 gallon pumping chamber. The pump chamber was equipped with 3 submersible, non-clog sewage pumps, each rated at 475 gpm. The pumps were float actuated and employed time recorders from which the volume of STE pumped to the mounds could be calculated.

The pump chamber discharged effluent through an 8 in. manifold to each mound. In-situ soils at the depth of construction were medium dense, fine sand with occasional seams of silt and/or clay. The mounds were constructed above grade with 12 inches of medium dense, course sand overlain by 10 inches of washed gravel.

The distribution network was comprised of an 8 in. manifold reducing to a 6 in., 14 ft long manifold, reducing to a 4 in., 12 ft long manifold. The two manifolds ran the width of the mounds located 50 ft. from either end of the mounds. The distribution header connects to six 5 ft high, 2 in. risers located 7 ft. on centers. The risers connect to a 2 in. tee with 50 ft. laterals extending from each side of the tee. The laterals were perforated and installed in 10 inch washed gravel beds overlain by protective filter fabric. The infiltrative area used for the design flow of 17,600 gpd. was 40,000 square feet. Three beds were provided with the following dimensions: mound 1 (229 ft. x 54 ft.), mound 2 (229 ft. x 59 ft.), mound 3 (231 ft. x 61 ft.) (see Figure 4). The system was designed to operate such that two beds received alternating doses of effluent for a three month period of time while the third mound was rested.

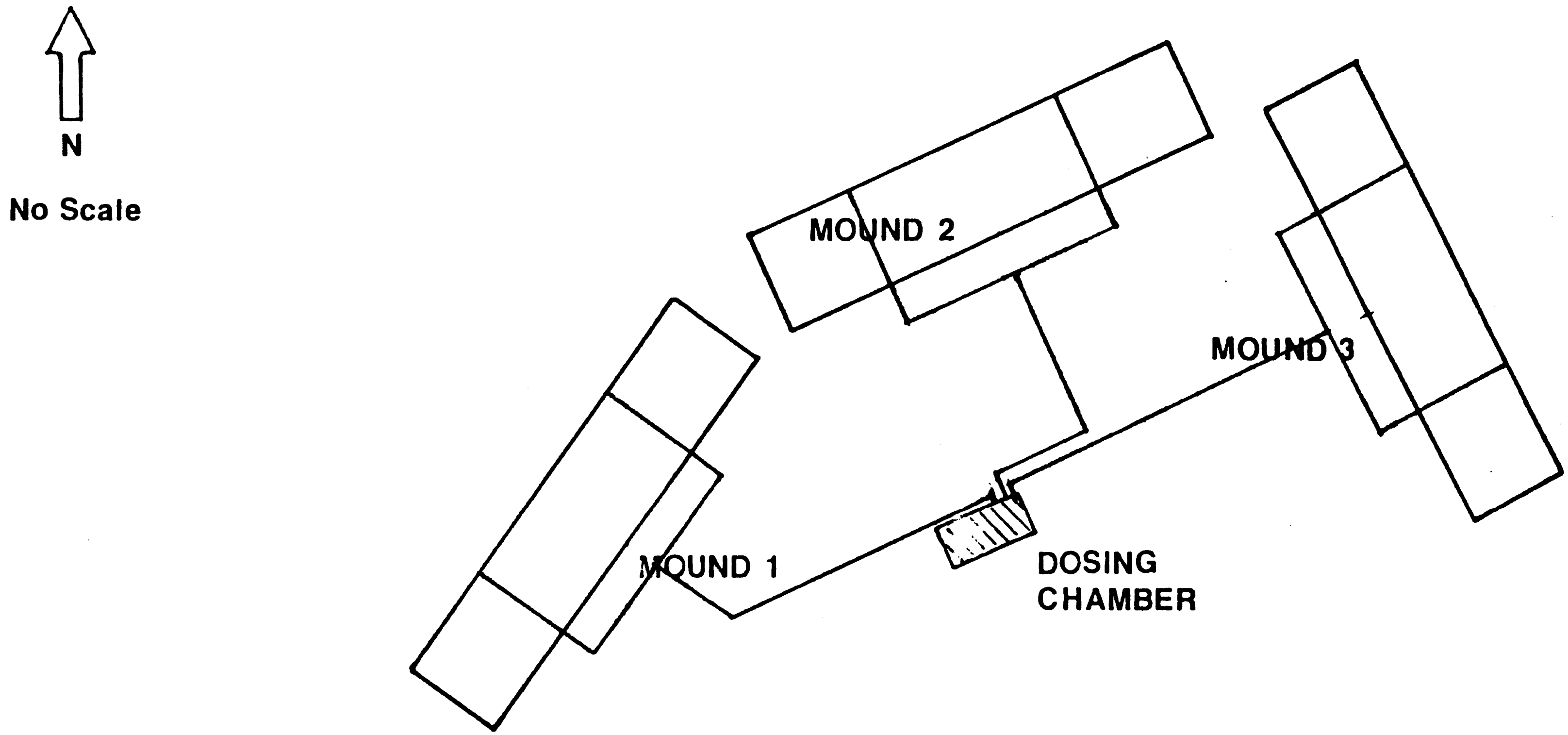


FIGURE 4
SITE MAP OF SOIL ABSORPTION MOUNDS
AT THE VILLAGE OF WYEVILLE, WISCONSIN

Site # 5 Westboro, Taylor County, Wisconsin

The need for centralized wastewater facilities in the community of Westboro arose out of public concerns over failing septic systems. In 1976, plans and specifications for the construction of a small diameter sewage collection system with lift stations, and a sewage treatment system consisting of individual septic tanks and a community drain field were submitted and approved by the Wisconsin Department of Industry, Labor and Human Relations. The system went into service in 1977.

The design service population was approximately 300 persons at 100 gpcd for a design flow rate of 30,000 gpd. The service population during the study was approximately 205 persons. Table 11 details a break down of the users of the systems.

Table 11.
Wastewater Sources Community of Westboro
Wisconsin

TYPE OF USER	# OF UNITS
Single Family Homes	68
Service Station	2
Machine Shop	1
Tavern	2
Grocery Store	1
Church	3
Post Office	1
School	1
Town Hall and Fire Station	1
Total	80

The population equivalent of the inventoried units was 205 persons at 100 gpcd.

The community was served by approximately 5839 ft. of 4 in. gravity sewer, 949 ft. of 8 in. gravity sanitary sewer main, 3130 ft. of 3 in. force main, 730 ft. of 2 in. force main, and 1650 ft. of 1-1/2 in. force main. During construction of the system all individual septic tanks were inspected and either replaced or rehabilitated. Each residence was served by an individual septic tank during the study. The septic tank effluent was pumped to one of two lift stations, effluent from the outer lift station was pumped to the central lift station.

The central lift station was equipped with two submersible, non-clog sewage pumps, each rated at 60 gpm. The pumps were float actuated and employed time recorders from which the volume of STE pumped to the absorption fields could be calculated.

The central lift station discharged through 1150 ft. of 3 in. force main to a 9540 gal. siphon chamber. The wastewater in the siphon chamber flowed through three 12 in. siphon lines each 1482 ft. in length to three soil absorption beds.

Each soil absorption field was approximately 13,000 square feet in area. In-situ soils at the depth of construction were predominantly very fine sand and silts interbedded with layers of coarser sands and gravels in the northern one-half of the site. The soils of the southern half of the site were predominantly more sandy and with less interbedded discontinuous lenses of very fine sands and silts.

The distribution network was comprised of a 12 in. siphon pipe; flow to each absorption field was split at a "T" section into two 8 in. header pipes. As each header pipe traveled the length of the field it reduced to 6 inches half way down its length and to 4 inches at 3/4 of its length. The distribution headers connected to 3 in. laterals located 5.25 ft on center and extended to the side and center of the bed. The laterals were perforated and installed in 18 in. of stone and covered with filter fabric, then backfilled with natural soil materials from the site. The infiltrative area used for the design flow of 30,000 gpd. was 39,000 square feet. Three beds each 130 ft. x 100 ft were provided in the drain field. Fifty percent excess area was provided with 3 beds (see Figure 5). The system was designed to operated such that two beds received alternating doses of effluent for a three month period while the third was being rested. In this manner no single bed was in service more than 6 months.

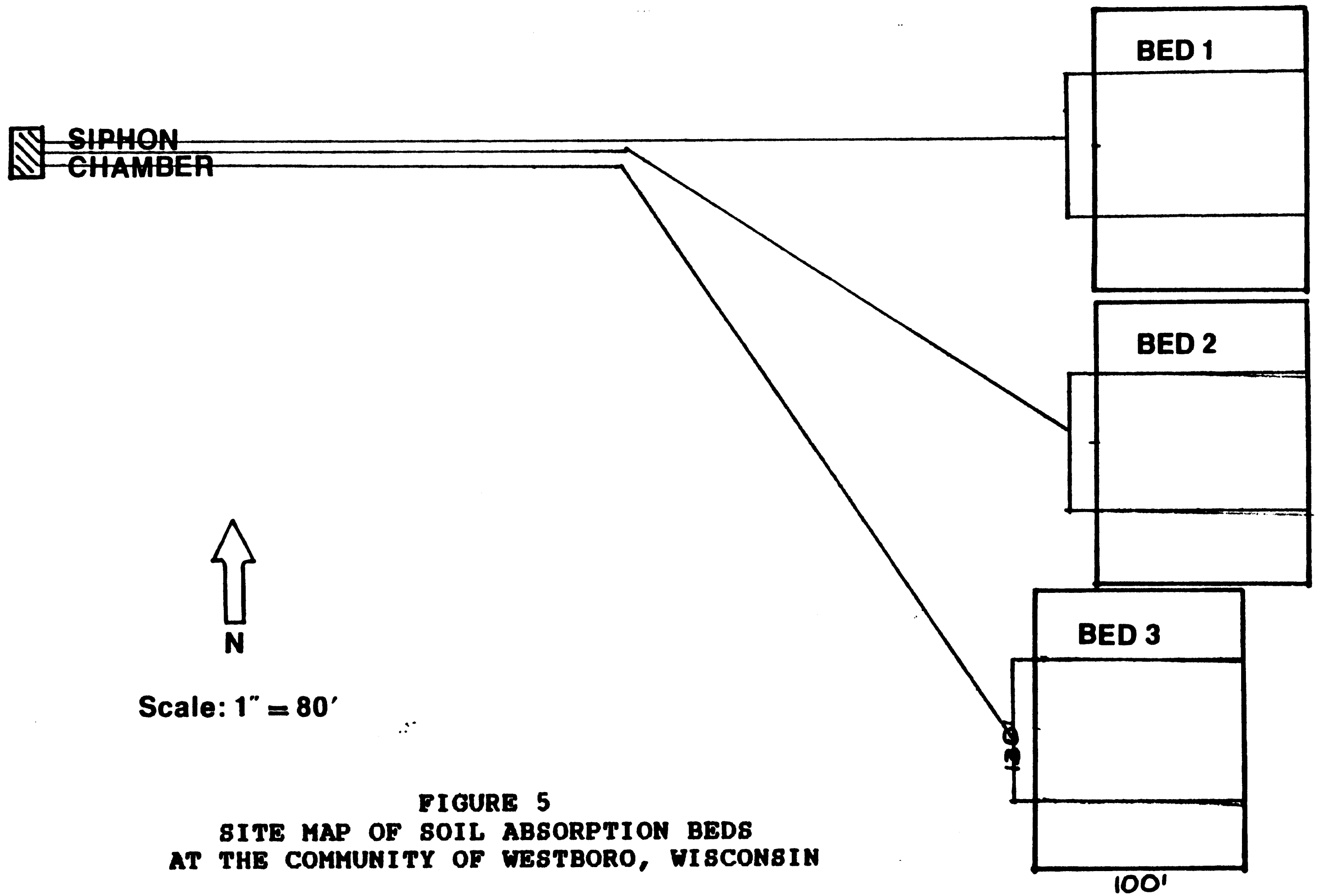


FIGURE 5
SITE MAP OF SOIL ABSORPTION BEDS
AT THE COMMUNITY OF WESTBORO, WISCONSIN

Site # 6 Don's Mobile Manor, Dane County, Wisconsin

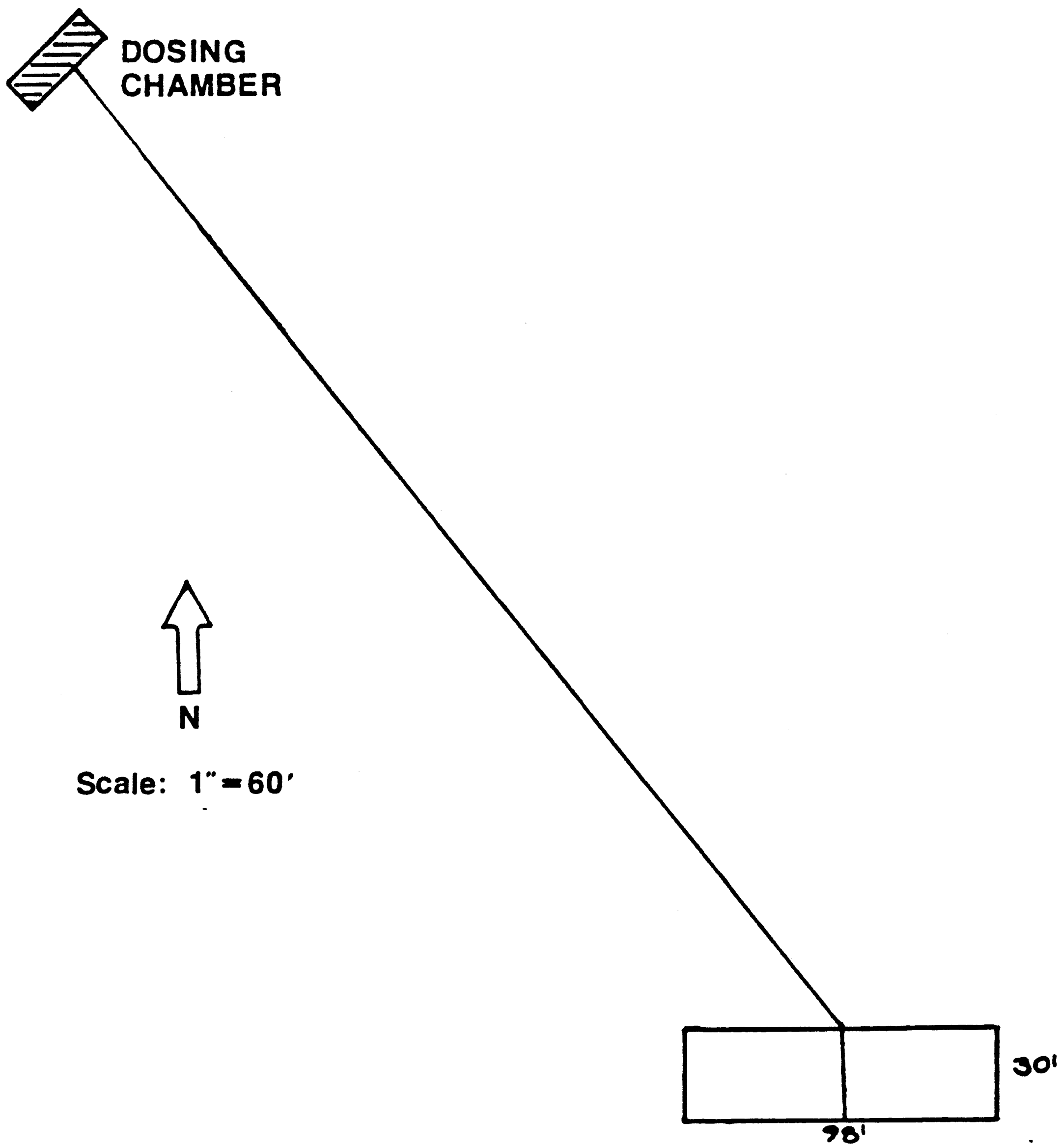
The need for replacement of centralized wastewater facilities at Don's Mobile Manor arose out of concern over failure of an existing system. In 1983 plans and specifications for the lift station and soil absorption bed were submitted to the Wisconsin Department of Industry, Labor and Human Relations. The system went into service in during 1984.

The system was designed to serve 10 mobile home units at a design flow rate of 2000 gpd. Approximately 400 ft of 3 in. gravity sewer served the ten trailers. The wastewater discharged to a 3750 gallon septic tank. The STE was discharged to a 4787 gallon dosing chamber. The lift station was equipped with one submersible, non-clog sewage pump. The lift station discharged through 384 of 3 in. force main to the soil absorption bed.

The soil absorption bed was approximately 2940 square feet in area. In-situ soils at the depth of construction were predominantly silty. Stratified layers of sand and gravel were seen in four soil borings on site.

The distribution network was comprised of a 3 in. manifold connected to 1-1/4 in. laterals located 6 ft. on center. The laterals were perforated and installed in 10 inches of gravel overlain by protective filter fabric. The bed provided was 98 ft x 30 ft. (see Figure 6).

FIGURE 6
SITE MAP OF SOIL ABSORPTION BED
AT DON'S MOBILE MANOR, DANE COUNTY, WISCONSIN



Field and Analytical Methods

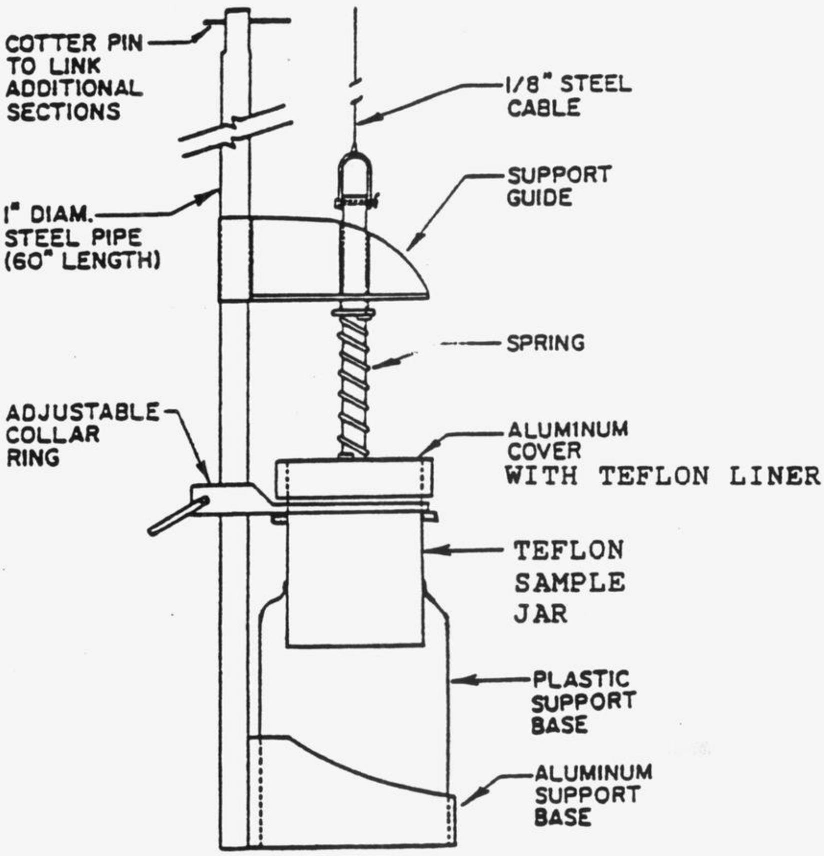
Septic tank effluent was collected from the dosing chamber, pumping chamber, or siphon chamber at each of the six sites. The specific point of sampling at each site, except for Kingston, is indicated on Figures 2-6 as follows:

Site	Sampling Point
Kingston (KS)	Pumping Chamber
Town of Scott (TS)	Dosing Tank
Maplewood (MW)	Dosing Chamber
Wyeville (WV)	Dosing Chamber
Westboro (WB)	Siphon Chamber
Don's Mobile Manor (DONS)	Dosing Chamber

The composition of STE was determined from grab samples collected between March 1986 and March 1987. Samples for VOC analysis were collected using a specially constructed apparatus consisting of a 300 mL wide-mouth teflon container mounted on a portable aluminum frame. The sample jar was capped with a teflon cap liner which could be remotely opened and closed by pulling or releasing a wire attached to it. The sample jar was submerged so that the lid was approximately 2 ft. below the liquid level and then the lid was raised and a 300 mL. sample was collected. The lid was closed prior to removing the jar from the liquid. Sampling in this manner excluded any scum or floating debris from the sample collected (see Figure 7).

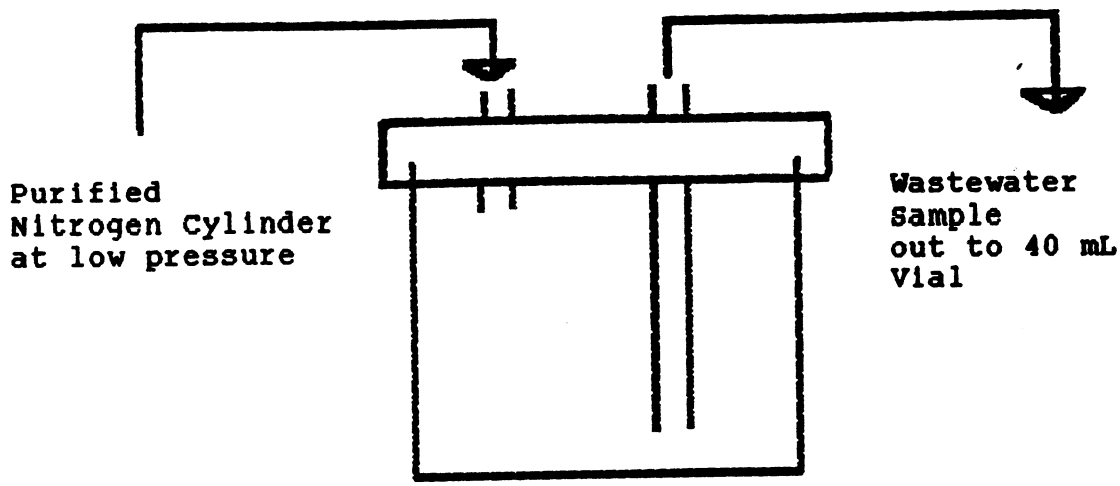
After the samples were collected the sample jar was removed from the sampling device and a teflon lid was screwed onto the sample jar. The lid was fitted with two teflon straight bulk head fittings. One of the fittings

FIGURE 7.
SEPTIC TANK EFFLUENT SAMPLING APPARATUS
(Adapted from Anderson et al. 1984)



terminated at the surface of the sample collection jar and was connected to a cylinder containing purified nitrogen. The other bulk head fitting extended to the bottom of the sample collection jar and was connected to a 2 ft. length of 1/4 in. teflon tubing. The cylinder was used to place a low positive pressure inside the sample jar to force sample from the bottom of the jar through 1/4 in. tubing to the collection vials (see Figure 8).

FIGURE 8.
TEFLON SAMPLING JAR
FOR SAMPLING SEPTIC TANK EFFLUENT



A slight pressure was used to produce laminar flow in the sample discharge tube. The sample was collected in a 40 mL VOC sampling vial. The vial was filled to the top and allowed to overflow for four seconds and then sealed with a screw-on teflon lined cap. Four vials were filled for each sample and a trip blank was carried with every two samples.

The sampling apparatus could also be fitted with a 4-liter, wide-mouth polyethylene bottle. The contents of the 4-liter sample bottle were divided into two one liter samples for subsequent physical and chemical analyses. The remaining sample volume was used for on-site determination of pH, temperature, and electrical conductivity.

The apparatus was used in the same manner to collect samples of septage from the community septic tanks at Kingston and Wyeville. Septage samples were collected and divided the same as STE samples.

The sampling apparatus was thoroughly cleaned with deionized water after each sampling. At sites where both STE and septage were sampled, STE was sampled first and the appartus cleaned before sampling septage.

Groundwater Monitoring

Groundwater monitoring wells were installed at the following four sites; Village of Kingston, Town of Scott, Village of Wyeville, and the Village of Maplewood.

The groundwater monitoring wells were installed using a Wisconsin Geological and Natural History Survey truck-mounted rotary drill head and a 6 in. continuous-flight, hollow stem auger. Inspection of soil cuttings during the drilling operations at each site confirmed previous subsoil classification below the absorption systems. The wells were constructed of 2 in., Schedule 40, threaded flush joint, PVC pipe. Each well was screened with 5 ft., of 2 in., slotted, 0.010 in., Schedule 40 PVC well screen. The screened portion of each well was back filled with sand cuttings and capped with a bentonite seal. The borehole was then filled to grade and a protective steel casing was installed and secured with a concrete plug. Well construction details are given in Appendix A.

Figure 9 indicates the location of groundwater monitoring wells and Figure 10 depicts the vertical elevation of wells at the Village of Kingston. Figure 11 shows the general groundwater flow pattern on October 16, 1984 which was to the northeast of the site (Swed 1985).

Figure 12 indicates the location of groundwater monitoring wells and Figure 13 depicts the vertical elevation of wells at the Town of Scott. Figure 14 shows the general groundwater flow pattern on February 3, 1987 which indicates mounding at the site with flow mostly to the east (WDNR 1987).

Figure 15 indicates the location of groundwater monitoring wells and Figure 16 depicts vertical elevation of wells at the Village of Maplewood. The author was unable to determine the general groundwater flow because of the limited number of data points at this site.

Figure 17 indicates the location of groundwater monitoring wells and Figure 18 indicates the vertical elevation of wells at the Village of Wyeville. Figure 19 shows the general groundwater flow pattern on November 11, 1987 with flow to the north of the site (WDNR 1987).

Sampling of groundwater wells was accomplished by use of a 5 ft., 1-3/4 in., stainless steel bailer. The bailer was attached to 15 ft. of 5/64 in. teflon coated stainless steel wire. Attached to the wire was 25 ft. of 3/16 in. polypropylene cord. This was done so that the sampling

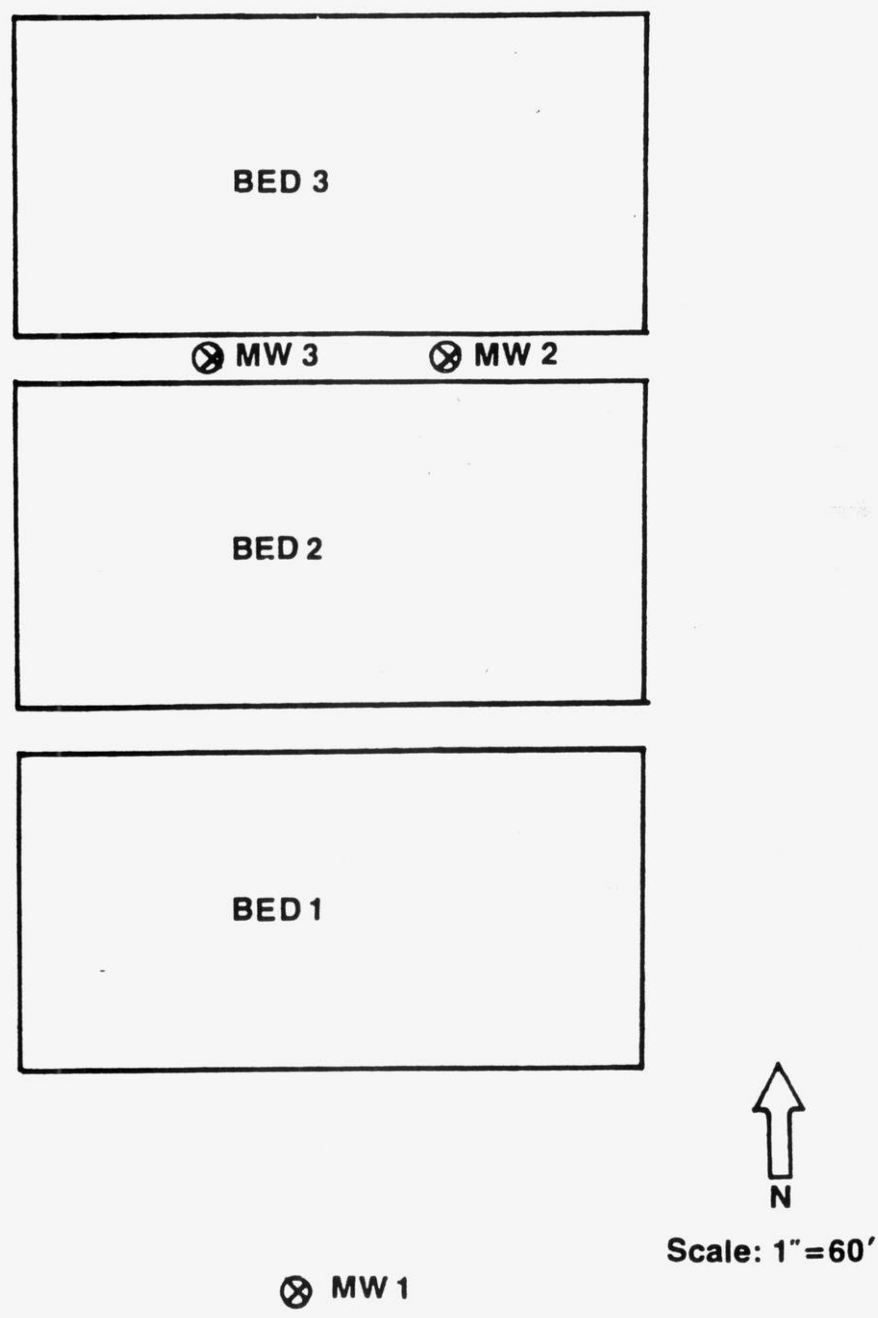


FIGURE 9
GROUNDWATER MONITORING WELL LOCATIONS
AT THE VILLAGE OF KINGSTON

FIGURE 10.
VERTICAL PLACEMENT OF MONITORING WELLS
AT THE VILLAGE OF KINGSTON

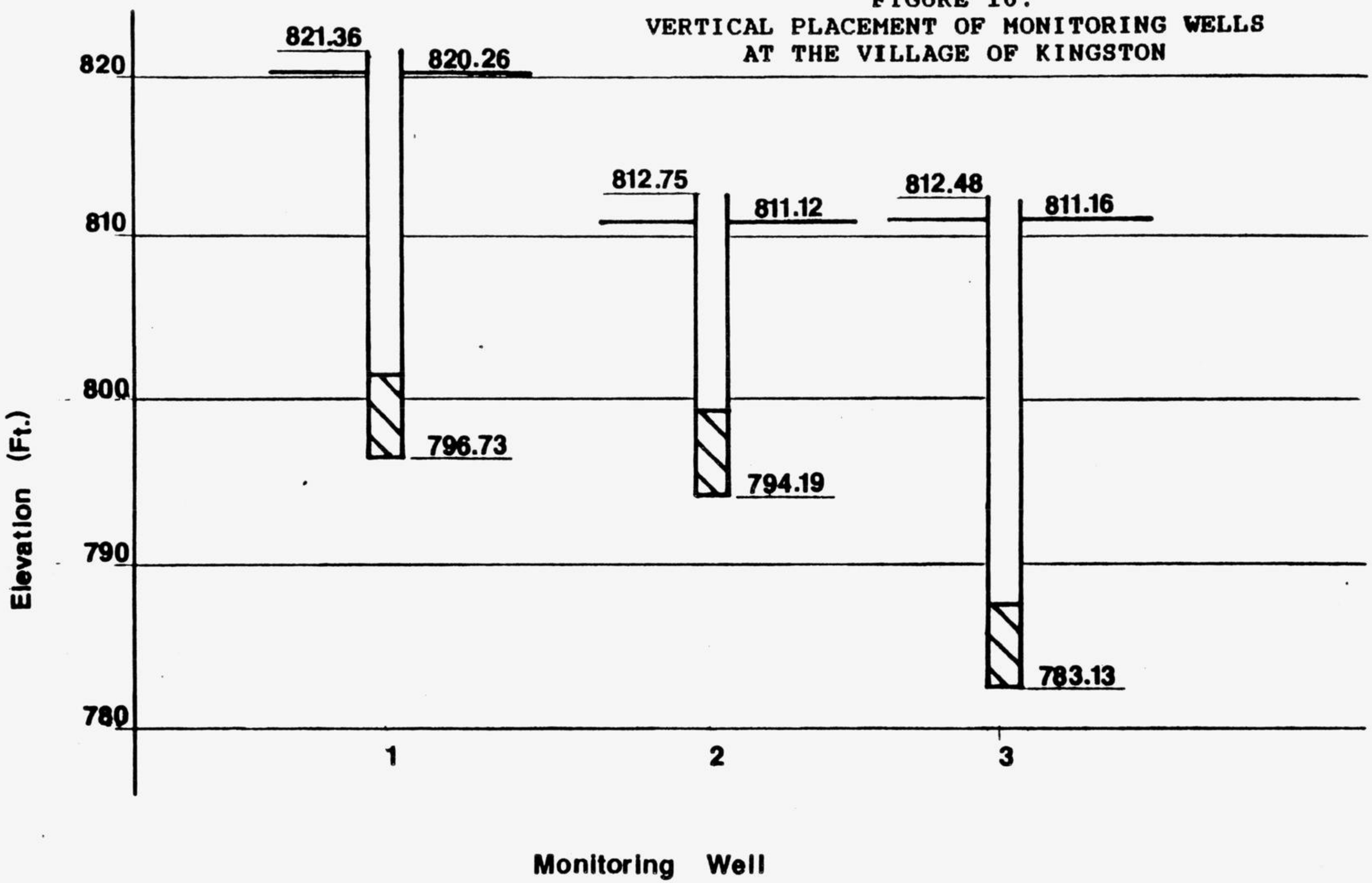
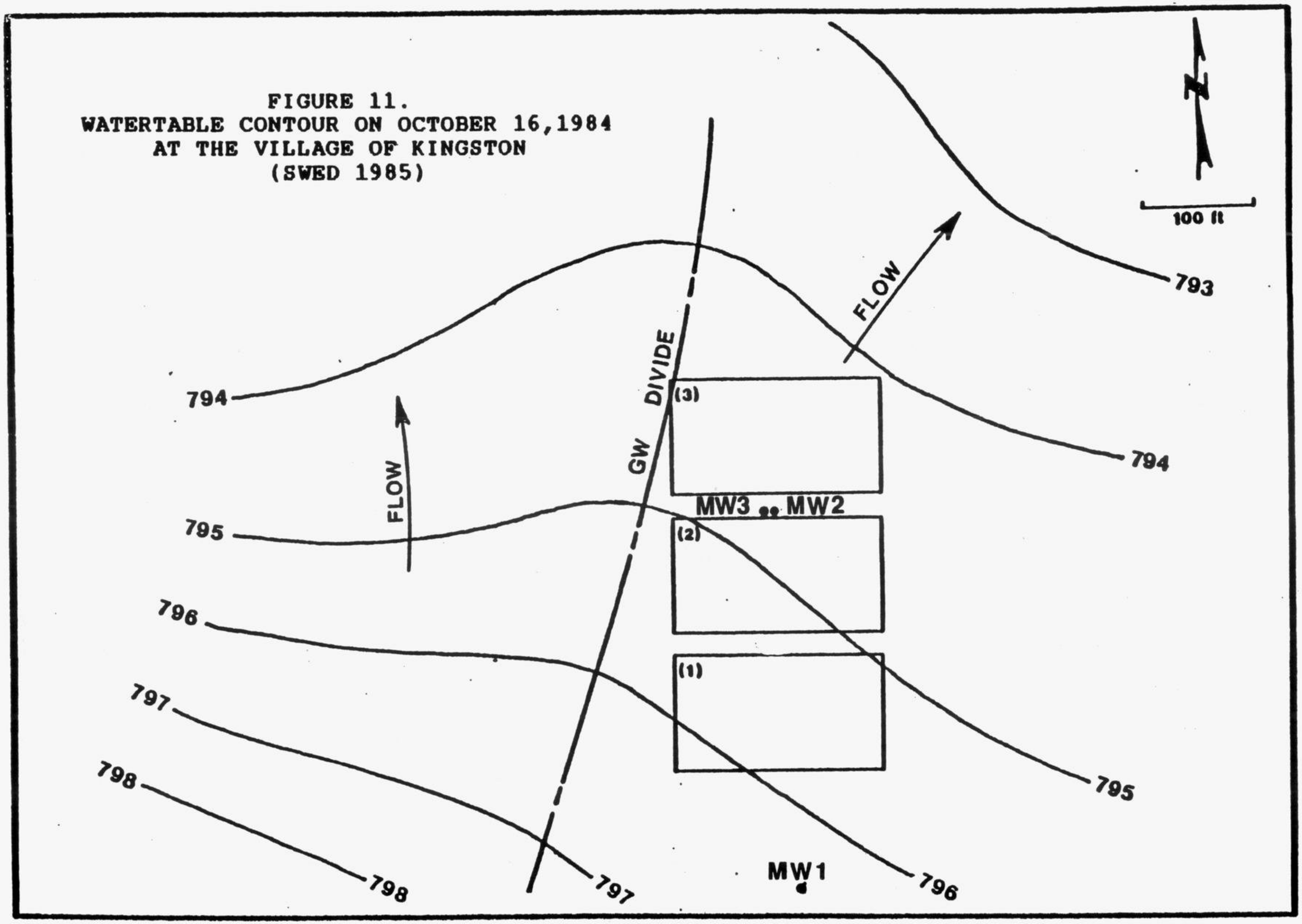


FIGURE 11.
WATERTABLE CONTOUR ON OCTOBER 16,1984
AT THE VILLAGE OF KINGSTON
(SWED 1985)



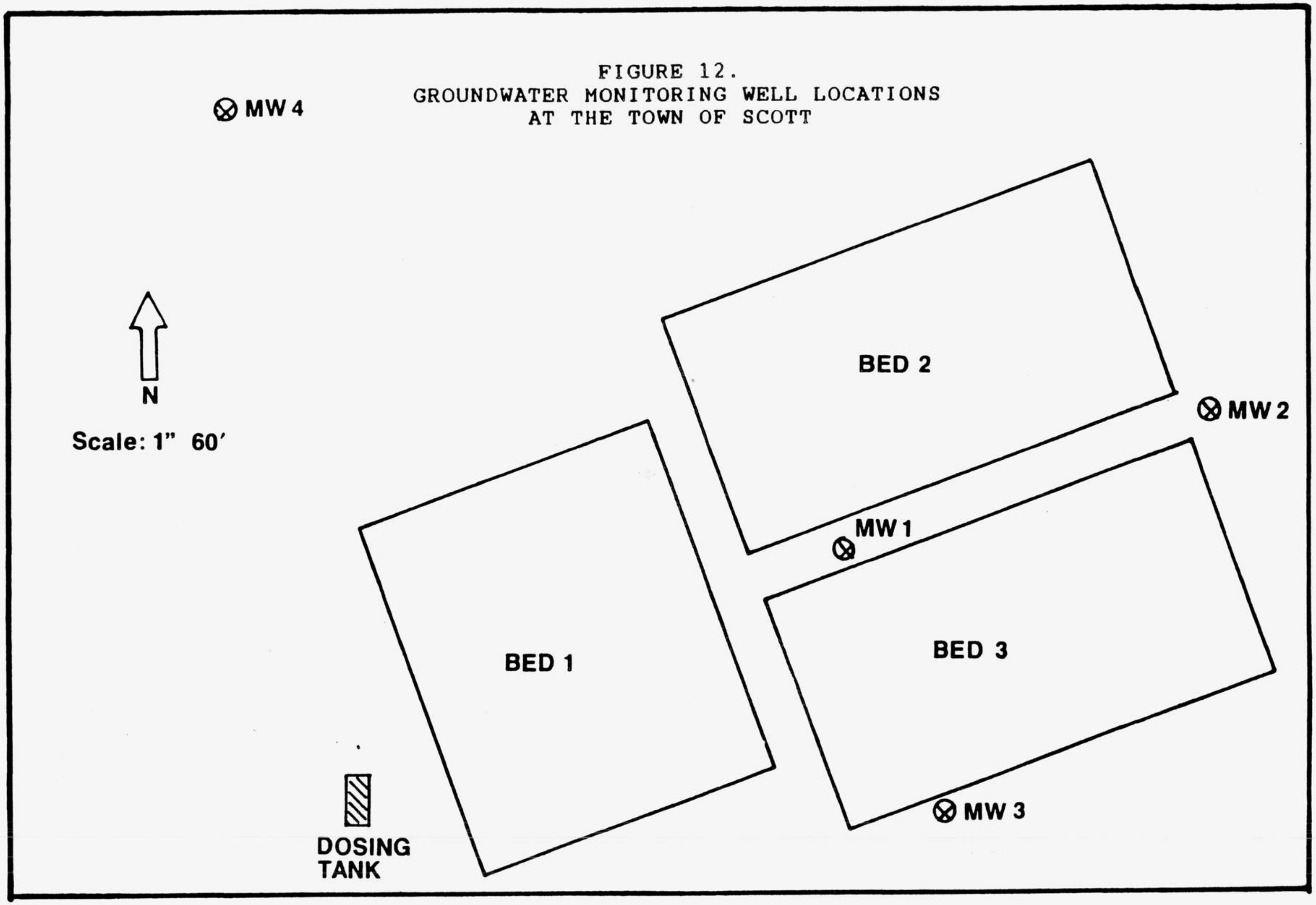


FIGURE 12.
GROUNDWATER MONITORING WELL LOCATIONS
AT THE TOWN OF SCOTT

FIGURE 13.
VERTICAL PLACEMENT OF MONITORING WELLS
AT THE TOWN OF SCOTT

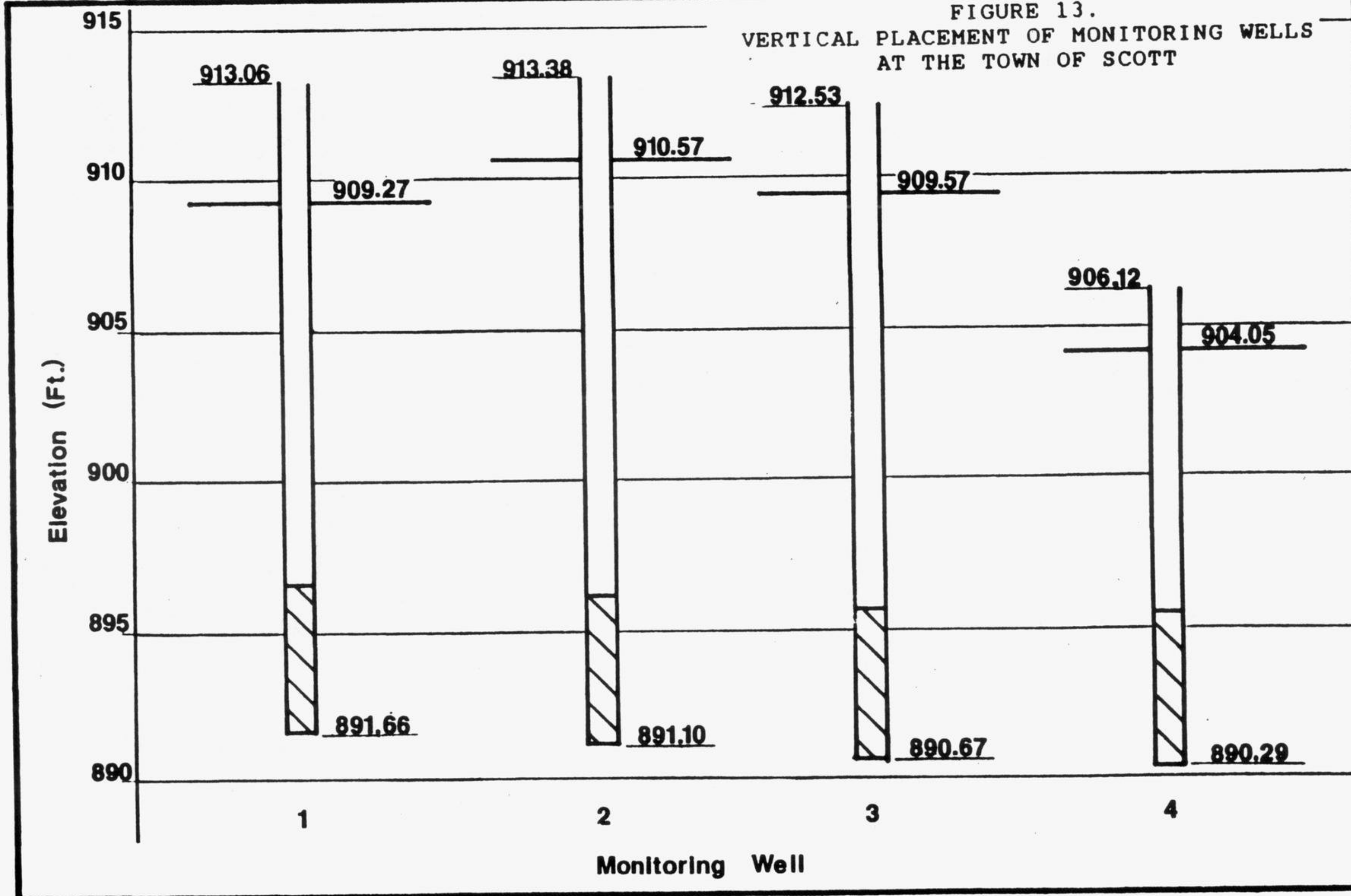
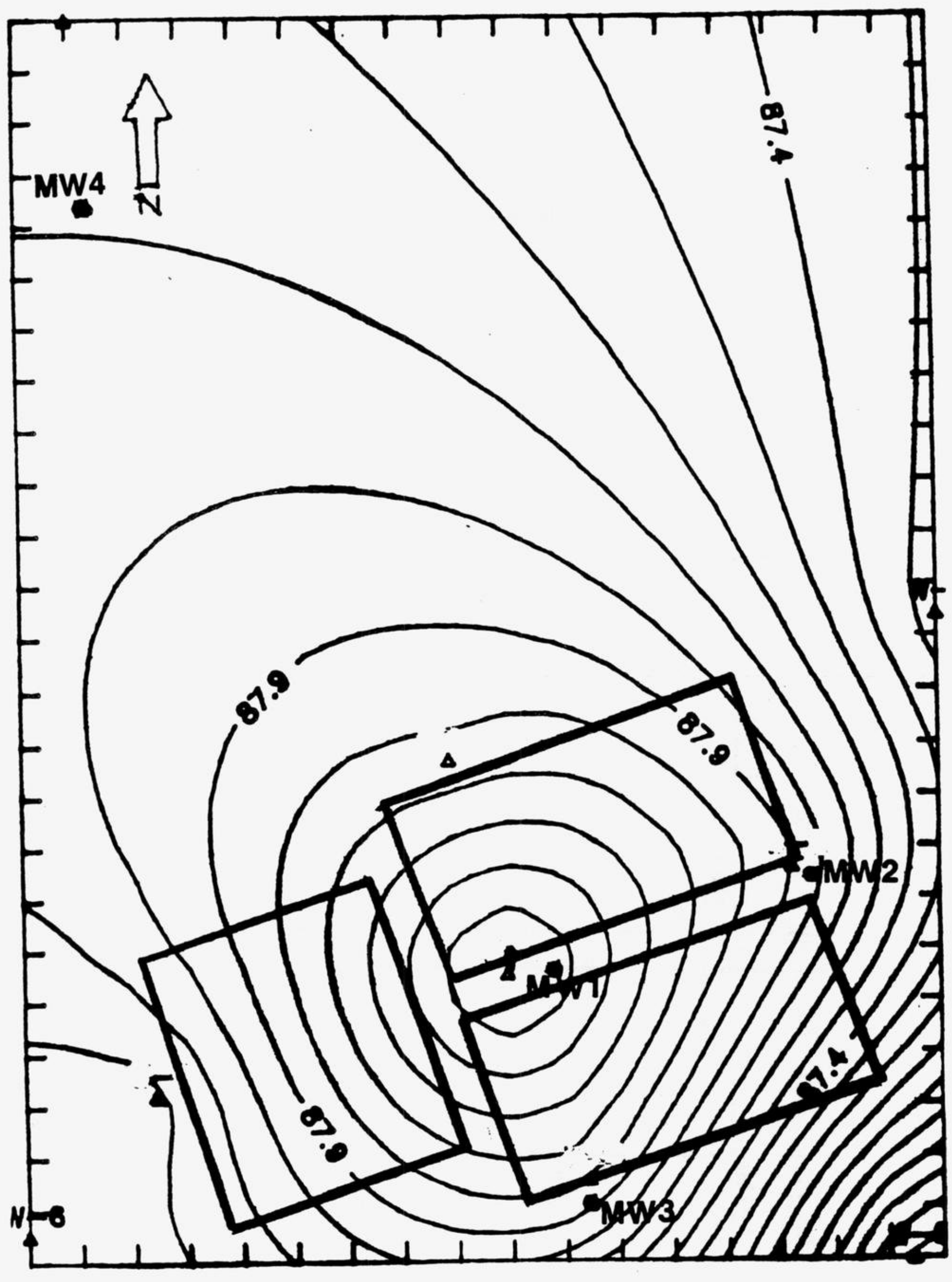


FIGURE 14.
WATERTABLE CONTOUR ON FEBRUARY 3,1987
AT THE TOWN OF SCOTT
(WDNR 1987)
NO SCALE



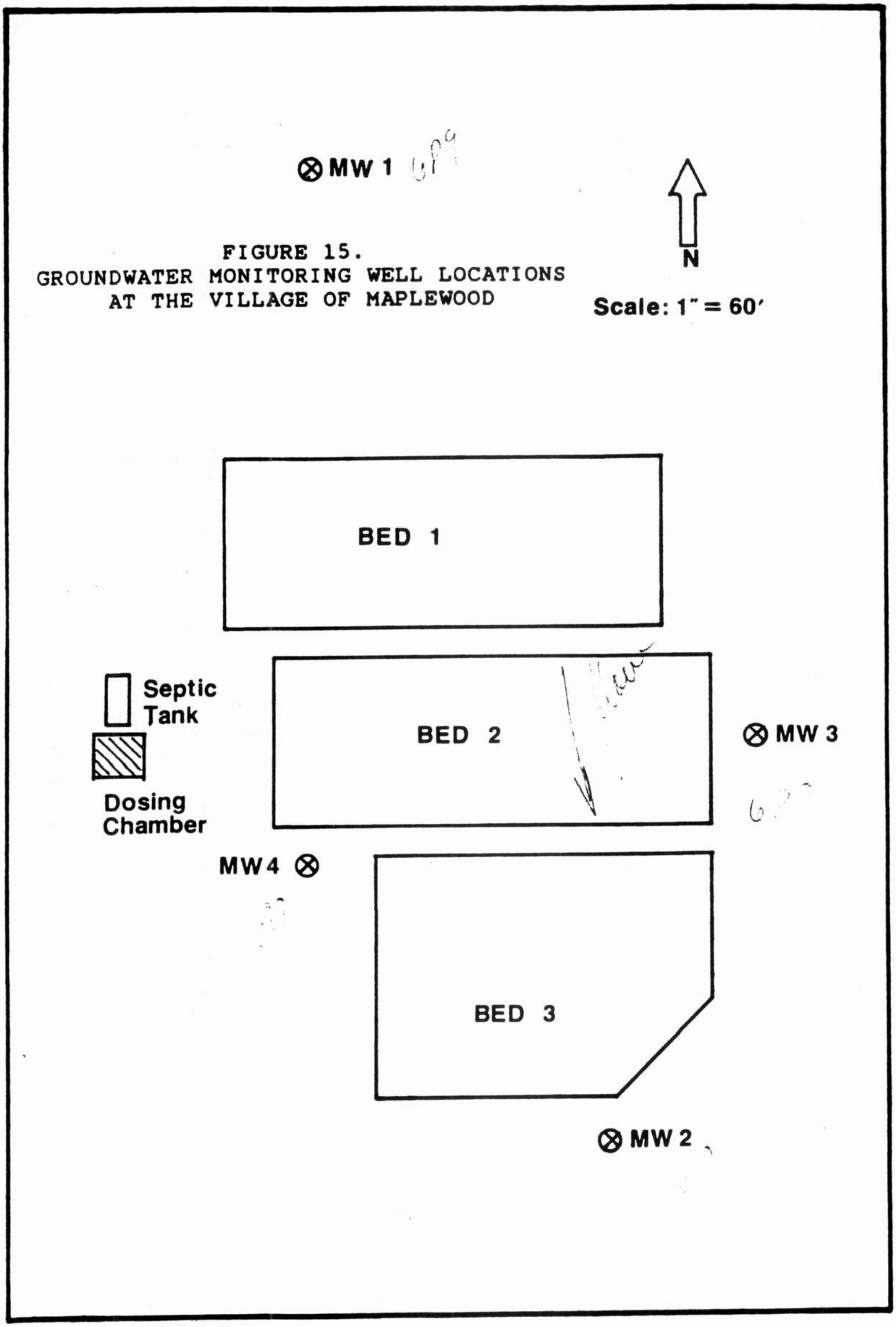
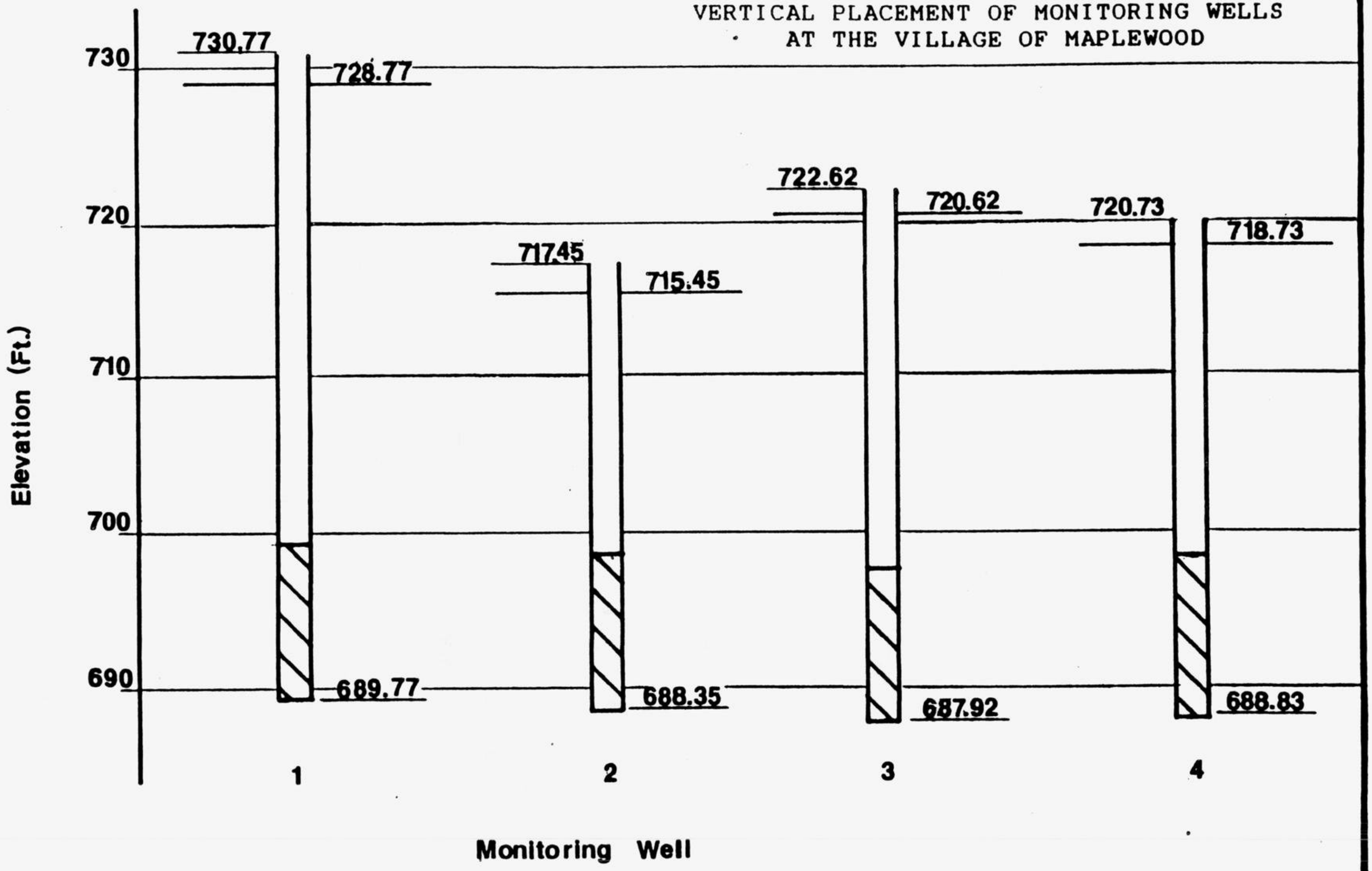


FIGURE 15.
GROUNDWATER MONITORING WELL LOCATIONS
AT THE VILLAGE OF MAPLEWOOD

FIGURE 16.
VERTICAL PLACEMENT OF MONITORING WELLS
AT THE VILLAGE OF MAPLEWOOD



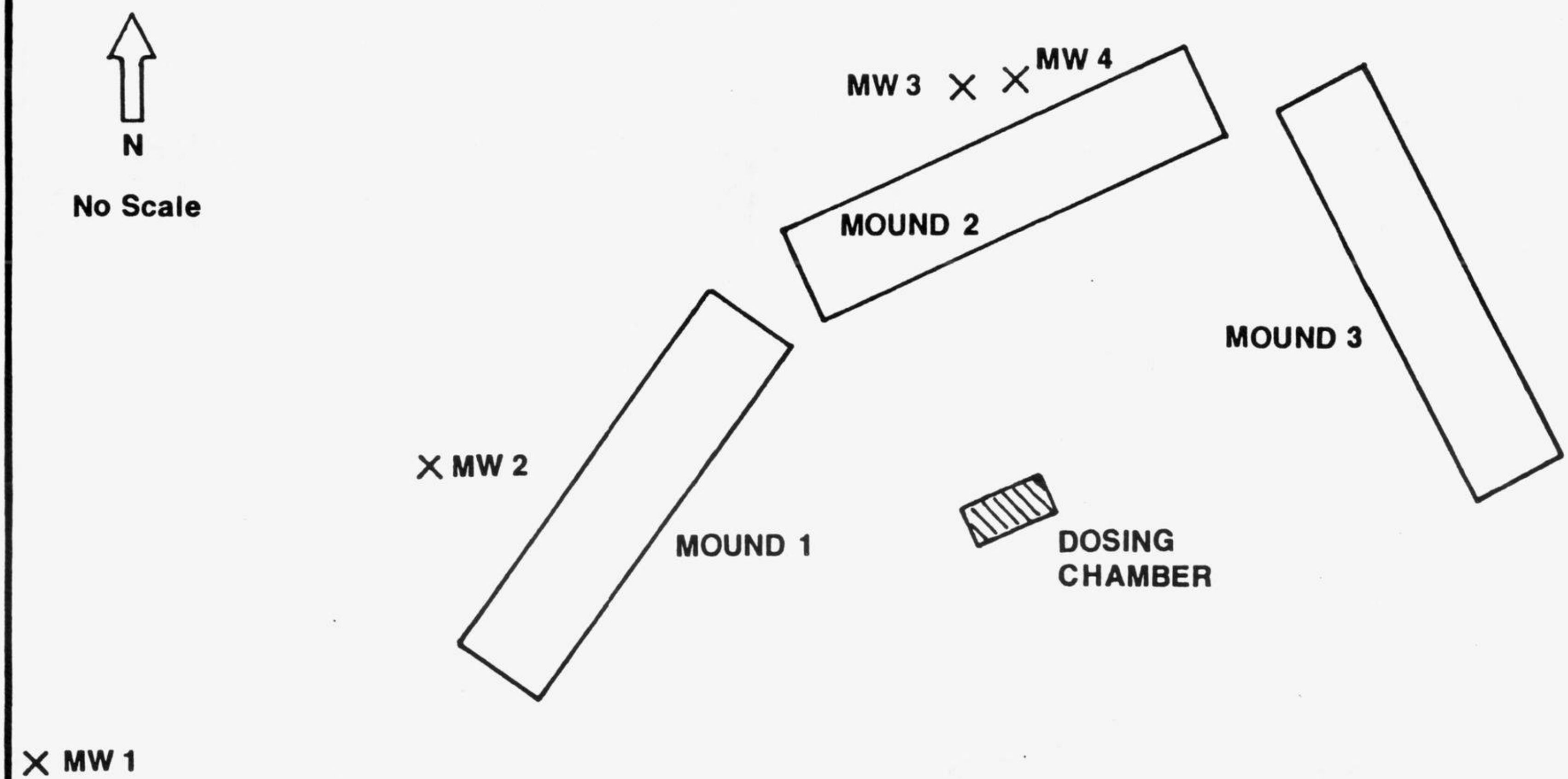


FIGURE 17.
GROUNDWATER MONITORING WELL LOCATIONS
AT THE VILLAGE OF WYEVILLE

FIGURE 18.
VERTICAL PLACEMENT OF MONITORING WELLS
AT THE VILLAGE OF WYEVILLE

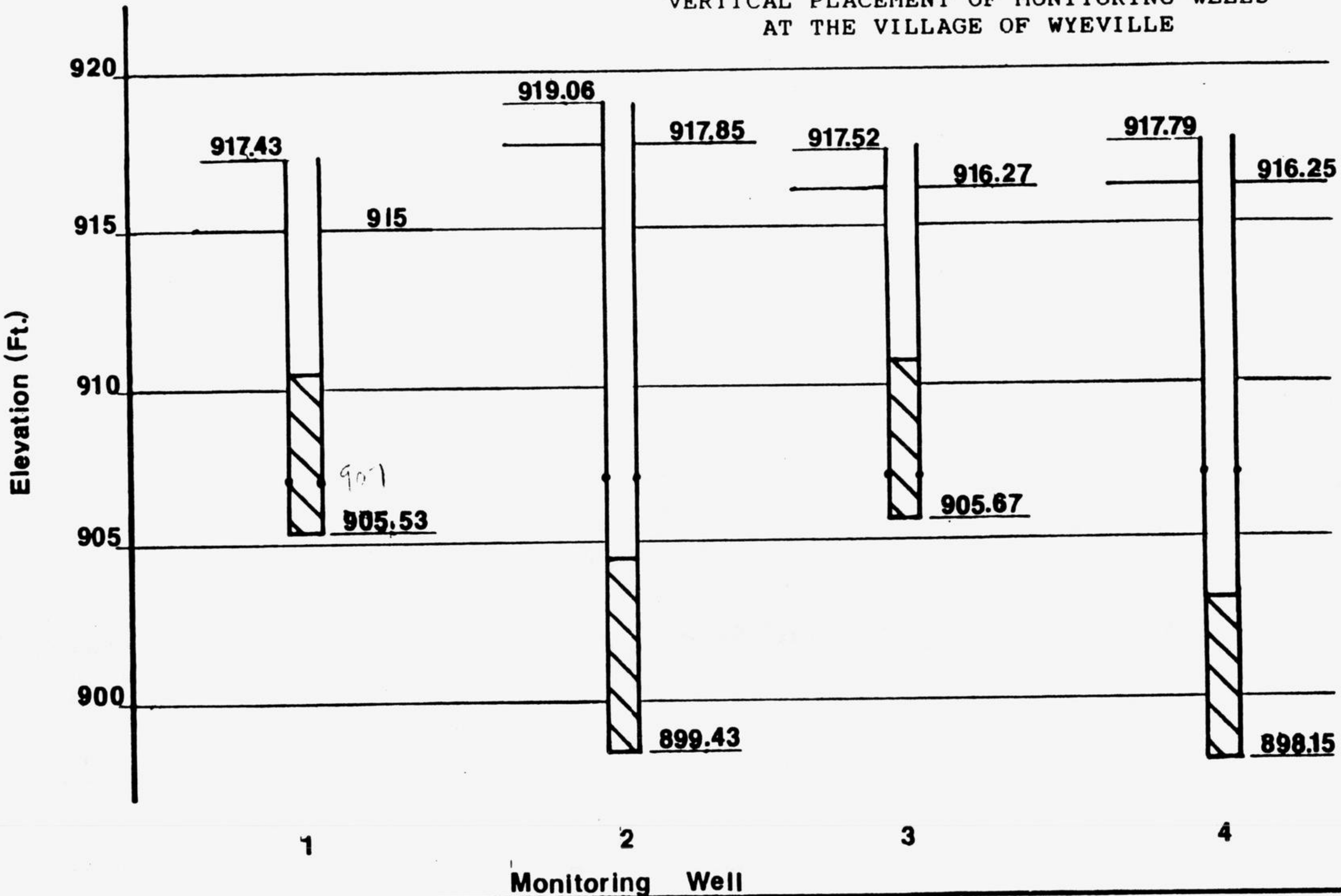
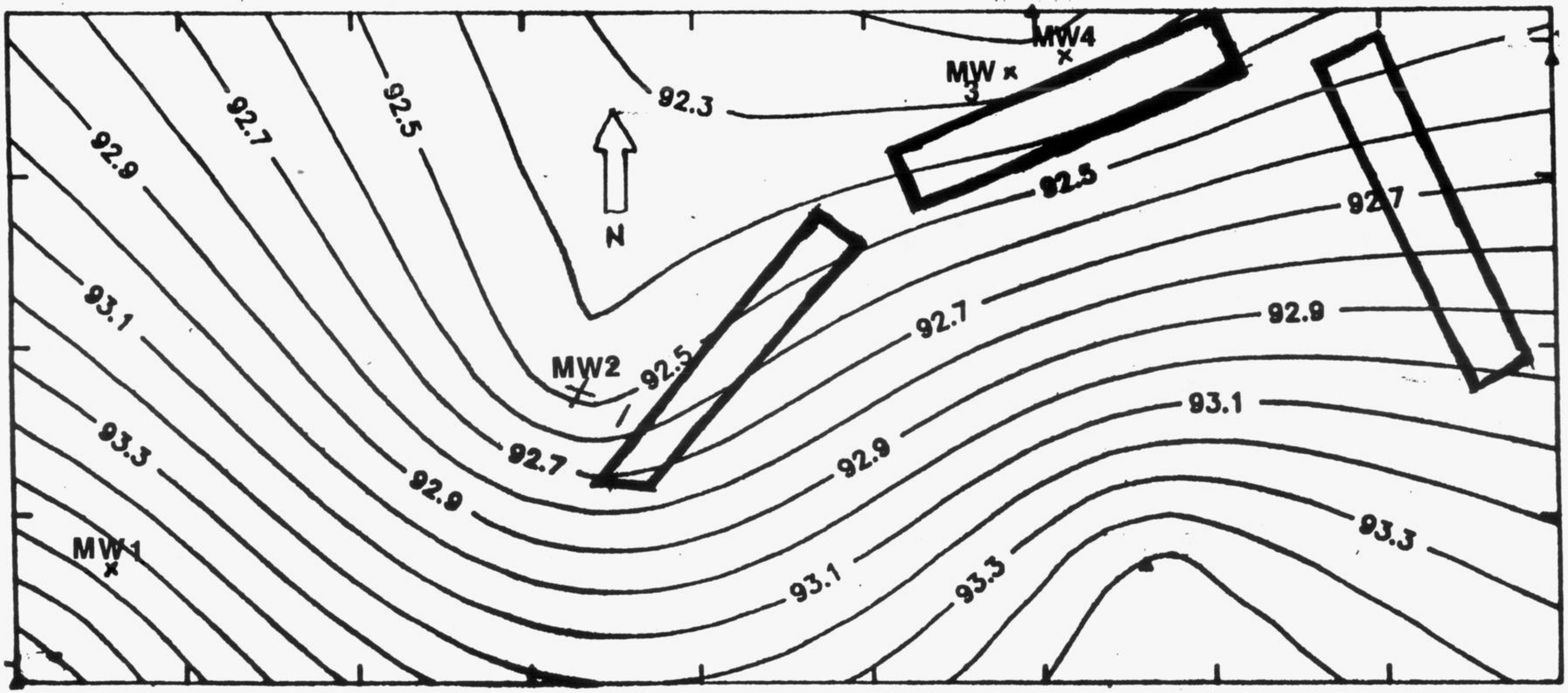


FIGURE 19.
GROUNDWATER CONTOUR ON NOVEMBER 4, 1987
AT THE VILLAGE OF WYEVILLE
(WDNR 1987)
NO SCALE



apparatus contacting groundwater was either stainless steel or teflon. A large plastic cloth was placed on the ground around the base of a well when sampling to prevent the bailer line from touching the ground. The bailer was lowered slowly into contact with the water surface in each well. Six volumes of standing water were removed from each well and discarded before sample collection. This was done to assure that collected sample was representative of actual groundwater and not stagnant water in the wells.

Two samples were collected in 1-L acid-washed plastic bottles and transported on ice to the U.W. Department of Civil and Environmental Engineering Laboratory. One sample was preserved with appropriate acid to pH less than 2.0 and the other sample was not preserved, both samples were stored at 4 degrees Celsius pending analysis.

A teflon bailer bottom-emptying device was used to collect VOC samples. The sample was collected on a fresh bailer full of water and emptied into 40 ml vials until slightly overflowing and a positive meniscus was formed. The samples were capped immediately and checked to make sure no air bubbles were present in the vial. The samples were transported on ice to the Wisconsin State Laboratory of Hygiene. Samples were stored at 4 degrees Celsius pending analysis.

The bailer, cord and emptying device were throughly rinsed with deionized water after sampling each well.

The test methods and instrumentation used to analyze STE, groundwater and septage samples are listed in Table 12. The BOD5 test was conducted on STE and septage samples only.

Table 12.
Analytical Methods

Parameter	Instrument	Method
pH (field)	Cole Parmer Digi-Sense pH meter	Direct Reading (USEPA 1979)
(lab)	Corning pH Meter Model 10	Direct Reading (USEPA 1979)
Conductivity	Lab Line Model "M"	Direct Reading (USEPA 1979)
TOC,POC	Dohrmann Model DC-80	EPA Method 415.2 (USEPA 1979) EPA Method 415.1 (USEPA 1979)
BOD5	YSI Oxygen Meter Model 54A	EPA Method 405.1 (USEPA 1979)
Solids	(standard apparatus)	EPA Method 160.2-4 (USEPA 1979)
NH3-N	Technicon Auto-Analyzer	EPA Method 350.1 (USEPA 1979)
NO3-N	Technicon Auto-Analyzer	EPA Method 353.2 (USEPA 1979)
NO2-N	Technicon Auto-Analyzer	EPA Method 353.2 (USEPA 1979)
Chloride	Technicon Auto-Analyzer	USGS Method (USGS 1979) I-2187-78
VOC	GC/MS (Head space)	Screening (Federal Register)
VOC	Gas Chromatography (see App. D for detection limits)	EPA Method (Federal Register) 601 & 602

RESULTS

System Results

Site #1 Kingston, Green Lake County, Wisconsin

The first area of interest was the quality and volume of STE applied to the absorption fields. Characteristics of Kingston STE are given in Table 13. The values reported are mean concentrations for seven sampling periods. The STE samples were collected at the system pump chamber. The data from sampling are listed in Appendix B.1.

Table 13.
STE Composition at the
Village of Kingston, Wisconsin

Parameter	Concentration (mg/L)
BOD5	194.
TOC	157.59
TS	1087.
TSS	49.
NH4-N	67.3
NO3-N	< 0.05
NO2-N	< 0.05
Cl	228.1

The measured concentrations were generally higher than those reported by other investigators (see Table 14.).

The average volume of STE pumped to the absorption fields was 14,204 gallons per day over the period of the study. The average daily flow for each month during the study is represented in Figure 20.

Table 15 indicates which beds where being dosed over time. In general, the beds were alternately loaded for 3 month periods. Depending on the rotation a single bed was loaded for either 3 or 6 months.

Table 14
Comparison of Septic Tank Effluent Composition As Determined by Various Investigators*.
(Siegrist et al., 1983)

Parameter	Units	Multiple Homes					Individual Homes		
		Westboro, WI	Bend, OR	Glide, OR	Manila, CA	College Sta., TX	Wisconsin	Pennsylvania	Oregon
BOD_5	mg/L	168	157	118	189	-	132	-	217
COD	mg/L	338	276	228	284	266	445	483	-
TS	mg/L	663	-	376	355	-	895	-	-
TSS	mg/L	85	36	52	75	-	87	108	146
TKN	mgN/L	57	41	50	-	29.5	81.5	74.4	57.1
NH_4	mgN/L	44	-	32	-	24.7	53.5	-	40.6
NO_3	mgN/L	6.4	-	0.5	-	0.2	0.95	<0.33	0.42
TP	mgP/L	8.1	-	-	-	8.2	21.8	18.2	-
pH	-	6.9-7.4	6.4-7.2	6.4-7.2	6.5-7.8	7.36	7.3	-	-
CL-	mg/L	62	-	-	-	1.83	164	230	-
EC	umhos/cm	1073	-	-	-	3204	909.8	-	-
Grease	mg/L		65	16	22	-	-	-	-
F. Coliforms	Log#/L	7.3	-	-	-	6.04	6.45	-	6.41
F. Streptococci	Log#/L	5.7	-	-	-	-	5.40	-	-
Flow	Lpcd	136	151-227	182	151-216		166	-	-

* Descriptions

Westboro, WI	-	Small diameter gravity sewer collected STE from a small community.
Bend, OR	-	Pressure sewer collected STE from 11 single family homes (Bowne, 1982).
Glide, OR	-	Pressure sewer collected STE from a small community (Bowne, 1982)
Manila, CA	-	Pressure sewer collected STE from 330 connection (Bowne, 1982).
College Sta., Texas	-	Ste from one septic tank serving 9 homes (Brown, et al., 1977)
Wisconsin	-	33 single family homes in Wisconsin (Harkin, et al., 1979)
Pennsylvania	-	10 single family homes in Pennsylvania (Cole and Sharpe, 1981)
Oregon	-	8 single family homes in Oregon (Ronayne, et al., 1982)

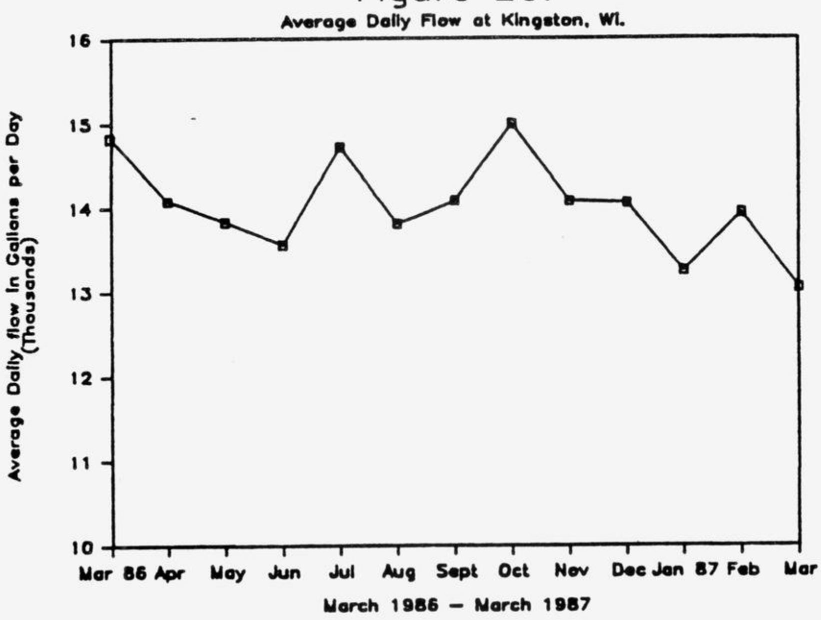
Table 15.
Bed loading at Kingston, Wisconsin
March 1986 through March 1987

March 1986 - March 1987

Bed	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
1	x	x	x	x		x	x	x	x	x	x		
2	x	x	x		x			x				x	x
3				x	x	x	x		x	x	x	x	x

x - indicates that bed was in service

Figure 20.



The volatile organic compounds detected in STE samples at Kingston, Wisconsin are presented in Table 16.

Table 16.
Concentration of Volatile Organic Compounds Detected in STE at the Village of Kingston, Wisconsin
(Concentrations = ppb)

	Date of Sample Collection						
Parameter	3/26/86	5/3/86	7/2/86	8/24/86	10/19/87	1/14/87	3/16/87
p-dichlorobenzene	2.0	2.2	2.0	*	2.0	-	4.4
Toluene	12.0	89.0	200.0	*	35.0	19.0	75.0
1,1,1-Trichloroethane	1.2	1.9	-	-	-	1.2	-
Chloroform	1.9	2.1	-	-	-	-	-
Xylenes	-	-	3.7	-	-	-	-
Benzene	-	-	1.4	-	-	-	-

Conc. = ppb., * = detected but not quantified, - = below detection limit

The concentrations of volatile organic compounds detected in septage at Kingston are presented in Table 17. The samples were collected from the central septic tank at Kingston.

Table 17.
Concentration of Volatile Organic Compounds in Septage at the Village of Kingston, Wisconsin

	October 1986 - March 1987		
Parameter	10/19/86	1/14/87	3/16/87
P-dichlorobenzene	-	-	4.4
Toluene	80.0	360.0	150.0

Conc. =ppb, - = below detection limit

The results of groundwater monitoring for conventional parameters are presented in Appendix C.1. The results indicated that wells KSMW2 and KSMW3 were located in the discharge plume from the system. The results of groundwater monitoring at Kingston indicated that volatile organic compounds were not present in detectable concentrations in the three wells sampled. The wells were sampled four times. A total of 12 groundwater samples were collected at Kingston.

Site #2 Town of Scott Sanitary District, Sheboygan County, Wisconsin

Characteristics of the STE at the Town of Scott are given in Table 18. The values reported are mean concentrations for seven sampling periods. The STE samples were collected at the systems, dosing chamber. The data from sampling are listed in Appendix B.2.

Table 18.
STE Composition at the Town of Scott, Wisconsin

Parameter	Concentration (mg/L)
BOD5	92.
TOC	97.
TS	870.
TSS	47.
NH4-N	73.4
NO3-N	< 0.05
NO2-N	< 0.05
Cl	194.2

The measured composition was lower in BOD5 and higher in NH4-N than that reported by other investigators (see Table 14.).

The average volume of STE pumped to the absorption fields was 14,195 gallons per day over the period of the study. The average daily flow for each month during the study is represented in Figure 21.

Table 19 indicates which beds where being dosed over time. Due to operator error Beds 1, 2 and 3 were dosed independently during start up of the soil absorption system. Normal operation of the system began during January 1987. In general, the beds were alternately loaded for 3 month periods.

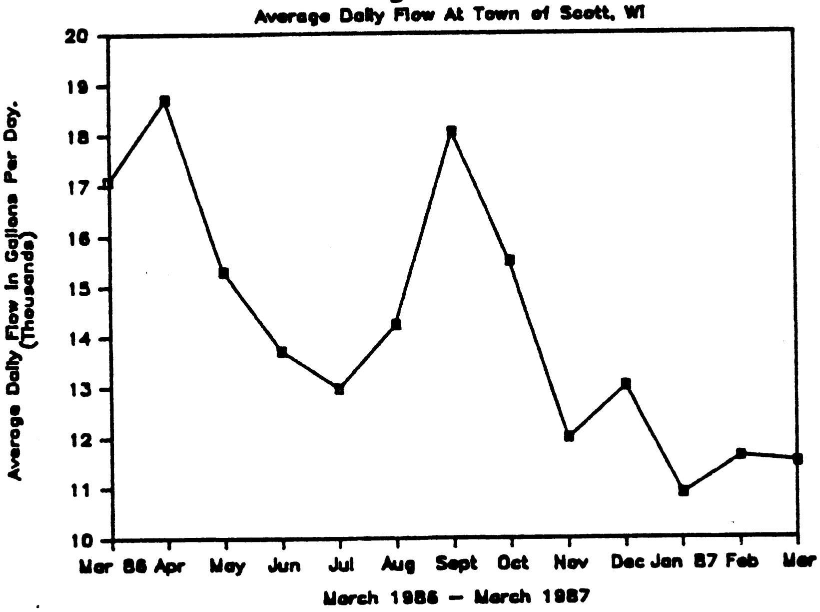
Table 19.
Bed loading at Town of Scott, Wisconsin
March 1986 through March 1987

March 1986 - March 1987

Bed	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
1	x												
2		x	x	x	x	x	x	x			x	x	x
3									x	x	x	x	x

x - indicates that bed was in service

Figure 21.
Average Daily Flow At Town of Scott, WI



The volatile organic compounds detected in STE samples at Town of Scott Sanitary District, Wisconsin are presented in Table 20.

Table 20.
Concentration of Volatile Organic Compounds Detected in STE at the Town of Scott, Wisconsin

	Date of Sample Collection						
Parameter	3/24/86	5/16/86	6/30/86	8/19/86	10/4/87	1/15/87	3/20/87
p-dichlorobenzene	-	-	-	2.5	20.0	4.4	2.6
Toluene	-	-	2.0	51.0	10.0	76.0	6.2
Tetrachloroethlyene	2.0	-	-	-	-	-	-

Conc. = ppb., * = detected but not quantified, - = below detection limit

The results and discussion of groundwater monitoring for conventional parameters are presented in Appendix C.2. The results indicated that monitoring wells TSMW 1, TSMW2, and TSMW3 were screened in the discharge plume from the system. The results of volatile organic compounds detected in groundwater at Town of Scott are presented in Table 21. The results are based on 16 groundwater samples. Refer to Figure 12 for the location of monitoring wells.

Table 21.
Concentration of Volatile Organic Compounds in Groundwater at Town of Scott, Wisconsin

	October 1986 - March 1987			
	8/19/86	10/4/86	10/4/86	3/20/87
Well No.	TSMW1	TSMW1	TSMW2	TSMW2
Parameter				
1,1,1-Trichloroethane	1.9	2.8	2.20	1.7

TSMW - denotes Town of Scott Monitoring well, Concentration in ppb.

Site #3 Maplewood Sanitary District, Door County, Wisconsin

Characteristics of Maplewood STE are given in Table 22. The values reported are mean concentrations for seven sampling periods. The STE samples were collected at the system sump chambers. The data from sampling are listed in Appendix B.3

Table 22.
STE Composition at the
Village of Maplewood, Wisconsin

Parameter	Concentration (mg/L)
BOD5	71.
TOC	84.16
TS	803.
TSS	27.
NH4-N	29.3
NO3-N	0.16
NO2-N	< 0.05
Cl	176.3

The measured composition was lower in BOD5 and TSS than that reported by other investigators (see Table 14.).

The average volume of STE pumped to the absorption fields was 18,017 gallons per day over the period of the study. The average daily flow for each month during the study is represented in Figure 22.

Table 23 indicates which beds where being dosed over time. In general, the beds were alternately loaded for 3 month periods. Depending on the rotation a single bed was loaded for either 3 or 6 months. Due to operator error beds 2 and 3 were loaded over the design period of 6 months

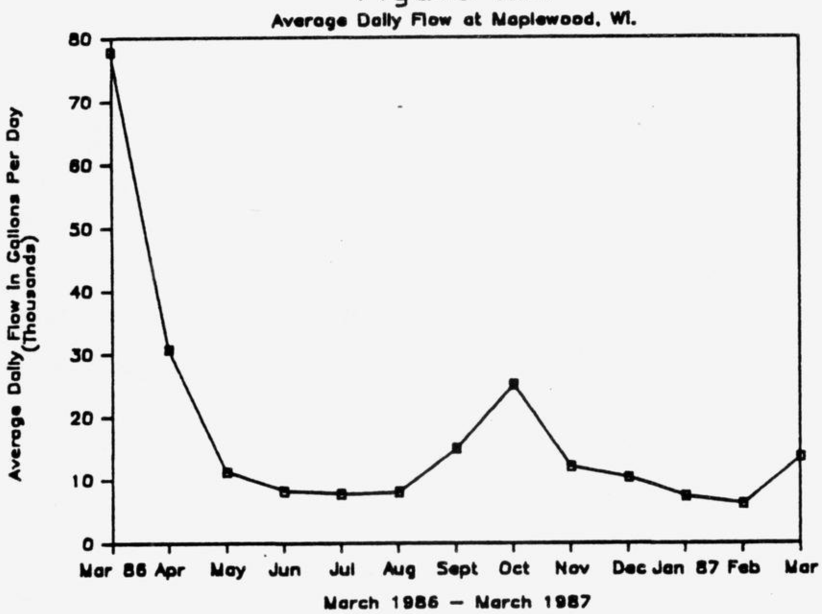
Table 23.
Bed loading at Village of Maplewood, Wisconsin
March 1986 through March 1987

March 1986 - March 1987

Bed	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
1	x	x	x	x	x				x	x	x		
2	x	x	x	x	x	x	x	x					x
3						x	x	x	x	x	x	x	

x - indicates that bed was in service

Figure 22.



The volatile organic compounds detected in STE samples at the Village of Maplewood, Wisconsin are presented in Table 24.

Table 24.
Concentration of Volatile Organic Compounds Detected in STE at the Village of Maplewood, Wisconsin
(Concentrations = ppb)

	Date of Sample Collection						
Parameter	3/24/86	5/16/86	6/30/86	8/18/86	10/4/87	1/6/87	3/28/87
p-dichlorobenzene	-	2.5	3.2	-	-	-	4.8
Toluene	-	14.0	26.0	*	3.3	18.0	-
1,1,1-Trichloroethane	-	-	-	-	-	-	-
Chloroform	-	2.2	-	-	-	-	-
Xylenes	-	-	2.0	-	-	-	-
Benzene	-	2.1	5.1	-	-	-	-
Ethylbenzene	-	-	1.8	-	-	-	-

Conc. = ppb., * = detected but not quantified, - = below detection limit

The results and discussion of groundwater monitoring for conventional parameters are presented in Appendix C.3. The results indicated that monitoring wells MWMW2, MWMW3 and MWMW4 were screened in the discharge plume from the system. The four wells were sampled four times. A total of 16 groundwater samples were collected over the study. The results of groundwater monitoring at Maplewood indicated that volatile organic compounds were not present in detectable concentrations.

Site #4 Wyeville, Monroe County, Wisconsin

Characteristics of Wyeville STE are given in Table 25. The values reported are mean concentrations for seven sampling periods. The STE samples were collected at the system sump chambers. The data from sampling are listed in Appendix B.4.

Table 25.
STE Composition at the
Village of Wyeville, Wisconsin

Parameter	Concentration (mg/L)
BOD5	165.
TOC	135.3
TS	589.
TSS	73.
NH4-N	56.0
NO3-N	< 0.05
NO2-N	< 0.05
Cl	116.0

The measured composition was similar to that reported by other investigators (see Table 14.).

The average volume of STE pumped to the absorption fields was 7,681 gallons per day over the period of the study. The average daily flow for each month during the study is represented in Figure 23.

Table 26 indicates which beds were being dosed over time. In general, the beds were alternately loaded for 3 month periods. Depending on the rotation a single bed was loaded for either 3 or 6 months.

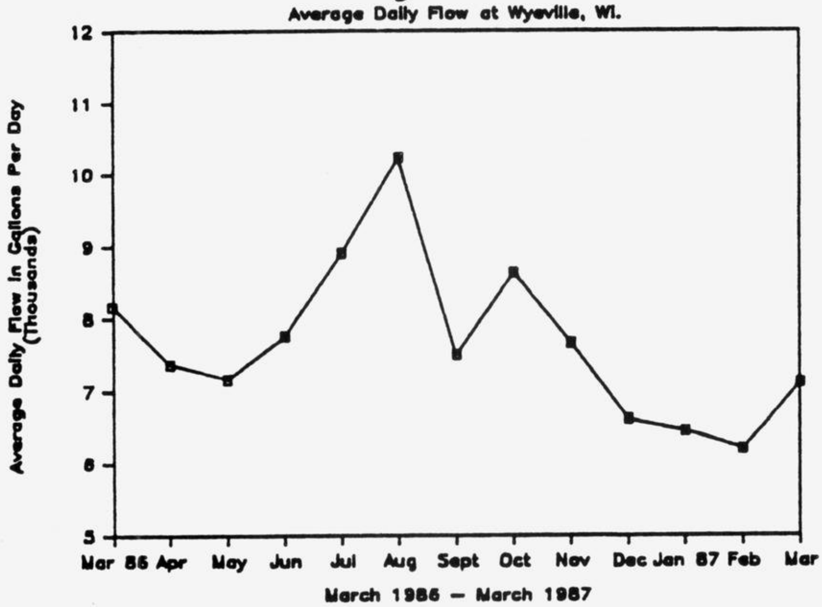
Table 26.
Bed loading at Wyeville, Wisconsin
March 1986 through March 1987

March 1986 - March 1987

Bed	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar
1	x	x	x	x	x				x	x			x
2		x	x			x	x	x			x	x	x
3	x			x	x	x	x	x	x	x	x	x	

x - indicates that bed was in service

Figure 23.
Average Daily Flow at Wyeville, WI.



The volatile organic compounds detected in STE samples at Wyeville, Wisconsin are presented in Table 27.

Table 27.
Concentration of Volatile Organic Compounds Detected in STE at the Village of Wyeville, Wisconsin
(Concentrations = ppb)

	Date of Sample Collection						
Parameter	3/25/86	5/15/86	6/29/86	8/23/86	10/11/87	1/13/87	3/17/87
p-dichlorobenzene	39.0	18.0	26.0	12.0	19.0	19.0	22.0
Toluene	2.4	14.0	12.0	40.0	28.0	23.0	24.0
Chloroform	-	2.5	-	-	-	2.4	1.6
Xylenes	6.9	9.7	6.8	2.0	15.0	-	4.9
Ethylbenzene	-	2.4	1.3	-	3.4	4.4	-

Conc. = ppb., * = detected but not quantified, - = below detection limit

The concentration of volatile organic compounds detected in septage at Wyeville are presented in Table 28. The samples were collected from the central septic tank.

Table 28.
Concentration of Volatile Organic Compounds in Septage at the Village of Wyeville, Wisconsin

	October 1986 - March 1987		
Parameter	10/11/86	1/13/87	3/16/87
P-Dichlorobenzene	37.0	25.0	44.0
Toluene	640.0	450.0	980.0
Tetrachloroethylene	-	1.4	-
Chloroform	-	1.3	-
Ethylbenzene	-	1.4	-
Xylenes	-	-	4.0

Conc. = ppb., - = below detection limit

The results and discussion of groundwater monitoring for conventional parameters are presented in Appendix C.4. The results indicated that monitoring wells WVMW 2, WVMW3, and WVMW4 were all screened in the discharge plume from the system. The wells were sampled four times during the course of the study. A total of 16 groundwater samples were collected. The results of volatile organic compounds detected in groundwater monitoring at the Village of Wyeville are presented in Table 29. Refer to Figure 17 for the location of monitoring wells.

Table 29.
Concentration of Volatile Organic Compounds
in Groundwater at Village of Wyeville, Wisconsin

October 1986 - March 1987

Well No.	8/23/86 WVMW2	10/11/86 WVMW2
Parameter		
Chloroform	1.4	-
p-Dichlorobenzene	-	2.6

WVMW - denotes Village of Wyeville Monitoring well, Concentration in ppb.

Site #5 Westboro, Taylor County, Wisconsin

Characteristics of Westboro STE are given in Table 30. The values reported are mean concentrations for seven sampling periods. The STE samples were collected at the system dosing chamber. The data from sampling are listed in Appendix B.5.

Table 30.
STE Composition at
Westboro, Wisconsin

Parameter	Concentration (mg/L)
BOD5	137.
TOC	118.72
TS	599.
TSS	61.
NH4-N	77.4
NO3-N	< 0.05
NO2-N	< 0.05
Cl	77.4

The measured composition was similar to that reported by other investigators (see Table 14.).

The average volume of STE pumped to the absorption fields was not tabulated during the study. Previous research between June 1981 and October 1982 indicated average daily discharge of 8,500 gal/d (Siegrist 1984). The loading of beds was not monitored during the study.

The volatile organic compounds detected in STE samples at Westboro, Wisconsin are presented in Table 31.

Table 31.
Concentration of Volatile Organic Compounds Detected in STE at Westboro, Wisconsin
(Concentrations = ppb)

	Date of Sample Collection						
Parameter	3/25/86	5/15/86	6/29/86	8/23/86	10/11/87	1/13/87	3/17/87
p-dichlorobenzene	*	*	3.2	-	4.9	8.4	13.0
Toluene	*	*	26.0	19.0	19.0	14.0	30.0
Chloroform	-	*	-	-	-	-	-
Xylenes	*	*	2.0	-	2.7	2.8	-
Benzene	*	*	5.1	-	4.6	4.5	-
Ethylbenzene	-	*	1.8	-	-	-	-
1,2-Dichloroethane	-	*	-	-	3.6	-	-
Carbon Disulfide	-	*	-	-	-	-	-

Conc. = ppb., * = detected but not quantified, - = below detection limit

Groundwater wells were not installed at Westboro, WI.

Site #6 Don's Mobile Manor Trailer Park, Dane County, Wisconsin

Characteristics of Don's STE are given in Table 32. The values reported are mean concentrations for seven sampling periods. The STE samples were collected at the system sump chambers. The data from sampling are listed in Appendix B.6

Table 32.
STE Composition at the
Dons Mobile Manor, Wisconsin

Parameter	Concentration (mg/L)
BOD5	104.
TOC	86.54
TS	480.
TSS	33.
NH4-N	32.9
NO3-N	< 0.05
NO2-N	< 0.05
Cl	29.0

The measured composition was similar to that reported by other investigators (see Table 14.).

The average volume of STE pumped to the absorption fields was not tabulated during the study. The STE was loaded to the single bed during the study.

The volatile organic compounds detected in STE samples at Don's Mobile Manor, Wisconsin are presented in Table 33.

Table 33.
Concentration of Volatile Organic Compounds Detected in STE at the Don's Mobile Manor, Wisconsin
(Concentrations = ppb)

	Date of Sample Collection						
	3/27/86	5/14/86	7/3/86	8/24/86	10/11/87	1/14/87	3/17/87
Parameter							
p-dichlorobenzene	2.2	-	-	-	-	-	-
Toluene	13.0	24.0	110.0	120.0	160.0	140.0	77.0
Tetrachloroethylene	-	1.2	-	-	-	-	-
Chloroform	2.5	-	-	-	-	-	-

Conc. = ppb., * = detected but not quantified, - = below detection limit

Groundwater monitoring wells were not installed at Don's Mobile manor.

Summary of Results

The overall occurrences of VOCs in STE from the six sites examined is presented in Table 34. The table presents the percent of samples in which a given VOC was detected during this 12 month study. The total column represents the average results from the 42 STE samples collected at the six sites.

The maximum concentrations of VOC's detected at each site are presented in table 35.

Table 34.
Percent of the Samples in which VOCs Were detected in STE Samples at Six Small Community Sites in Wisconsin

	WV n=7	MW n=7	WB n=7	KS n=7	TS n=7	DONS n=7	Total n=42
P-Dichlorobenzene	100%	28.6%	71.4%	85.7%	57.1%	14.3%	59.5%
Toluene	100	85.7	100	100	71.4	100	92.9
1,1,1-Trichloroethane	0	0	0	28.6	0	0	4.8
Tetrachloroethylene	0	0	0	14.3	14.3	14.3	7.1
Xylenes	85.7	0	57.1	14.3	0	0	26.2
Ethylbenzene	57.1	0	28.6	0	0	0	14.3
1,2-Dichloroethane	0	0	28.6	0	0	0	4.8
Chloroform	28.6	14.3	14.3	28.6	0	0	14.3
Benzene	0	14.3	57.1	14.3	0	0	14.3
Carbon Disulfide	0	0	14.3	0	0	0	2.4

WV=Wyeville, MW=Maplewood, WB=Westboro, KS=Kingston, Dons= Don's Mobile Manor

Table 35.
Maximum STE Concentrations of VOCs for Seven Sample Periods

	WV	MW	WB	KS	TS	DONS
P-Dichlorobenzene	39.0	2.6	13.0	2.0	20.0	2.2
Toluene	40.0	38.0	30.0	200.0	76.0	160.
1,1,1-Trichloroethane	-	-	-	19.0	-	-
Tetrachloroethylene	-	-	-	1.2	2.0	1.2
Xylenes	15.0	-	28.0	3.7	-	-
Ethylbenezene	4.4	-	1.0	-	-	-
1,2-Dichloroethane	-	-	3.6	-	-	-
Chloroform	2.0	2.2	D	2.1	-	2.5
Benzene	-	2.1	5.1	1.4	-	-
Carbon Disulfide	-	-	D	-	-	-

WV=Wyeville, MW=Maplewood, WB=Westboro, KS=Kingston, Dons= Don's Mobile Manor
Conc. = ppb, D-detected but not quantified, - below detection limit

The overall occurrence of volatile organic compounds in septage from Kingston and Wyeville is presented in Table 36. The central septic tank at each of these sites was sampled three times. The total column represents the average results from the 6 septage samples collected.

The maximum concentration of VOC's detected at each site are presented in Table 37.

Table 36
Percentage of VOCs in Septage Samples
at two Small Community Sites in Wisconsin

	WVSS n=3	KSSS n=3	Total n=6
P-Dichlorobenzene	100%	33.3%	66.7
Toluene	100	100	100
Tetrachloroethylene	33.3	0	16.7
Xylenes	33.3	0	16.7
Ethylbenezene	33.3	0	16.7
Chloroform	33.3	0	16.7

Table 37.
Maximum Septage Concentrations
of VOCs for Three Sample Periods

	WVSS	KSSS
P-Dichlorobenzene	44	4.4
Toluene	360	160.0
Tetrachloroethylene	1.4	-
Xyleness	4.0	-
Ethylbenezene	1.4	-
Chloroform	1.3	-

(Conc = ppb, - = below detection limit)

The overall occurrence of volatile organic compounds in groundwater from Kingston, Town of Scott, Maplewood and Wyeville is presented in Table 38. The maximum concentration of VOCs detected in groundwater is presented in Table 39.

Table 38
Percentage of VOCs in Groundwater Samples
at Four Small Community Sites in Wisconsin

	WV n=16	MW n=16	KS n=12	TS n=16	Total n=60
1,1,1-Trichloroethane	0	0	0	25	6.7
Chloroform	6.25	0	0	0	1.67
P-dichlorobenzene	6.25	0	0	0	1.67

Table 39
Maximum Concentration of VOCs in
Groundwater Samples from Four Small Community
Systems in Wisconsin

	WV n=16	MW n=16	KS n=12	TS n=16
1,1,1-Trichloroethane	-	-	-	2.8
Chloroform	1.4	-	-	-
P-dichlorobenzene	2.6	-	-	-

Conc. = ppb, - = below detection limit

DISCUSSION

The frequency of occurrence of 45 screened VOCs present in STE from six small community soil absorption systems is presented in Table 34. Ten VOCs were detected in STE samples at some point during the investigation. Eight of the ten VOCs detected are considered priority pollutants. Two of the compounds, p-dichlorobenzene and toluene, were detected in at least 50 percent of STE samples during the investigation. Xylene was detected in 26.2 percent of the STE samples. Toluene occurred at an average maximum concentration of 90.7 ug/L in the STE samples. P-dichlorobenzene occurred at an average maximum concentration of 13.3 ug/L. Xylenes occurred at an average maximum concentration of 7.8 ug/L.

Two sites, Kingston and Westboro, indicated the greatest number of VOCs detected in STE samples. Kingston contained seven VOCs and Westboro contained eight VOCs in STE samples. The two sites had the largest service populations and the largest design flow rates. Kingston's design flow rate was 32,800 gpd and Westboro's design flow rate was 30,000 gpd. The increased number of VOCs detected at both sites may be a result of the larger commercial wastewater inputs from these larger communities as compared to residential wastewater input. Kingston was the largest community studied and had the most commercial businesses of the six sites. The VOCs present in Kingston STE may result from the commercial inputs to the system which include two restaurants, a metal fabricator, a woodworking shop and an automotive garage. These businesses would have the potential for input of VOCs: cleaning solvents and disinfectants at the restaurants, varnishes and paint products from the woodworking shop, and oil and hydrocarbons from the automotive garage.

The potential input of VOCs from commercial units in Westboro was less diverse than that in Kingston. The most notable businesses in Westboro were two service stations and a tavern. The input of VOCs could be from hydrocarbons at the service station and cleaning solvents at the tavern. These businesses, however, were not notably different from those found in some of the smaller communities. It was found during the study that many of the private groundwater wells in the community had been contaminated by a leaking underground storage tank. The residents were still using their water supplies for all household activities except for drinking water. It was not possible to test the individual residental water supply wells during the study. However, analyses which had been conducted on certain individual wells by the Wisconsin Department of Natural Resources, showed that xylene, benzene, ethyl benzene, toluene and 1,2-dichloroethane were detected in the water supplies of several residences at Westboro. The presence of VOCs in residental water supplies could result in the presence of these compounds in the STE at Westboro.

The results of STE analysis at the four smaller communities (Wyeville, Maplewood, Town of Scott and Don's Mobile Manor) indicated that fewer VOCs were present as compared to the larger sites. Wyeville had five VOCs present while Maplewood and Don's Mobile Manor each had four VOCs present. The Town of Scott had three VOCs present in STE samples. The three community sites each serviced approximately the same population with the Town of Scott serving 170 residences, Maplewood serving 130 residences and Wyeville 163 residences. The commercial inputs from these communities was similar. Don's serviced approximately 10 residences and had no commercial inputs. It is interesting that the VOCs detected in STE of the three small community systems were similar to that of the mobile home park which serviced only residential users. The predominant VOCs present in these residential wastwaters are toluene and p-dichlorobenzene.

The results of the analyses of STEs are similar to those reported by Dewalle (1980) (Table 5) with toluene occurring at the highest concentration. Toluene was found to be a major common component of solvents used in paint products (Ridgley 1982). It was also found in other household products including contact cements, detergents, paint brush cleaners, degreasers and dandruff shampoo (Hathaway 1980). P-dichlorobenzene is a common component of toilet bowl cleaners and deodorizers (Ridgley 1982). It was also found in other household products including household cleaners, bathroom deodorants, toilet bowl cleaner, spray household deodorants, diaper cleaner, fabric dyes and rug cleaners (Hathaway 1980). Xylene was found to be a component of solvents used in paint products with 26% of xylene produced being backblended into gasoline and 9% being used as solvent (Ridgley 1982).

Certain VOC's such as 1,1,1-trichloroethane, tetrachloroethylene, ethylbenzene, 1,2-dichloroethane, chloroform, and benzene were detected in low concentrations during periods of normal system discharge rates. These compounds are found in household products. 1,1,1-trichloroethane was found in drain and pipe cleaners, degreasers deoderizers, and oven cleaners (Hathaway 1980). It is also used in spray paint coating and paint remover (Ridgley 1982). Tetrachloroethylene was found in degreasers, wax removers and rug cleaners (Hathaway 1980). It is also used in spray paint coating and paint strippers (Ridgley 1982). Ethylbenzene was found not to be used in household products. 1,2-dichloroethane was found to be used in gasoline to remove lead oxides (Ridgley 1982). Chlorform was not found in any household products. Benzene was a component of detergents, oven cleaners, tar removers, solvents and thinners (Hathaway 1980). It is also used as a constituent of gasoline (Ridgley 1982). The presence of these chemicals in low concentrations in STE may indicate that products containing these compounds are used less frequently in the home.

It is important to examine the system flows of Maplewood and the Town of Scott when considering the concentration of VOCs in STE samples. It should be noted that both sites experienced high flow rates in March of 1986. This flow was assumed to result from excessive clearwater inflow to the systems. The clearwater was probably the result of the spring snow melt during March of 1986. The average daily flow for March 1986 at Maplewood was 599 g.p.c.d.. At Town of Scott the average daily flow was 79 g.p.c.d. during March 1986. These high discharge rates likely resulted in a dilution of the measured VOCs to below analytical detection limits in STE. The analytical results in March 1986 indicated that no VOCs were present above detection limits in STE at Maplewood (Table 24). High flow rates were also seen in October of 1986 and March of 1987 at Maplewood (Figure 22). The analytical results in both months indicated the presence of only one VOC at low concentrations (Table 24). At the Town of Scott during March 1986 only tetrachloroethylene was detected at 2.0 ug/l in STE.

The frequency of occurrence of 45 screened VOCs present in septage from two small community central septic tanks is presented in Table 36. Six VOCs were detected in septage samples at some point during the investigation . Five of the VOCs detected were considered priority pollutants. Two of the compounds, p-dichlorobenzene and toluene, were detected in at least 50 percent of septage samples. Toluene occurred at an average maximum concentration of 260 ug/L in septage samples and p-dichlorobenzene occurred at an average maximum concentration of 24.2 ug/L. The results of this abbreviated septage sampling program (Tables 16 and 28) indicate that concentrations of VOCs were similar to those detected in STE samples with the exception of toluene which showed an order of magnitude increase of concentration in septage over that found in STE. These results indicate limited removal of VOCs in the septic tank. Dewalle (1980) found similar results in removal of VOCs in a septic tank (Table 5). The presence of high concentrations of VOCs in septage samples (Table 6) was seen by Ridgley (1982). Toluene was found in concentrations similar to those of this study.

Other VOCs including tetrachloroethylene, xylenes, ethylbenzene and chlorform were present in septage samples but their frequency of detection was low. These compounds were all found in STE and were detected at concentrations similar to those seen in STE samples. The presence of these chemicals in low concentration in septage may indicate that products containing these compounds are used in lower concentrations or are used less frequently in the home.

The results indicate that VOC's are present in the septage from small community systems. It is assumed that the VOCs present in the septage samples entered the wastewater stream as a component of household products as those described in the discussion of STE. Concentration of VOCs in septage with the exception of toluene did not exceed Preventive Action Limits set for groundwater quality standards by the WDNR. In areas were septage is land disposed, only toluene has the potential to exceed groundwater quality standards.

The results of monitoring for 45 volatile organic compounds in groundwater from four small community systems indicated the presence of 3 VOCs (Table 38 and Table 39). Groundwater samples from two sites, Kingston and Maplewood, indicated that no VOCs were present during the period of sampling. Both systems were older systems, the Kingston system was 5 years old and the Maplewood system was 8 1/2 years old. The older systems may have a greater treatment capacity for VOCs as the result of a more mature biological systems below the absorption beds. It is also interesting to note that both the systems are underlain by loamy sand at Kingston and sandy loam at Maplewood. This indicates a higher organic fraction which may produce increased absorption of VOCs in the soil treatment zone.

The results of groundwater monitoring at the Town of Scott (Table 21) indicated the presence of one VOC. The compound 1,1,1-trichloroethane was detected twice in monitoring well 1 and in monitoring well 2. The concentrations detected were below the Preventive Action Limits set by the WDNR (Table 38). 1,1,1-trichloroethane was not detected in STE samples during the investigation. It is suspected that the compound may be a result of solvent cement used during the construction of the system.

Table 40.
Public Health Groundwater Quality Standards
(Wisconsin Department of Natural Resources 1985)

Public Health Groundwater Quality Standards

Substance	Enforcement Standard (micrograms per liter - except as noted)	Preventive Action Limit (micrograms per liter - except as noted)
(1) Aldicarb	10	2
(2) Arsenic	50	5
(3) Bacteria, Total Coliform	Less than one in 100 ml for membrane filter method or not present in any 10 ml portion by fermantation tube method for both preventive action limit and enforcement standard	
(4) Barium	1 milligram/liter (mg/l)	.2 mg/l
(5) Benzene	.67	.067
(7) Cadmium	10	1
(8) Carbofuren	50	10
(9) Chromium	50	5
(10) Cyanide	460	92
(11) 1,2-Dibromoethane	.010	.001
(12) 1,2-Dibromo-3-chloropropane (DBCP)	.05	.005
(13) p-Dichlorobenzene	750	150
(14) 1,2-Dichloroethane	.5	.05
(15) 1,1-Dichloroethylene	.24	.024
(16) 2,4-Dichlorophenoxyacetic Acid	100	20
(17) Dinoseb	13	2.6
(18) Endrin	.2	.02
(19) Fluoride	2.2 mg/l	.44 mg/l
(20) Lead	50	5
(21) Lindane	.02	.002
(22) Mercury	2	.2
(23) Methoxychlor	100	20
(24) Methylene Chloride	150	15
(25) Nitrate + Nitrite (as N)	10 mg/l	2 mg/l
(27) Selenium	10	1
(28) Silver	50	10
(29) Simazine	2.15 mg/l	.43 mg/l
(30) Tetrachloroethylene	1	.1
(31) Toluene	343	68.6
(32) Toxaphene	.0007	.00007
(33) 1,1,1-Trichloroethane	200	40
(34) 1,1,2-Trichloroethane	.6	.06
(35) Trichloroethylene	1.8	.18
(36) 2,4,5-Trichlorophenoxypropionic Acid	10	2
(38) Vinyl Chloride	.015	.0015
(39) Xylene	620	124

History: Cr. Register, September, 1985, No. 357, eff. 10-1-85.

NR 140.12 Public welfare related groundwater standards. The groundwater quality standards for substances of public welfare concern are listed in Table 2.

Note: For each substance of public welfare concern, the preventive action limit is 50% of the established enforcement standard.

Register, October, 1985, No. 358

The results of groundwater monitoring at Wyeville indicated the presence of two VOCs (Table 29). The compounds were chloroform and p-dichlorobenzene. Chloroform was detected in WVMW2 (Figure 17) at a concentration of 1.4 ug/l. P-dichlorobenzene was detected in WVMW2 at a concentration of 2.6 ug/l. Both of these compounds were detected in the STE samples at Wyeville (Table 27). The average concetration of p-dichlorobenzene during the study was 22 ug/L (Table 22). Chloroform was detected in three STE samples at an overall average concentration of 1.0 ug/l in STE samples. Based on this abbreviated sampling program there is some indication that there is minimal removal of chloroform in the soil zone at Wyeville. Concentrations seen in groundwater are similar to those found in STE samples.

P-dichlorobenzene and 1,1,1-trichloroethane are listed as substances of public health concern by the Wisconsin Department of Natural Resources (Table 38). Chloroform has no public health groundwater quality standards set by the WDNR. The preventive action limit set by the WDNR for p-dichlorobezene is 150 ug/l. The concentrations at Wyeville are significantly below this concentration. The preventive action limit set by the WDNR for 1,1,1-trichlrorethane is 40 ug/l. The concentrations at the Town of Scott are significantly below this concentration. Based on this study VOCs do not appear to exceed groundwater quality standards set by the WDNR for discharges from the communites using septic tank soil absorption systems.

Both the Wyeville and Town of Scott systems are underlain by predominantly sandy soils. This would indicate that soils low in organic matter content are not as efficient in the removal of VOC's as higher organic content soils (as seen at Kingston and Maplewood). Both the Wyeville and Town of Scott systems were relatively new systems with both going into service during September of 1985. This could result in limited development of the biological system in the soil treatment zone. This result may indicate that VOCs were not effectively removed in systems that had recently been placed into service.

SUMMARY AND CONCLUSIONS

This study evaluated the presence of 45 screened VOCs in STE, septage, and groundwater at communities using septic tank soil absorption systems. Six communities serving populations ranging from 10 to 346 persons and ranging in age from 1 to 9 years were studied over a one year period. The results of this study indicate that:

1. Ten VOCS occurred in STE from small community soil absorption systems, with toluene and p-dichlorobenzene being found in the greatest frequency.

2. The concentration of VOCs in STE were below preventive action limits set by the WDNR, with one exception, toluene, which was detected at higher concentrations in some samples.

3. The larger communities studied appeared to have more VOCs present in STE, possibly the result of larger commercial wastewater inputs as compared to domestic.

4. Septage samples generally showed no significant increase in concentrations of VOCs over STE, the exception being toluene, which was found at approximately an order of magnitude greater concentration in septage .

5. VOCs were detected in groundwater below sites underlain by sandy soils and from sites that were relatively young in age (Approximately 1 year old).

6. VOCs that were detected in groundwater were found below preventive action limits set by the WDNR.

RECOMMENDATIONS

1. Evaluate the presence of priority pollutants other than VOCs in wastewater from small communities using septic tank soil absorption systems.

2. Conduct column studies in a controlled laboratory to assess the migration of VOCs in soil.

3. Conduct a more intensive study of one of the larger community sites to assess the chemical composition and flow of commercial industrial wastewater.

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APPENDIX A

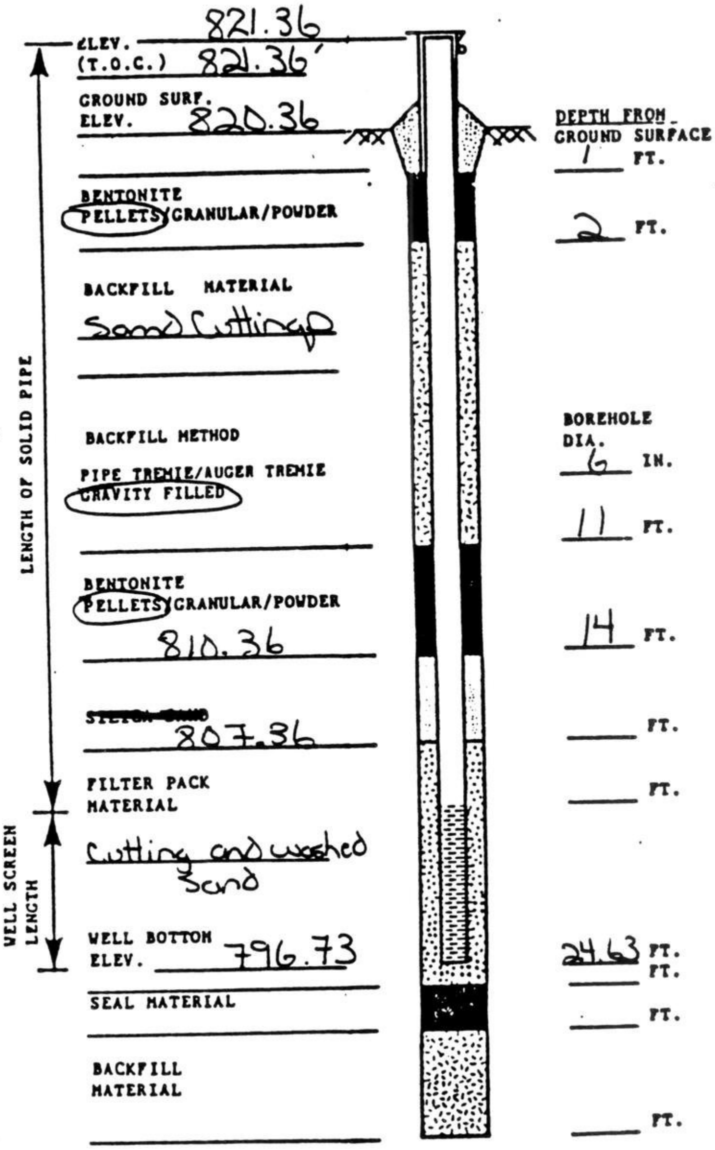
GROUNDWATER MONITIORING CONSTRUCTION LOGS

PROJECT NAME: ______ NO. ______

WELL NO. KSMW-1

DATE INSTALLED 8/12/86

A-1



1) CASING DETAILS

A) TYPE OF PIPE:

(PVC) STAINLESS, TEFLON, OTHER ______

PIPE SCHEDULE 40

B) TYPE OF PIPE JOINTS;

COUPLINGS, (THREADED) (W/TAPE?), OTHER ______

C) WAS SOLVENT USED? YES OR (NO)

D) TYPE OF WELL SCREEN:

(PVC) STAINLESS, TEFLON, OTHER ______

E) WELL SCREEN SLOT SIZE .01"

F) PIPE DIA: ID IN. ______ OD IN. 2IN

G) INSTALLED PROTECTOR PIPE W/LOCK? (YES) OR ~~NO~~
PROTECTOR PIPE DIA. 4 IN.

2) WELL DEVELOPMENT

A) METHOD

(BAILING), PUMPING, SURGING, COMPRESSED AIR

OTHER ______

(NOTE ADDITIONAL COMMENTS BELOW)

B) TIME SPENT FOR DEVELOPMENT? 1 hr

C) APPROXIMATE WATER VOLUME: REMOVED 6

ADDED ______

D) WATER CLARITY BEFORE DEVELOPMENT?

CLEAR, (TURBID), OPAQUE

E) WATER CLARITY AFTER DEVELOPMENT?

CLEAR, (SLIGHTLY TURBID), TURBID, OPAQUE

F) ODOR? YES OR (NO)

3) WATER LEVEL SUMMARY

A) DEPTH FROM TOP OF CASING AFTER DEVELOPMENT?

______ FT. OR DRY

B) OTHER MEASUREMENTS (T.O.C.):

DATE/TIME ______ FT.

DATE/TIME ______ FT.

DATE/TIME ______ FT.

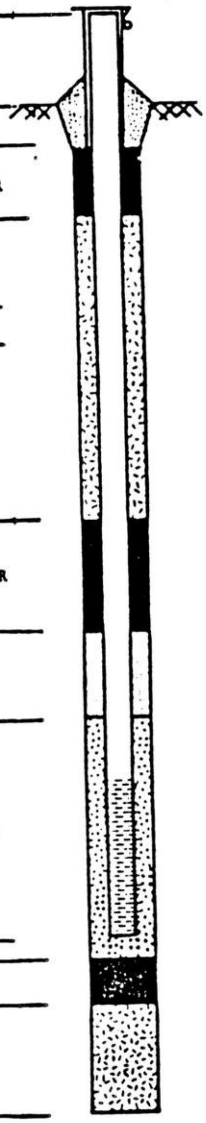
ADDITIONAL COMMENTS: KSMW-1

PROJECT NAME: ____________ NO. ________

WELL NO. KSMW-2

DATE INSTALLED 8/12/86

A-2



ELEV. (T.O.C.) 812.75

GROUND SURF. ELEV. 811.12

DEPTH FROM GROUND SURFACE

1 FT.

BENTONITE (PELLETS) GRANULAR/POWDER

2 FT.

BACKFILL MATERIAL Sand Cuttings

3.56 FT. LENGTH OF SOLID PIPE

BACKFILL METHOD

PIPE TREMIE/AUGER TREMIE (GRAVITY FILLED)

BOREHOLE DIA. 6 IN.

8 FT.

BENTONITE (PELLETS) GRANULAR/POWDER

11 FT.

SILICA SAND

11 FT.

FILTER PACK MATERIAL ________ FT.

5 FT. WELL SCREEN LENGTH

WELL BOTTOM ELEV. 794.19

18.63 FT.

____ FT.

SEAL MATERIAL ____ FT.

BACKFILL MATERIAL ____ FT.

1) CASING DETAILS

A) TYPE OF PIPE:

(PVC), STAINLESS, TEFLON, OTHER ________

PIPE SCHEDULE ________

B) TYPE OF PIPE JOINTS:

COUPLINGS, (THREADED) (W/TAPE?), OTHER ________

C) WAS SOLVENT USED? YES OR (NO)

D) TYPE OF WELL SCREEN:

(PVC), STAINLESS, TEFLON, OTHER ________

E) WELL SCREEN SLOT SIZE .01

F) PIPE DIA: ID IN. ____ OD IN. 2 IN

G) INSTALLED PROTECTOR PIPE W/LOCK? (YES) OR NO

PROTECTOR PIPE DIA. ____ IN.

2) WELL DEVELOPMENT

A) METHOD

(BAILING), PUMPING, SURGING, COMPRESSED AIR

OTHER ________

(NOTE ADDITIONAL COMMENTS BELOW)

B) TIME SPENT FOR DEVELOPMENT? ________

C) APPROXIMATE WATER VOLUME: REMOVED ________

ADDED ________

D) WATER CLARITY BEFORE DEVELOPMENT?

CLEAR, (TURBID), OPAQUE

E) WATER CLARITY AFTER DEVELOPMENT?

CLEAR, (SLIGHTLY TURBID), TURBID, OPAQUE

F) ODOR? YES OR (NO)

3) WATER LEVEL SUMMARY

A) DEPTH FROM TOP OF CASING AFTER DEVELOPMENT?

____ FT. OR DRY

B) OTHER MEASUREMENTS (T.O.C.):

DATE/TIME ________ FT.

DATE/TIME ________ FT.

DATE/TIME ________ FT.

ADDITIONAL COMMENTS: KSMW-2

PROJECT NAME: ______ NO. ______

WELL NO. KSMW-3

DATE INSTALLED 8/12/86

A-3

.35 FT.

LENGTH OF SOLID PIPE

ELEV. (T.O.C.) 812.48

GROUND SURF. ELEV. 811.16

BENTONITE PELLETS/GRANULAR/POWDER (PELLETS circled)

BACKFILL MATERIAL Sand Cuttings

BACKFILL METHOD

PIPE TREMIE/AUGER TREMIE GRAVITY FILLED (GRAVITY FILLED circled)

BENTONITE PELLETS/GRANULAR/POWDER (PELLETS circled)

SILICA SAND

FILTER PACK MATERIAL

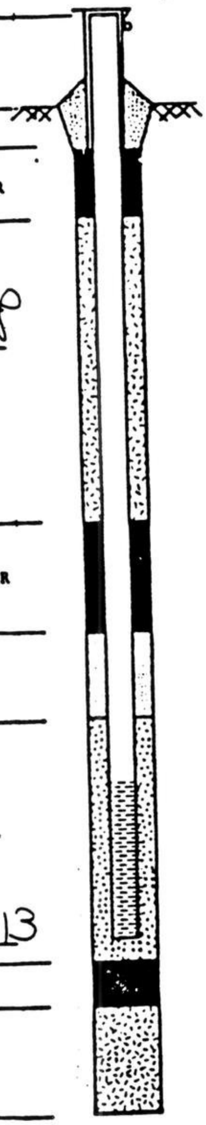
FT.

WELL SCREEN LENGTH

WELL BOTTOM ELEV. 783.13

SEAL MATERIAL

BACKFILL MATERIAL



DEPTH FROM GROUND SURFACE

1 FT.

2 FT.

BOREHOLE DIA. 6 IN.

13 FT.

16 FT.

16 FT.

___ FT.

29.35 FT.

___ FT.

___ FT.

___ FT.

1) CASING DETAILS

A) TYPE OF PIPE:

PVC, STAINLESS, TEFLON, OTHER ______ (PVC circled)

PIPE SCHEDULE ______

B) TYPE OF PIPE JOINTS:

COUPLINGS, THREADED (W/TAPE?), OTHER ______ (THREADED circled)

C) WAS SOLVENT USED? YES OR NO (NO circled)

D) TYPE OF WELL SCREEN:

PVC, STAINLESS, TEFLON, OTHER ______ (PVC circled)

E) WELL SCREEN SLOT SIZE .01

F) PIPE DIA: ID IN. ______ OD IN. ______

G) INSTALLED PROTECTOR PIPE W/LOCK? YES OR NO

PROTECTOR PIPE DIA. ____ IN.

2) WELL DEVELOPMENT

A) METHOD

BAILING, PUMPING, SURGING, COMPRESSED AIR (BAILING circled)

OTHER ______

(NOTE ADDITIONAL COMMENTS BELOW)

B) TIME SPENT FOR DEVELOPMENT? 1 hr

C) APPROXIMATE WATER VOLUME: REMOVED 6

ADDED ______

D) WATER CLARITY BEFORE DEVELOPMENT?

CLEAR, TURBID, OPAQUE (TURBID circled)

E) WATER CLARITY AFTER DEVELOPMENT?

CLEAR, SLIGHTLY TURBID, TURBID, OPAQUE (SLIGHTLY TURBID circled)

F) ODOR? YES OR NO (NO circled)

3) WATER LEVEL SUMMARY

A) DEPTH FROM TOP OF CASING AFTER DEVELOPMENT?

______ FT. OR DRY

B) OTHER MEASUREMENTS (T.O.C.):

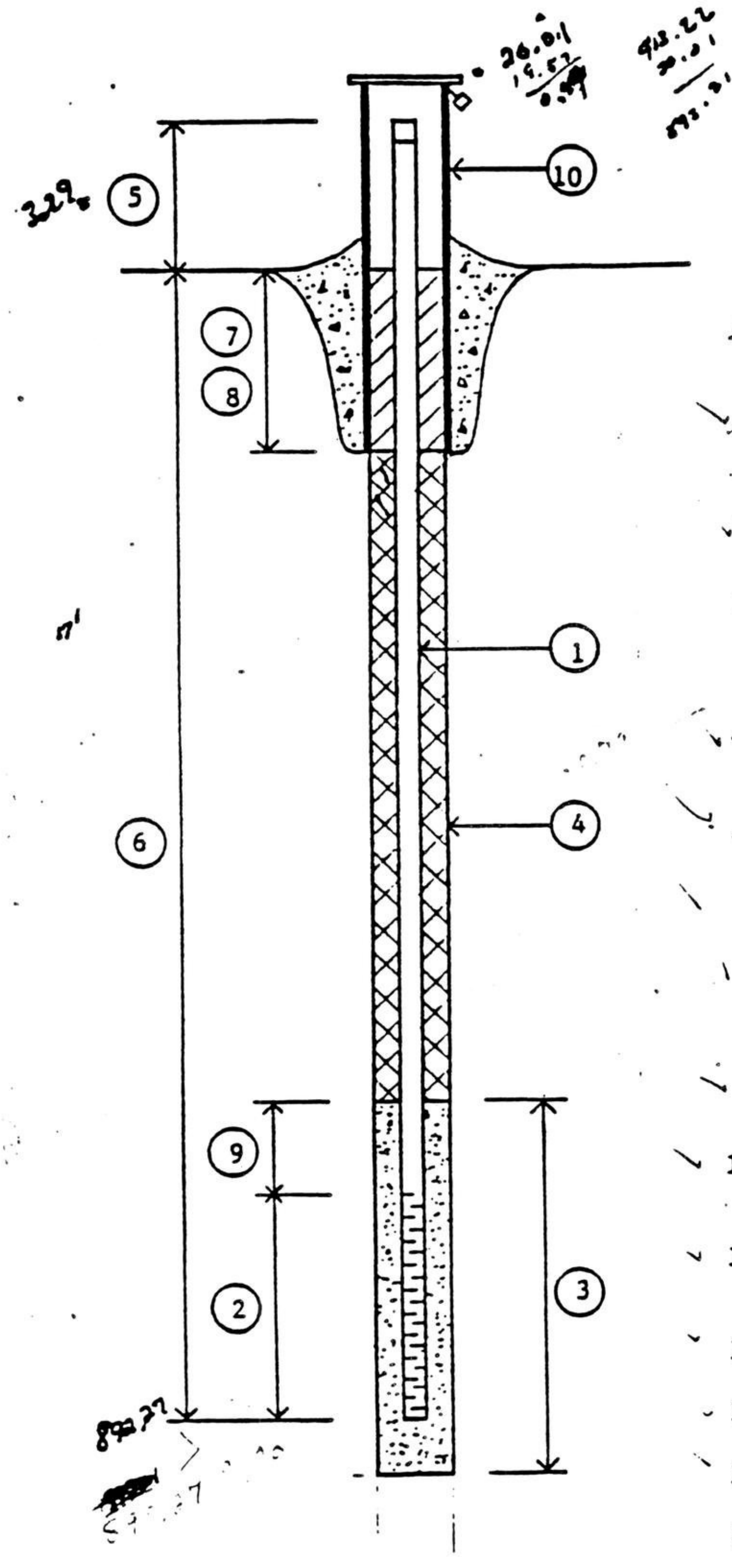
DATE/TIME ______ FT.

DATE/TIME ______ FT.

DATE/TIME ______ FT.

ADDITIONAL COMMENTS: KSMW-3

OBSERVATION WELL INSTALLATION DATA



PROJECT: Town of Scott Monitoring Wells

JOB NO. 8757 WELL NO. MW-1 DATE 7-24-85

GROUND EL. 909.27 TOP OF PIPE EL. 913.06

TOP OF PROTECTIVE CASING ELEV. 913.22

1 TYPE OF WELL CASING: 15.79' of 2" Sch 40 threaded flush joint PVC pipe

2 LENGTH AND TYPE OF WELL SCREEN: 5'-2" Sch 40 #10 slot thd. flush joint PVC

3 TYPE AND THICKNESS OF FILTER MATERIAL: 11' of silica sand (17-6)

4 TYPE OF BACKFILL MATERIAL: Silica sand

5 DISTANCE FROM GROUND SURFACE TO TOP OF WELL: 3.79'

6 DISTANCE FROM GROUND SURFACE TO BOTTOM OF WELL: 17' to Elevation 892.27

7 THICKNESS OF CONCRETE PLUG: 3.05'

8 THICKNESS OF BENTONITE SEAL: 6.0' from Elevation 903.27 to 909.27

9 DISTANCE FILTER PACK EXTENDS ABOVE TOP OF WELL SCREEN: 6.0'

10 PROTECTIVE DEVICES: 7'x 6"

11 DRILLING METHOD USED: 7-5/8" O.D. hollow stem augers

12 DRILLING MUD USED: None

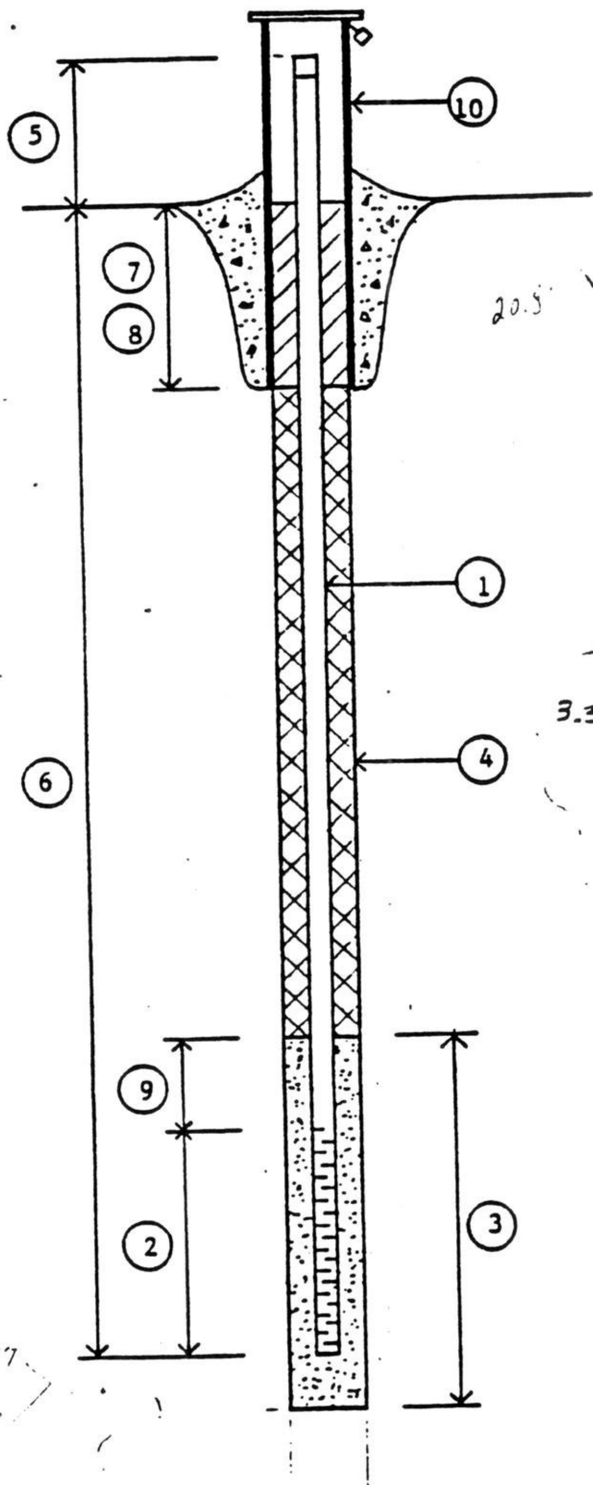
13 TOTAL DEPTH TO BORING: 19.0'to El.890.27

14 DEPTH TO GROUNDWATER: Elev.894.3,7-24-85

15 DEPTH TO TOP OF ROCK: Not obtained

MILLER CONSULTING ENGINEERS
SHEBOYGAN, WISCONSIN

OBSERVATION WELL INSTALLATION DATA



PROJECT: Town of Scott Monitoring Wells

JOB NO. 8757 WELL NO. MW-2 DATE 7-24-85

GROUND EL. 910.57 TOP OF PIPE EL. 913.92

TOP OF PROTECTIVE CASING ELEV. 913.92

1 TYPE OF WELL CASING: 15.81' of 2" Sch 40 threaded flush joint PVC pipe

2 LENGTH AND TYPE OF WELL SCREEN: 5'of 2" Sch 40 #10 slot thd. flush joint PVC

3 TYPE AND THICKNESS OF FILTER MATERIAL: 18.4' of silica sand (17-6)

4 TYPE OF BACKFILL MATERIAL: Silica sand

5 DISTANCE FROM GROUND SURFACE TO TOP OF WELL: 2.81'

6 DISTANCE FROM GROUND SURFACE TO BOTTOM OF WELL: 18' to Elevation 892.57

7 THICKNESS OF CONCRETE PLUG: 3.65'

8 THICKNESS OF BENTONITE SEAL: 4.6' from Elevation 905.97 to 910.57

9 DISTANCE FILTER PACK EXTENDS ABOVE TOP OF WELL SCREEN: 8.4'

10 PROTECTIVE DEVICES: 7'x 6" steel casing w/locking cap. Bottom Elev.=906.92

11 DRILLING METHOD USED: 7-5/8" O.D. hollow stem augers

12 DRILLING MUD USED: None

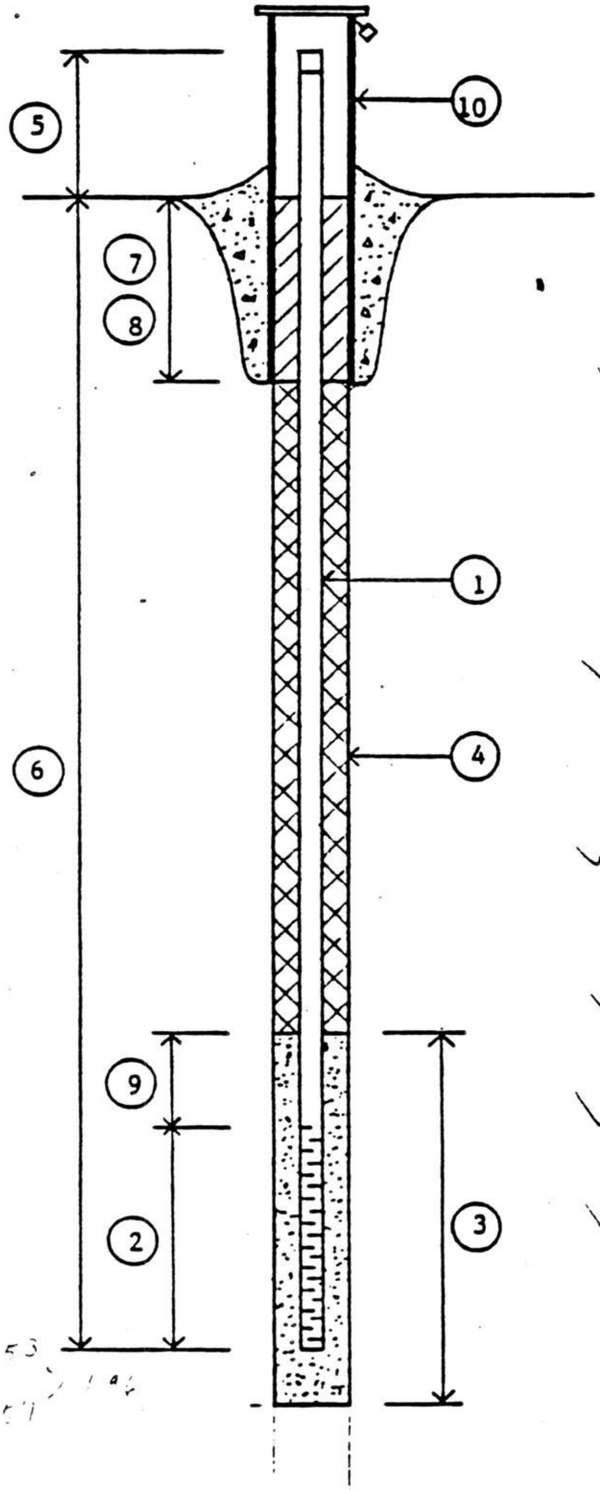
13 TOTAL DEPTH TO BORING: 22.0'to El.888.57

14 DEPTH TO GROUNDWATER: Elev.892.1,7-24-85

15 DEPTH TO TOP OF ROCK: Not determined

MILLER CONSULTING ENGINEERS
SHEBOYGAN, WISCONSIN

OBSERVATION WELL INSTALLATION DATA



PROJECT: Town of Scott Monitoring Wells

JOB NO. 8757 WELL NO. MW-3 DATE 7-24-85

GROUND EL. 909.57 TOP OF PIPE EL. 912.53

TOP OF PROTECTIVE CASING ELEV. 912.75

1 TYPE OF WELL CASING: 17' of 2" Sch 40 threaded flush joint PVC pipe

2 LENGTH AND TYPE OF WELL SCREEN: 5' of 2" Sch 40 #10 slot thd. flush joint PVC

3 TYPE AND THICKNESS OF FILTER MATERIAL: 15' of silica sand

4 TYPE OF BACKFILL MATERIAL: Silica sand

5 DISTANCE FROM GROUND SURFACE TO TOP OF WELL: 2.96'

6 DISTANCE FROM GROUND SURFACE TO BOTTOM OF WELL: 19.04' to Elevation 890.53

7 THICKNESS OF CONCRETE PLUG: 3.82'

8 THICKNESS OF BENTONITE SEAL: 6.0' from Elevation 903.57 to 909.57

9 DISTANCE FILTER PACK EXTENDS ABOVE TOP OF WELL SCREEN: 8.04'

10 PROTECTIVE DEVICES: 7'x 6" steel casing w/locking cap. Bottom Elev.=905.75

11 DRILLING METHOD USED: 7-5/8" O.D. hollow stem augers

12 DRILLING MUD USED: None

13 TOTAL DEPTH TO BORING: 21.0' to El. 888.57

14 DEPTH TO GROUNDWATER: Elev. 894.1, 7-24-85

15 DEPTH TO TOP OF ROCK: Not determined

MILLER CONSULTING ENGINEERS
SHEBOYGAN, WISCONSIN

PROJECT NAME: ________ NO. ________

WELL NO. TSMW-4

DATE INSTALLED ________

A-7

ELEV. (T.O.C.) 906.12

GROUND SURF. ELEV. 904.05

BENTONITE (PELLETS)/GRANULAR/POWDER

BACKFILL MATERIAL Sand Cuttings

BACKFILL METHOD

PIPE TREMIE/AUGER TREMIE (GRAVITY FILLED)

BENTONITE (PELLETS)/GRANULAR/POWDER

SILICA SAND

FILTER PACK MATERIAL

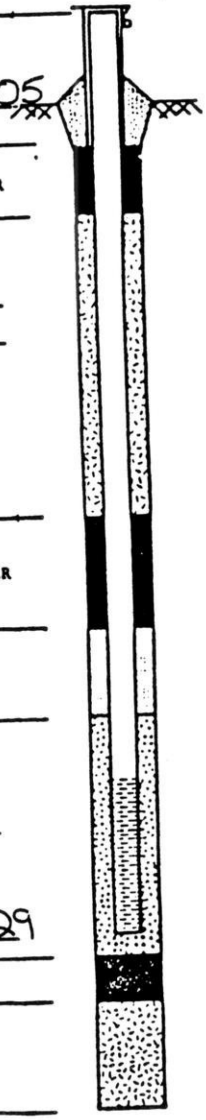
WELL BOTTOM ELEV. 890.29

SEAL MATERIAL

BACKFILL MATERIAL

LENGTH OF SOLID PIPE 0.83 FT.

WELL SCREEN LENGTH 5 FT.



DEPTH FROM GROUND SURFACE

1 FT.

2 FT.

BOREHOLE DIA. 6 IN.

4.83 FT.

8.83 FT.

____ FT.

____ FT.

15.83 FT.

____ FT.

____ FT.

____ FT.

1) CASING DETAILS

A) TYPE OF PIPE:

(PVC), STAINLESS, TEFLON, OTHER ________

PIPE SCHEDULE ________

B) TYPE OF PIPE JOINTS;

COUPLINGS, (THREADED) (W/TAPE?), OTHER ________

C) WAS SOLVENT USED? (YES) OR NO

D) TYPE OF WELL SCREEN:

(PVC), STAINLESS, TEFLON, OTHER ________

E) WELL SCREEN SLOT SIZE .01

F) PIPE DIA: ID IN. ____ OD IN. 2

G) INSTALLED PROTECTOR PIPE W/LOCK? YES OR NO

PROTECTOR PIPE DIA. 4 IN.

2) WELL DEVELOPMENT

A) METHOD

(BAILING), PUMPING, SURGING, COMPRESSED AIR

OTHER ________

(NOTE ADDITIONAL COMMENTS BELOW)

B) TIME SPENT FOR DEVELOPMENT? 2 hrs

C) APPROXIMATE WATER VOLUME: REMOVED ________

ADDED ________

D) WATER CLARITY BEFORE DEVELOPMENT?

CLEAR, (TURBID), OPAQUE

E) WATER CLARITY AFTER DEVELOPMENT?

CLEAR, (SLIGHTLY TURBID), TURBID, OPAQUE

F) ODOR? YES OR (NO)

3) WATER LEVEL SUMMARY

A) DEPTH FROM TOP OF CASING AFTER DEVELOPMENT?

____ FT. OR DRY

B) OTHER MEASUREMENTS (T.O.C.):

DATE/TIME ________ FT.

DATE/TIME ________ FT.

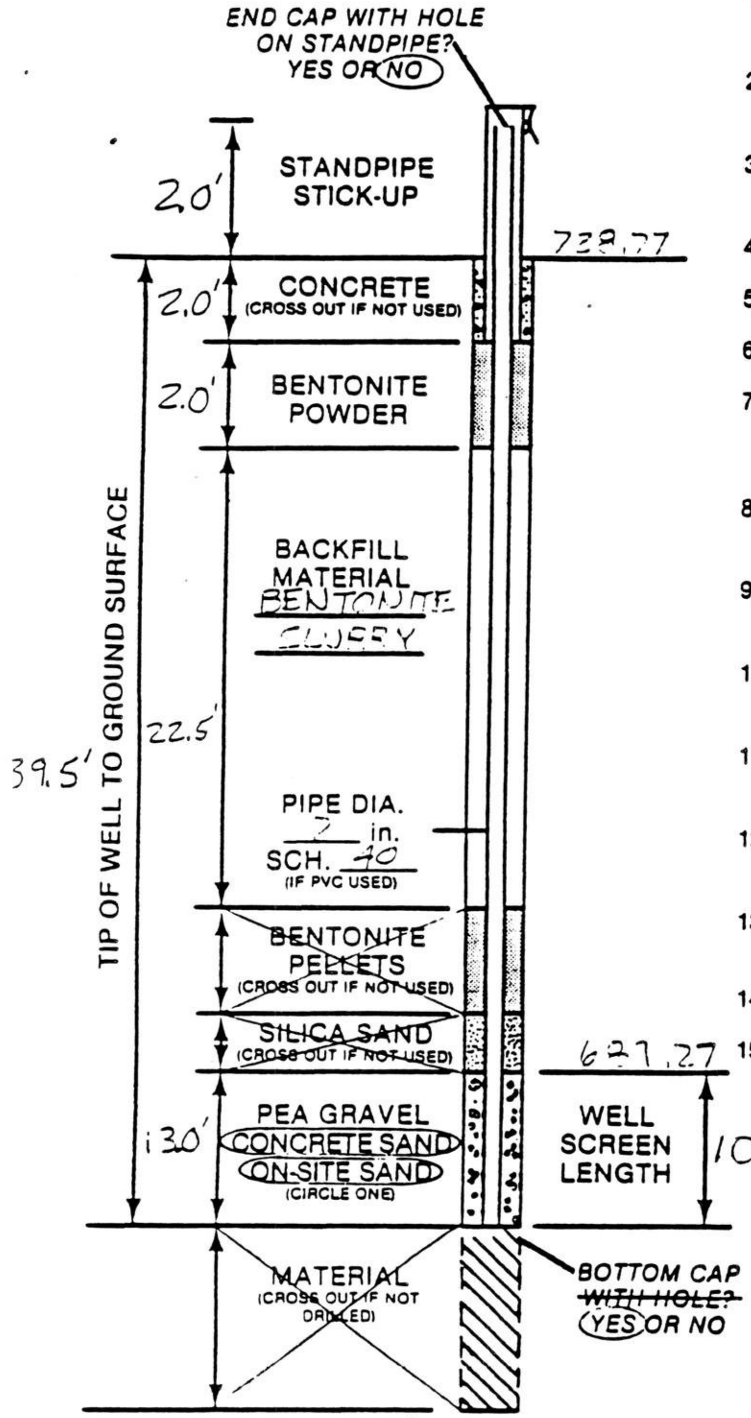
DATE/TIME ________ FT.

ADDITIONAL COMMENTS: ________

STS Consultants Ltd.

A-8

FIELD WELL INSTALLATION DIAGRAM



1) TYPE OF PIPE?
(PVC) GALVANIZED, STAINLESS, OTHER ______

2) TYPE OF PIPE JOINTS?
BELLED, COUPLINGS, **(THREADED)** OTHER ______

3) TYPE OF WELL SCREEN
(PVC) GALVANIZED, STAINLESS, OTHER ______

4) SCREEN SIZE 0.010

5) INSTALLED PROTECTOR PIPE W/LOCK? **(YES)** OR NO

6) WAS SOLVENT USED? YES OR **(NO)**

7) WAS DRILLING MUD USED? NO
SOLID AUGER, HOLLOW STEM AUGER,
(WATER) REVERT, BENTONITE

8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
YES OR **(NO)**

9) HOW WAS WELL DEVELOPED?
(BAILING) PUMPING, SURGING, COMPRESSED AIR

10) TIME SPENT FOR WELL DEVELOPMENT?
5 min., 15 min., **(30 min.)** OTHER ______

11) APPROXIMATE WATER VOLUME **(REMOVED)** OR ADDED?
5 gal., **(10 gal.)** 15 gal., OTHER ______

12) WATER CLARITY BEFORE DEVELOPMENT?
CLEAR, **(TURBID)** OPAQUE

13) WATER CLARITY AFTER DEVELOPMENT?
CLEAR, **(TURBID)** OPAQUE

14) DID THE WATER SMELL? YES OR **(NO)**

15) WATER LEVEL SUMMARY

1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT?
34.7 Ft. or DRY

2) OTHER MEASUREMENTS:

DATE ______, ______ Ft. FROM T, ST. PIPE

DATE ______, ______ Ft. FROM T, ST. PIPE

DATE ______, ______ Ft. FROM T, ST. PIPE

DATE ______, ______ Ft. FROM T, ST. PIPE

Well No. MWMW-1 DATE INSTALLED 6-17-96 DRILL RIG =40

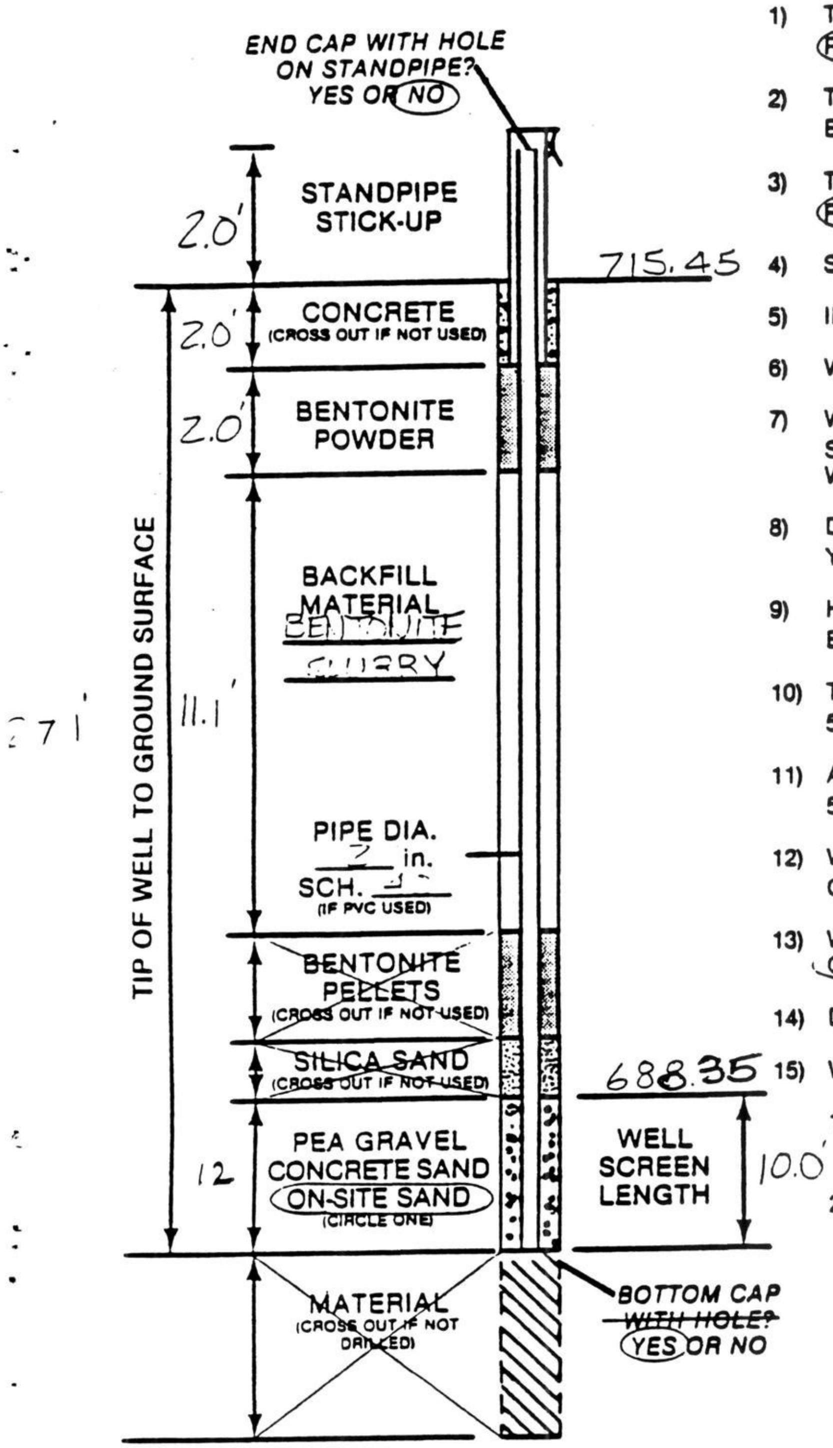
DRILLER EVH DRILL CREW JB

JOB/CLIENT MAPLE WOOD WELLS STS JOB No. 144[illegible]

FW: 1-983

STS Consultants Ltd.

FIELD WELL INSTALLATION DIAGRAM



1) TYPE OF PIPE?
(PVC), GALVANIZED, STAINLESS, OTHER ________

2) TYPE OF PIPE JOINTS?
BELLED, COUPLINGS, (THREADED) OTHER ________

3) TYPE OF WELL SCREEN
(PVC), GALVANIZED, STAINLESS, OTHER ________

4) SCREEN SIZE 0.010

5) INSTALLED PROTECTOR PIPE W/LOCK? (YES) OR NO

6) WAS SOLVENT USED? YES OR (NO)

7) WAS DRILLING MUD USED? NO
SOLID AUGER, (HOLLOW STEM AUGER,)
WATER, REVERT, BENTONITE

8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
YES OR (NO)

9) HOW WAS WELL DEVELOPED?
BAILING, (PUMPING,) SURGING, COMPRESSED AIR

10) TIME SPENT FOR WELL DEVELOPMENT?
5 min., 15 min., (30 min.,) OTHER ________

11) APPROXIMATE WATER VOLUME (REMOVED) OR ADDED?
5 gal., 10 gal., 15 gal., OTHER ________

12) WATER CLARITY BEFORE DEVELOPMENT?
CLEAR, (TURBID) OPAQUE

13) WATER CLARITY AFTER DEVELOPMENT?
(CLEAR,) TURBID, OPAQUE

14) DID THE WATER SMELL? YES OR (NO)

15) WATER LEVEL SUMMARY

1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT?
________ Ft. or DRY

2) OTHER MEASUREMENTS:

DATE ________, ________ Ft. FROM T, ST. PIPE

DATE ________, ________ Ft. FROM T, ST. PIPE

DATE ________, ________ Ft. FROM T, ST. PIPE

DATE ________, ________ Ft. FROM T, ST. PIPE

Well No. MWMW-2 DATE INSTALLED ________ DRILL RIG ________

DRILLER ________ DRILL CREW ________

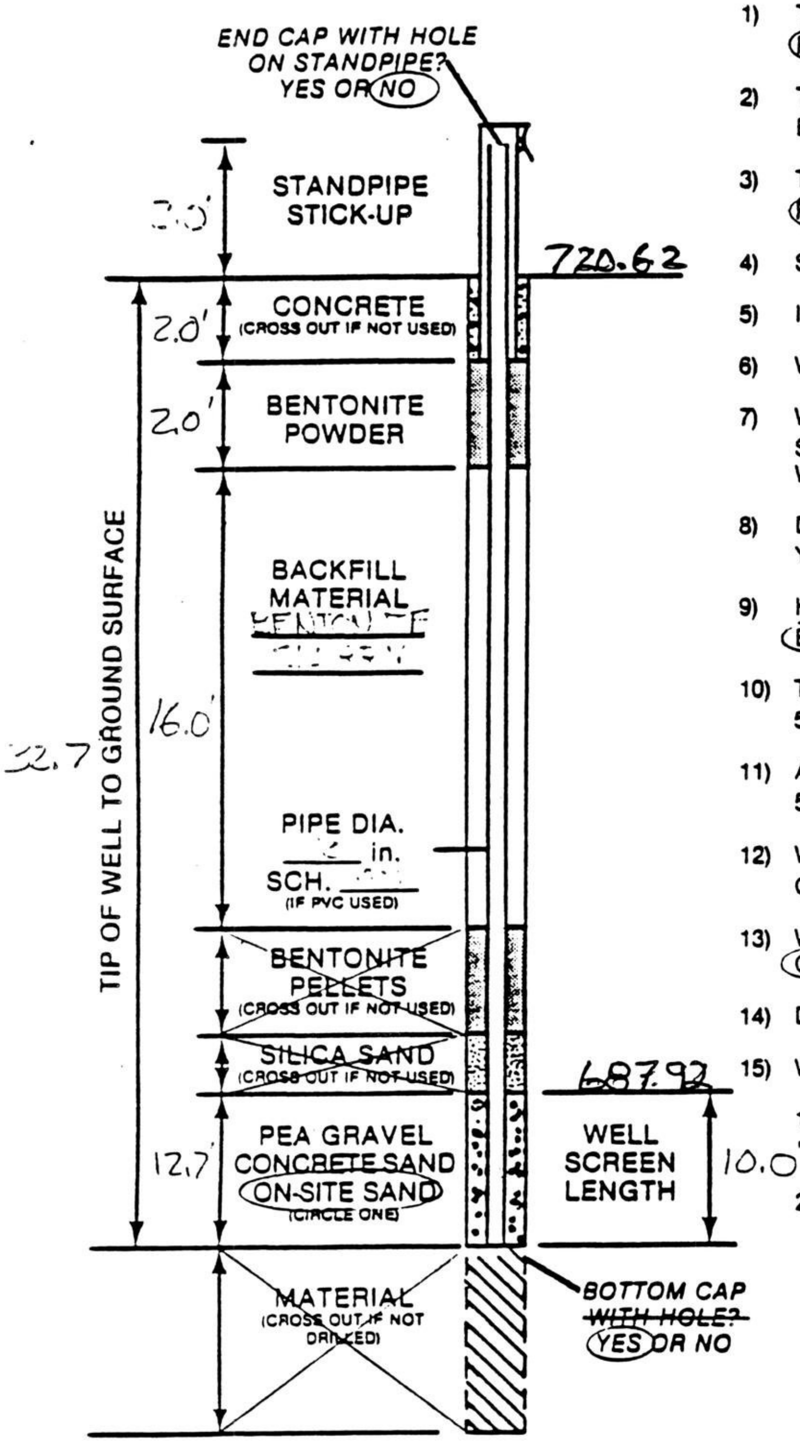
JOB/CLIENT MAPLE WOOD WELLS STS JOB No. ________

FW: 1-983

STS Consultants Ltd.

A-10

FIELD WELL INSTALLATION DIAGRAM



1) TYPE OF PIPE?
(PVC) — circled, GALVANIZED, STAINLESS, OTHER ______

2) TYPE OF PIPE JOINTS?
BELLED, COUPLINGS, (THREADED) — circled, OTHER ______

3) TYPE OF WELL SCREEN
(PVC) — circled, GALVANIZED, STAINLESS, OTHER ______

4) SCREEN SIZE 0.010

5) INSTALLED PROTECTOR PIPE W/LOCK? (YES) — circled OR NO

6) WAS SOLVENT USED? YES OR (NO) — circled

7) WAS DRILLING MUD USED? NO
SOLID AUGER, (HOLLOW STEM AUGER) — circled,
WATER, REVERT, BENTONITE

8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
YES OR (NO) — circled

9) HOW WAS WELL DEVELOPED?
(BAILING) — circled, PUMPING, SURGING, COMPRESSED AIR

10) TIME SPENT FOR WELL DEVELOPMENT?
5 min., 15 min., (30 min.) — circled, OTHER ______

11) APPROXIMATE WATER VOLUME (REMOVED) — circled OR ADDED?
5 gal., 10 gal., (15 gal.) — circled, OTHER ______

12) WATER CLARITY BEFORE DEVELOPMENT?
CLEAR, (TURBID) — circled, OPAQUE

13) WATER CLARITY AFTER DEVELOPMENT?
(CLEAR) — circled, TURBID, OPAQUE

14) DID THE WATER SMELL? YES OR (NO) — circled

15) WATER LEVEL SUMMARY

1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT?
27.4 Ft. or DRY

2) OTHER MEASUREMENTS:

DATE ______, ______ Ft. FROM T. ST. PIPE

DATE ______, ______ Ft. FROM T. ST. PIPE

DATE ______, ______ Ft. FROM T. ST. PIPE

DATE ______, ______ Ft. FROM T. ST. PIPE

Well No. MWMW-3 DATE INSTALLED 6-17-93 DRILL RIG ______

DRILLER ______ DRILL CREW JB

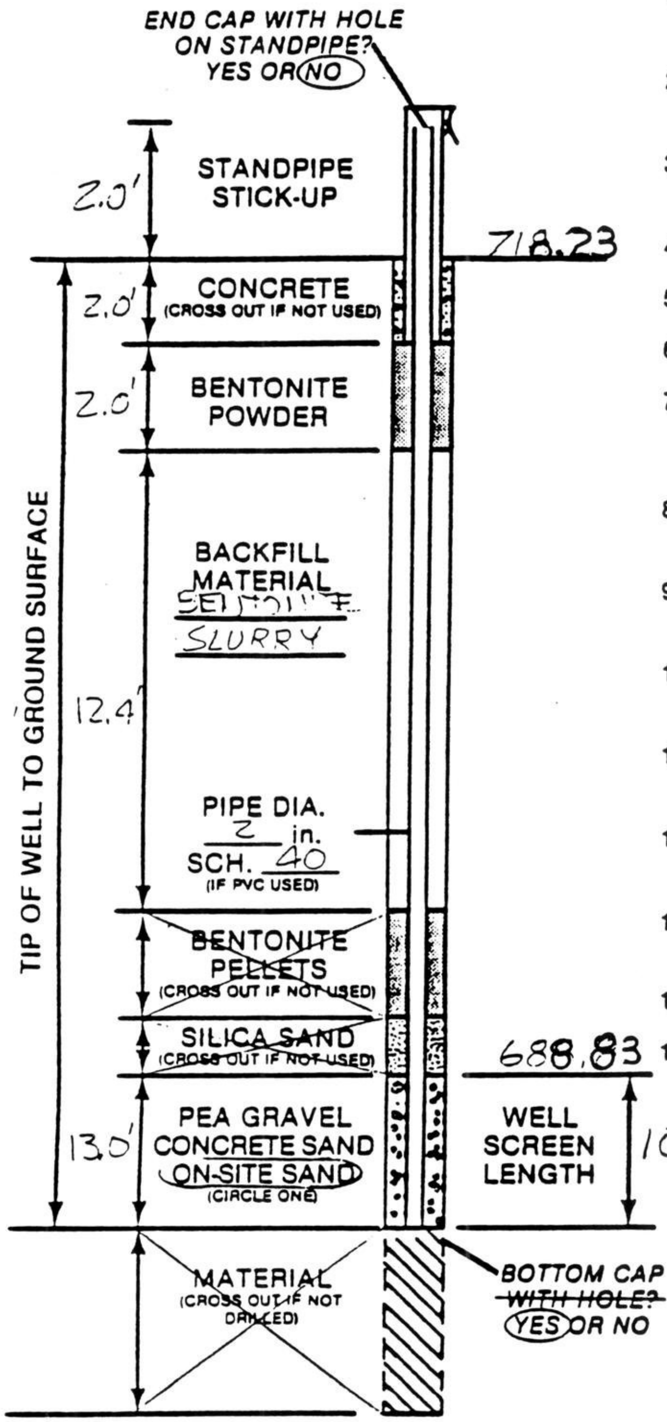
JOB/CLIENT MAPLE WOOD WELLS STS JOB No. 14466

FW: 1-983

A-11

STS Consultants Ltd.

FIELD WELL INSTALLATION DIAGRAM



1) TYPE OF PIPE?
PVC, GALVANIZED, STAINLESS, OTHER ________

2) TYPE OF PIPE JOINTS?
BELLED, COUPLINGS, THREADED, OTHER ______

3) TYPE OF WELL SCREEN
PVC, GALVANIZED, STAINLESS, OTHER ________

4) SCREEN SIZE 0.010

5) INSTALLED PROTECTOR PIPE W/LOCK? YES OR NO

6) WAS SOLVENT USED? YES OR NO

7) WAS DRILLING MUD USED? NO
SOLID AUGER, HOLLOW STEM AUGER,
WATER, REVERT, BENTONITE

8) DID STANDPIPE COME UP WHEN CASING WAS PULLED?
YES OR NO

9) HOW WAS WELL DEVELOPED?
BAILING, PUMPING, SURGING, COMPRESSED AIR

10) TIME SPENT FOR WELL DEVELOPMENT?
5 min., 15 min., 30 min., OTHER ________

11) APPROXIMATE WATER VOLUME REMOVED OR ADDED?
5 gal., 10 gal., 15 gal., OTHER 60 GALLONS

12) WATER CLARITY BEFORE DEVELOPMENT?
CLEAR, TURBID, OPAQUE

13) WATER CLARITY AFTER DEVELOPMENT?
CLEAR, TURBID, OPAQUE

14) DID THE WATER SMELL? YES OR NO

15) WATER LEVEL SUMMARY

1) DEPTH FROM T. STANDPIPE AFTER DEVELOPMENT?
7.5' Ft. or DRY

2) OTHER MEASUREMENTS:

DATE ________, ________ Ft. FROM T, ST. PIPE

DATE ________, ________ Ft. FROM T, ST. PIPE

DATE ________, ________ Ft. FROM T, ST. PIPE

DATE ________, ________ Ft. FROM T, ST. PIPE

. No. MWMW-4 DATE INSTALLED 6-18-[illegible] DRILL RIG 40

DRILLER EVH DRILL CREW JB

OB/CLIENT MAPLE WOOD WELLS STS JOB No. [illegible]

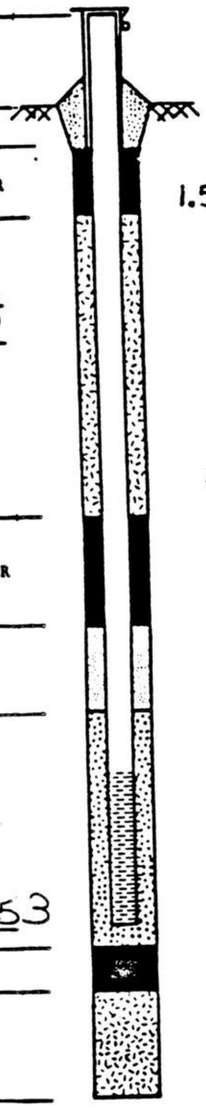
FW: 1-983

PROJECT NAME: ________ NO. ________

WELL NO. WV-MW-1

DATE INSTALLED 8/11/86

A-12



ELEV. (T.O.C.) 917.43

GROUND SURF. ELEV. 915

DEPTH FROM GROUND SURFACE 1 FT.

BENTONITE (PELLETS)/GRANULAR/POWDER — 1.5 FT.

BACKFILL MATERIAL Sand Cutting

LENGTH OF SOLID PIPE 6.9 FT.

BACKFILL METHOD
PIPE TREMIE/AUGER TREMIE
(GRAVITY FILLED)

BOREHOLE DIA. 6 IN.

2.9 FT.

BENTONITE (PELLETS)/GRANULAR/POWDER — 4.9 FT.

SILICA SAND ____ FT.

FILTER PACK MATERIAL — 6.90 FT.

WELL SCREEN LENGTH 5 FT.

WELL BOTTOM ELEV. 905.53 — 11.90 FT.

____ FT.

SEAL MATERIAL ____ FT.

BACKFILL MATERIAL ____ FT.

1) CASING DETAILS

A) TYPE OF PIPE:

(PVC), STAINLESS, TEFLON, OTHER ________

PIPE SCHEDULE ________

B) TYPE OF PIPE JOINTS;

COUPLINGS, (THREADED) (W/TAPE?), OTHER ________

C) WAS SOLVENT USED? YES OR (NO)

D) TYPE OF WELL SCREEN:

(PVC), STAINLESS, TEFLON, OTHER ________

E) WELL SCREEN SLOT SIZE .01"

F) PIPE DIA: ID IN. 2" OD IN. ____

G) INSTALLED PROTECTOR PIPE W/LOCK? (YES) OR NO
PROTECTOR PIPE DIA. ____ IN.

2) WELL DEVELOPMENT

A) METHOD

(BAILING), PUMPING, SURGING, COMPRESSED AIR

OTHER ________

(NOTE ADDITIONAL COMMENTS BELOW)

B) TIME SPENT FOR DEVELOPMENT? 1 hr

C) APPROXIMATE WATER VOLUME: REMOVED 6 well volu

ADDED ________

D) WATER CLARITY BEFORE DEVELOPMENT?

CLEAR, (TURBID), OPAQUE

E) WATER CLARITY AFTER DEVELOPMENT?

CLEAR, (SLIGHTLY TURBID), TURBID, OPAQUE

F) ODOR? YES OR (NO)

3) WATER LEVEL SUMMARY

A) DEPTH FROM TOP OF CASING AFTER DEVELOPMENT?

____ FT. OR DRY

B) OTHER MEASUREMENTS (T.O.C.):

DATE/TIME ________ FT.

DATE/TIME ________ FT.

DATE/TIME ________ FT.

ADDITIONAL COMMENTS: WVMW-1

PROJECT NAME: ______ NO. ______

WELL NO. WVMW-2

DATE INSTALLED 8/11/86

A-13

ELEV. (T.O.C.) 919.06

GROUND SURF. ELEV. 917.85

BENTONITE (PELLETS)/GRANULAR/POWDER

BACKFILL MATERIAL Sand Cutting

LENGTH OF SOLID PIPE 4.63 FT.

BACKFILL METHOD

PIPE TREMIE/AUGER TREMIE (GRAVITY FILLED)

BENTONITE (PELLETS)/GRANULAR/POWDER

SILICA SAND

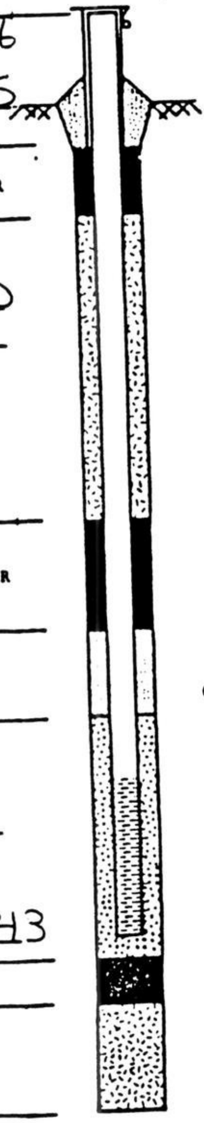
FILTER PACK MATERIAL

WELL SCREEN LENGTH 5 FT.

WELL BOTTOM ELEV. 899.43

SEAL MATERIAL

BACKFILL MATERIAL



DEPTH FROM GROUND SURFACE

1 FT.

1.5 FT.

BOREHOLE DIA. 6 IN.

10.6 FT.

12.63 FT.

[illegible] FT.

14.63 FT.

19.63 FT.

___ FT.

___ FT.

___ FT.

1) CASING DETAILS

A) TYPE OF PIPE: (PVC), STAINLESS, TEFLON, OTHER ______

PIPE SCHEDULE ______

B) TYPE OF PIPE JOINTS;

COUPLINGS, (THREADED) (W/TAPE?), OTHER ______

C) WAS SOLVENT USED? YES OR (NO)

D) TYPE OF WELL SCREEN:

(PVC), STAINLESS, TEFLON, OTHER ______

E) WELL SCREEN SLOT SIZE .01

F) PIPE DIA: ID IN. ______ OD IN. 2

G) INSTALLED PROTECTOR PIPE W/LOCK? (YES) OR NO

PROTECTOR PIPE DIA. 4 IN.

2) WELL DEVELOPMENT

A) METHOD

(BAILING), PUMPING, SURGING, COMPRESSED AIR

OTHER ______

(NOTE ADDITIONAL COMMENTS BELOW)

B) TIME SPENT FOR DEVELOPMENT? 1 hr

C) APPROXIMATE WATER VOLUME: REMOVED ______

ADDED ______

D) WATER CLARITY BEFORE DEVELOPMENT?

CLEAR, (TURBID), OPAQUE

E) WATER CLARITY AFTER DEVELOPMENT?

CLEAR, (SLIGHTLY TURBID), TURBID, OPAQUE

F) ODOR? YES OR (NO)

3) WATER LEVEL SUMMARY

A) DEPTH FROM TOP OF CASING AFTER DEVELOPMENT?

______ FT. OR DRY

B) OTHER MEASUREMENTS (T.O.C.):

DATE/TIME ______ FT.

DATE/TIME ______ FT.

DATE/TIME ______ FT.

ADDITIONAL COMMENTS: WVMW-2

PROJECT NAME: ______ NO. ______

WELL NO. WVMW-3

DATE INSTALLED 8/11/86

A-14

ELEV. (T.O.C.) 917.52

GROUND SURF. ELEV. 916.27

DEPTH FROM GROUND SURFACE 1 FT.

BENTONITE **PELLETS**/GRANULAR/POWDER — 1.5 FT.

BACKFILL MATERIAL Sand Cuttings

LENGTH OF SOLID PIPE 6.85 FT.

BACKFILL METHOD

PIPE TREMIE/AUGER TREMIE

GRAVITY FILLED

BOREHOLE DIA. 6 IN.

2.85 FT.

BENTONITE **PELLETS**/GRANULAR/POWDER — 4.85 FT.

SILICA SAND ______ FT.

FILTER PACK MATERIAL — 6.85 FT.

WELL SCREEN LENGTH 5 FT.

WELL BOTTOM ELEV. 905.67 — 11.85 FT.

______ FT.

SEAL MATERIAL ______ FT.

BACKFILL MATERIAL ______ FT.

1) CASING DETAILS

A) TYPE OF PIPE: **PVC**, STAINLESS, TEFLON, OTHER ______

PIPE SCHEDULE ______

B) TYPE OF PIPE JOINTS;

COUPLINGS, **THREADED** (W/TAPE?), OTHER ______

C) WAS SOLVENT USED? ~~YES~~ OR **NO**

D) TYPE OF WELL SCREEN:

PVC, STAINLESS, TEFLON, OTHER ______

E) WELL SCREEN SLOT SIZE .01

F) PIPE DIA: ID IN. ______ OD IN. 2

G) INSTALLED PROTECTOR PIPE W/LOCK? **YES** OR NO

PROTECTOR PIPE DIA. 4 IN.

2) WELL DEVELOPMENT

A) METHOD

BAILING, PUMPING, SURGING, COMPRESSED AIR

OTHER ______

(NOTE ADDITIONAL COMMENTS BELOW)

B) TIME SPENT FOR DEVELOPMENT? 1 hr

C) APPROXIMATE WATER VOLUME: REMOVED ______

ADDED ______

D) WATER CLARITY BEFORE DEVELOPMENT?

CLEAR, **TURBID**, OPAQUE

E) WATER CLARITY AFTER DEVELOPMENT?

CLEAR, **SLIGHTLY TURBID**, TURBID, OPAQUE

F) ODOR? YES OR **NO**

3) WATER LEVEL SUMMARY

A) DEPTH FROM TOP OF CASING AFTER DEVELOPMENT?

______ FT. OR DRY

B) OTHER MEASUREMENTS (T.O.C.):

DATE/TIME ______ FT.

DATE/TIME ______ FT.

DATE/TIME ______ FT.

ADDITIONAL COMMENTS: WVMW-3

PROJECT NAME: ______ NO. ______

WELL NO. WVMW-4

DATE INSTALLED 8/11/86

ELEV. (T.O.C.) 917.79

GROUND SURF. ELEV. 916.25

DEPTH FROM GROUND SURFACE 1 FT.

BENTONITE (PELLETS)/GRANULAR/POWDER — 2.0 FT.

BACKFILL MATERIAL Sand Cuttings

LENGTH OF SOLID PIPE ___ FT.

BACKFILL METHOD

PIPE TREMIE/AUGER TREMIE (GRAVITY FILLED)

BOREHOLE DIA. 6 IN.

10.64 FT.

BENTONITE (PELLETS)/GRANULAR/POWDER — 12.64 FT.

SILICA SAND ___ FT.

FILTER PACK MATERIAL — 14.64 FT.

WELL SCREEN LENGTH ___ FT.

WELL BOTTOM ELEV. 898.15 — 19.64 FT.

___ FT.

SEAL MATERIAL ___ FT.

BACKFILL MATERIAL ___ FT.

1) CASING DETAILS

A) TYPE OF PIPE: (PVC), STAINLESS, TEFLON, OTHER ______

PIPE SCHEDULE ______

B) TYPE OF PIPE JOINTS;

COUPLINGS, (THREADED) (W/TAPE?), OTHER ______

C) WAS SOLVENT USED? YES OR (NO)

D) TYPE OF WELL SCREEN:

(PVC), STAINLESS, TEFLON, OTHER ______

E) WELL SCREEN SLOT SIZE .01

F) PIPE DIA: ID IN. ____ OD IN. 2

G) INSTALLED PROTECTOR PIPE W/LOCK? (YES) OR NO

PROTECTOR PIPE DIA. 4 IN.

2) WELL DEVELOPMENT

A) METHOD

(BAILING), PUMPING, SURGING, COMPRESSED AIR

OTHER ______

(NOTE ADDITIONAL COMMENTS BELOW)

B) TIME SPENT FOR DEVELOPMENT? 1 hr

C) APPROXIMATE WATER VOLUME: REMOVED ______

ADDED ______

D) WATER CLARITY BEFORE DEVELOPMENT?

CLEAR, (TURBID), OPAQUE

E) WATER CLARITY AFTER DEVELOPMENT?

CLEAR, (SLIGHTLY TURBID), TURBID, OPAQUE

F) ODOR? YES OR (NO)

3) WATER LEVEL SUMMARY

A) DEPTH FROM TOP OF CASING AFTER DEVELOPMENT?

____ FT. OR DRY

B) OTHER MEASUREMENTS (T.O.C.):

DATE/TIME ______ FT.

DATE/TIME ______ FT.

DATE/TIME ______ FT.

ADDITIONAL COMMENTS: WVMW-4

Appendix B.1

Kingston, Wisconsin STE data for seven sampling periods

	KSE	KSE	KSE	KSE	KSE	KSE	KSE
DATE	3/26/86	5/13/86	7/2/86	8-24-86	10-19-86	1-14-87	3-16-87
TOTAL SOLIDS	1001	1159	1147	1131	1137	1017	1019
TOTAL VOLATILE SOLIDS	774	802	906	797	913	764	705
TOTAL SUSPENDED SOLIDS	57	101	58	46	30	57	42
VOLATILE SUSPENDED SOLIDS	30	28	9	10	16	16	5
TEMPERATURE (Celsius)	9	12.0	18.0	22.0	15.0	9.5	8.0
CONDUCTIVITY (umhos/cm)	1.32E3	1.40E3	1.62E3	1.89E3	2.20E3	1.85E3	1.90E3
pH	7.44	6.98	6.78	6.87	6.78	6.91	7.13
BIOCHEMICAL OXYGEN DEMAND	140	275	216	140	71	125	383
PURGABLE ORGANIC CARBON	1.597	3.022	6.530	0.218	3.073	2.679	0.6033
TOTAL ORGANIC CARBON	127.3	171.67	148.17	130.50	91.94	153.10	280.48
CHLORIDE	150.4	153.4	221.7	278.6	343.4	192.3	256.5
AMMONIA-N	85.9	61.4	49.7	57.0	84.0	64.7	67.3
NITRATE -N	<0.05	0.10	0.00	0.05	0.02	0.00	0.02
NITRITE -N	-	-	-	0.03	0.04	0.02	0.01

(Concentration = mg/L except as noted, Conductivity @ 25 Celsius)

Appendix B.2

Town of Scott STE data for seven sampling periods

	TSE	TSE	TSE	TSE	TSE	TSE	TSE
DATE	3/24/86	5/16/86	6/30/86	8-19-86	10-4-86	1-5-87	3-20-87
TOTAL SOLIDS	724	748	872	854	725	947	1221
TOTAL VOLATILE SOLIDS	562	598	643	630	502	617	965
TOTAL SUSPENDED SOLIDS	30	56	44	13	30	96	66
VOLATILE SUSPENDED SOLIDS	14	18	19	3	8	40	33
TEMPERATURE (Celsius)	5	12.0	16.0	19.0	15.0	8.0	5.5
CONDUCTIVITY (umhos/cm)	.795E3	1.36E3	.525E3	1.41E3	1.49E3	1.20E3	2.30E3
pH	7.20	7.93	7.36	7.33	7.58	7.70	7.43
BIOCHEMICAL OXYGEN DEMAND	30	47	106	139	35	66	218
PURGABLE ORGANIC CARBON	0.186	0.230	0.590	0.716	0.398	0.010	0.6746
TOTAL ORGANIC CARBON	46.89	133.0	129.27	66.45	86.87	132.9	80.73
CHLORIDE	88.0	104.0	101.4	417.9	122.3	87.1	438.0
AMMONIA-N	72.7	26.2	39.0	44.2	83.6	67.0	49.4
NITRATE-N	<0.05	0.00	0.00	0.05	0.02	0.00	0.03
NITRITE-N	-	-	-	0.05	0.04	0.06	0.05

(Concentration = mg/L except as noted, Conductivity @ 25 Celsius)

Appendix B.3

Maplewood, Wisconsin STE data for seven sampling periods

	MVE	MVE	MVE	MVE	MVE	MVE	MVE
DATE	3/24/86	5/16/86	6/30/86	8-18-86	10-4-86	1-6-87	3-20-87
TOTAL SOLIDS	468	1092	823	955	664	842	782
TOTAL VOLATILE SOLIDS	388	889	664	786	518	627	618
TOTAL SUSPENDED SOLIDS	5	27	40	22	24	26	44
VOLATILE SUSPENDED SOLIDS	5	13	14	4	24	0.	15
TEMPERATURE (Celsius)	4	15.0	16.0	18.5	15.0	5.0	5.0
CONDUCTIVITY (umhos/cm)	.605E3	1.41E3	1.22E3	1.65E3	1.32E3	0.99E3	1.60E3
pH	7.01	7.14	7.18	7.25	7.20	7.61	7.74
BIOCHEMCIAL OXYGEN DEMAND	11	84	103	85	14	29	172
PURGABLE ORGANIC CARBON	0.019	0.624	0.701	0.944	0.311	0.376	0.1423
TOTAL ORGANIC CARBON	26.07	212.63	61.30	87.10	47.07	92.44	62.64
CHLORIDE	80.8	140.4	107.6	257.3	195.1	177.6	187.4
AMMONIA-N	9.3	27.0	37.9	44.2	17.7	42.3	27.0
NITRATE-N	0.05	0.00	0.00	0.07	0.97	0.01	0.01
NITRITE-N	-	-	-	0.05	0.04	0.01	0.02

(Concentration = mg/L except as noted, Conductivity @ 25 Celsius)

Appendix B.4

Wyeville, Wisconsin STE data for seven sampling periods

	WVE	WVE	WVE	WVE	WVE	WVE	WVE
DATE	3/25/86	5/15/86	6/29/86	8-23-86	10-11-86	1-13-87	3-17-87
TOTAL SOLIDS	575	670	473	514	563	681	648
TOTAL VOLATILE SOLIDS	348	362	337	286	360	334	364
TOTAL SUSPENDED SOLIDS	88	68	38	70	42	76	132
VOLATILE SUSPENDED SOLIDS	60	20	12	27	0.	6.	46
TEMPERATURE (Celsius)	5	12.0	17.0	20.0	16.0	5.0	5.0
CONDUCTIVITY (umhos/cm)	1.05E3	1.16E3	.64E3	.62E3	1.05E3	1.22E3	1.22E3
pH	7.44	7.07	6.71	6.44	6.69	7.20	7.36
BIOLOGICAL OXYGEN DEMAND	170.6	190.0	157.35	120.75	150.9	169.0	190.32
PURGABLE ORGANIC CARBON	0.533	0.492	0.789	0.095	1.249	0.1337	0.157
TOTAL ORGANIC CARBON	132.7	117.67	68.02	83.00	124.0	251.05	169.57
CHLORIDE	103.1	118.66	116.1	81.90	141.70	103.18	147.26
AMMONIA-N	50.63	60.04	22.55	33.09	84.337	74.70	66.50
NITRATE-N	0.07	0.113	0.00	0.042	0.017	0.000	0.029
NITRITE-N	-	-	-	0.044	0.052	0.046	0.037

(Concentration = mg/L except as noted, Conductivity @ 25 Celsius)

Appendix B.5

Westboro, Wisconsin STE data for seven sampling periods.

	VBE	VBE	VBE	VBE	VBE	VBE	VBE
DATE	3/25/86	5/15/86	6/29/86	8-23-86	10-11-86	1-13-87	3-17-87
TOTAL SOLIDS	572	631	593	523	569	687	621
TOTAL VOLATILE SOLIDS	326	421	406	409	373	323	365
TOTAL SUSPENDED SOLIDS	138	30	40	36	50	40	94
VOLATILE SUSPENDED SOLIDS	66	9	13	0	22	14	18
TEMPERATURE (Celsius)	8	11.0	17.0	18.0	16.0	5.0	5.5
CONDUCTIVITY (umhos/cm)	.81E3	1.08E3	.93E3	.94E3	1.30E3	1.21E3	1.24E3
pH	7.18	7.18	7.16	7.04	7.19	7.37	7.64
BIOCHEMICAL OXYGEN DEMAND	136	132	144	139	25	111.	270
PURGABLE ORGANIC CARBON	1.560	1.071	0.924	0.830	0.582	0.465	0.3095
TOTAL ORGANIC CARBON	130.6	96.00	68.73	110.50	72.22	222.2	130.80
CHLORIDE	63.8	74.3	84.9	0.1	106.9	51.4	87.3
AMMONIA-N	136.1	50.2	42.1	49.2	0.1	68.6	57.4
NITRATE-N	<0.05	0.00	0.00	0.05	0.01	0.01	0.0
NITRITE-N	-	-	-	0.03	0.04	0.03	0.02

(Concentration = mg/L except as noted, Conductivity @ 25 Celsius)

Appendix B.6

Don's Mobile Manor, Wisconsin STE data for seven sample periods.

	DONS	DONS	DONS	DONS	DONS	DONS	DONS
DATE	3/27/86	5/14/86	7/3/86	8-24-86	10-19-86	1-14-87	3-16-87
TOTAL SOLIDS	312	559	556	489	531	469	450
TOTAL VOLATILE SOLIDS	220	345	359	344	381	325	282
TOTAL SUSPENDED SOLIDS	45	27	23	43	28	49	21
VOLATILE SUSPENDED SOLIDS	37	6	0	0.	4	3	0
TEMPERATURE (Celsius)	7	15.0	20.0	21.0	18.0	11.0	5.0
CONDUCTIVITY (umhos/cm)	.14E3	0.67E3	.94E3	.84E3	1.20E3	0.84E3	0.89E3
pH	7.27	7.31	7.26	7.01	7.18	7.01	7.01
BIOCHEMICAL OXYGEN DEMAND	21.	98	156	181.	70	54	146
PURGABLE ORGANIC CARBON	2.555	1.051	1.934	2.990	2.99	1.257	0.280
TOTAL ORGANIC CARBON	43.19	80.28	104.80	119.50	98.96	80.40	78.46
CHLORIDE	36.2	24.0	32.9	0.05	34.3	23.1	20.4
AMMONIA-N	9.2	34.1	37.9	37.7	0.02	31.5	26.1
NITRATE-N	<0.05	0.00	0.00	0.059	0.024	0.036	0.012
NITRITE -N	-	-	-	0.04	0.06	0.01	0.01

(Concentration = mg/L except as noted, Conductivity @ 25 Celsius)

Appendix C.1

Groundwater Data For Kingston, WI.

The composition of the groundwater in the vicinity of the wastewater absorption beds was determined through sampling of 3 groundwater monitoring wells (Figure 9 and 10). Representative groundwater surface contours near the system were depicted in Figure 11. The general flow pattern was to the northeast, the surface topography also sloped to the northeast of the site. The water table surface varied approximately two feet during the investigation (see Table C1.1-2 for elevations).

The monitoring wells located closest (KSMW 2&3) to the absorption beds revealed significant increases of measured parameters in the groundwater relative to background levels (KSMW1) (Table C.1-1). In particular samples from monitoring wells 2 and 3 exhibited mean concentrations of total solids, chlorides and conductivity comparable to the concentrations in the applied STE. These concentrations of conservative parameters indicated that the monitoring wells were installed so that the samples were withdrawn within the effluent plume. The mean ammonia concentration measured in well 2 was approximately 100 times greater than the background levels (KSMW1). The concentration of nitrate in the vicinity of the beds was approximately 5 to 10 times the background levels.

This data also indicates that the groundwater monitoring wells 2 and 3 were installed so that samples from these wells were representative of the water quality in the effluent plume.

Table C.1-1
Mean Concentrations of Conservative Parameters Measured in Groundwater at Kingston, Wisconsin

	KSMW1	KSMW2	KSMW3
TOTAL SOLIDS	556	805	1106
TOTAL VOLATILE SOLIDS	401	654	849
CONDUCTIVITY (umhos/cm)	.645E3	1.57E3	1.67E3
TOTAL ORGANIC CARBON	5.700	7.869	12.120
CHLORIDE	5.7	207.0	212.3
AMMONIA-N	<0.01	9.0	.7
NITRATE-N	3.5	18.0	41.6
NITRITE-N	<0.05	<0.05	<0.05

(Concentration = mg/L except as noted, Conductivity @ 25 Celsius)

Table C.1-2
Results of Groundwater Monitoring for Conventional Parameters at Kingston, Wisconsin

	KSMW 1	KSMW 2	KSMW 3	KSMW 1	KSMW 2	KSMW 3
DATE	8-24-86	8-24-86	8-24-86	10-19-86	10-19-86	10-19-86
TOTAL SOLIDS	870	478	1240	462	987	969
TOTAL VOLATILE SOLIDS	660	289	939	315	810	706
TEMPERATURE (Celsius)	-	-	-	12.0	14.0	16.0
CONDUCTIVITY (umhos/cm)	.58E3	1.44E3	1.65E3	0.69E3	1.55E3	1.51E3
pH	7.13	7.06	6.70	6.71	6.99	6.84
TOTAL ORGANIC CARBON	3.670	12.72	5.096	3.160	3.195	10.260
CHLORIDE	5.9	208.3	249.9	10.2	219.2	178.5
AMMONIA-N	0.02	16.8	0.04	0.06	13.05	0.06
NITRATE-N	4.0	1.0	64.9	2.5	10.6	34.4
NITRITE-N	0.01	0.01	0.03	0.04	0.04	0.04
WATER LEVEL-feet	798.16	796.12	795.51	798.66	797.23	796.56

Table C.1-2 (continued)

	KSMW 1	KSMW 2	KSMW 3	KSMW 1	KSMW 2	KSMW 3
DATE	1-14-87	1-14-87	1-14-87	3-16-87	3-16-87	3-16-87
TOTAL SOLIDS	442.	940.	1223.	451	1127	984
TOTAL VOLATILE SOLIDS	325.	725	994	306	792	758
TEMPERATURE (Celsius)	7.0	9.0	6.0	5.0	5.0	9.0
CONDUCTIVITY (umhos/cm)	0.66E3	1.60E3	1.91E3	0.65E3	1.70E3	1.60E3
pH	7.13	7.16	7.26	7.04	7.30	7.04
TOTAL ORGANIC CARBON	MISS	7.215	3.340	10.527	0.3195	21.76
CHLORIDE	3.0	157.0	204.2	3.6	243.1	216.6
AMMONIA-N	0.0	4.64	0.00	0.03	0.97	2.00
NITRATE-N	3.00	10.12	53.90	3.19	50.30	13.32
NITRITE-N	0.01	0.01	0.04	0.00	0.01	0.00
WATER LEVEL-feet	797.67	795.73	795.10	797.45	795.36	795.43

(Concentration = mg/L except as noted, Conductivity @ 25 Celsius)

Table C.1-3
Results of Septage monitoring for
Conventional Parameters

	KS-SS	KS-SS	KS-SS
DATE	10-19-86	1-14-87	3-16-87
TOTAL SOLIDS	1060	1894	2001
TOTAL VOLATILE SOLIDS	709	1041	931
TOTAL SUSPENDED SOLIDS	50	494	200
VOLATILE SUSPENDED SOLIDS	20	112	10
TEMPERATURE (Celsius)	16.0	9.5	7.0
CONDUCTIVITY (umhos/cm)	-	1.80E3	1.95E3
pH	7.32	6.78	7.01
BIOCHEMICAL OXYGEN DEMAND	165	363	1150

Table C.1-3 (continued)

TOTAL ORGANIC CARBON	181.0	827.25	365.47
CHLORIDE	252.69	192.34	316.10
AMMONIA	95.489	64.624	62.70
NITRATE	0.024	0.019	0.038
NITRITE	0.055	0.050	0.019

(Concentration = mg/L except as noted, Conductivity @ 25 Celsius)

Appendix C.2

Groundwater Data for the Town of Scott

The composition of the groundwater in the vicinity of the wastewater absorption beds was determined through sampling of 4 groundwater monitoring wells (Figure 12 and 13). Representative groundwater surface contours near the system were depicted in Figure 14. The general flow pattern was to the southeast, the surface topography also sloped to the southeast of the site. The groundwater surface also indicated mounding in the vicinity of the absorption beds. The water table surface varied approximately two feet during the investigation (see Table C.2-2 for elevations).

The monitoring wells located closest (TSMW 1, 2 & 3) to the absorption beds revealed significant increases of measured parameters in the groundwater relative to background levels (TSMW4) (Table C.2-1). In particular, samples from monitoring wells 1, 2 and 3 exhibited mean concentrations ot total solids, chloride and conductivity comparable to the concentrations in the applied STE. These concentrations of conservative parameters indicated that the monitoring wells were installed so that the samples were withdrawn within the effluent plume. The mean ammonia concentrations measured in well 1 and 2 were approximately 100 times greater than the background levels (TSMW4). The concentrations of nitrate in the vicinity of the beds were approximately 50 to 100 times the background levels.

This data also indicates that the groundwater monitoring wells 2 and 3 were installed so that samples from these wells were representative of the water quality in the effluent plume.

Table C.2-1
Mean Concentrations of Conservative Parameters
Measured in Groundwater at Town of Scott, Wisconsin

	TSMW1	TSMW2	TSMW3	TSMW4
TOTAL SOLIDS	993	923	747	523
TOTAL VOLATILE SOLIDS	656	710	493	357
CONDUCTIVITY (umhos/cm)	1.47E3	1.52E3	1.09E3	0.78E3
TOTAL ORGANIC CARBON	8.27	11.37	7.99	0.73
CHLORIDE	91.1	114.0	87.1	11.3
AMMONIA-N	3.7	3.4	<0.05	<0.05
NITRATE-N	30.51	10.53	12.05	.24
NITRITE-N	0.21	0.27	<0.05	<0.05

(Concentration = mg/L except as noted, Conductivity @ 25 Celsius)

Table C.2-2
Results of Groundwater Monitoring
for Conventional Parameters at Kingston, Wisconsin

	TSMW 1	TSMW 2	TSMW 3	TSMW 4	TSMW 1	TSMW 2	TSMW 3	TSMW 4
DATE	8-19-86	8-19-86	8-19-86	8-19-86	10-4-86	10-4-86	10-4-86	10-4-86
TOTAL SOLIDS	898	942	734	516	939	938	772	532
TOTAL VOLATILE SOLIDS	609	732	504	374	708	721	486	354
TEMPERATURE (Celsius)	-	-	-	-	12.5	13.0	12.5	12.0
CONDUCTIVITY (umhos/cm)	1.36E3	1.38E3	1.00E3	.76E3	1.50E3	1.52E3	1.30E3	0.90E3
pH	7.83	7.97	7.93	7.90	6.91	6.91	6.91	6.98
TOTAL ORGANIC CARBON	14.70	14.59	10.24	10.59	4.443	4.027	3.939	2.900
CHLORIDE	103.5	99.3	106.7	11.4	84.9	135.2	131.2	11.0
AMMONIA-N	12.7	0.9	0.06	0.04	0.22	3.2	0.1	0.1
NITRATE-N	49.78	33.27	14.93	0.39	29.34	21.29	13.10	0.59
NITRITE-N	0.17	0.03	0.01	0.01	0.10	0.69	0.04	0.04
WATER LEVEL-feet	895.89	895.48	894.82	894.91	896.75	896.14	895.58	894.78

Table C.2-2 (continued)

	TSMW 1	TSMW 2	TSMW 3	TSMW 4	TSMW 1	TSMW 2	TSMW 3	TSMW 4
DATE	1-5-87	1-5-87	1-5-87	1-5-87	3-20-87	3-20-87	3-20-87	3-20-87
TOTAL SOLIDS	823	911	680	508	1097	904	803	537
TOTAL VOLATILE SOLIDS	557	716	479	336	750	674	504	364
TEMPERATURE (Celsius)	11.0	11.0	11.0	9.5	8.0	9.0	7.0	7.5
CONDUCTIVITY (umhos/cm)	1.40E3	1.65E3	0.74E3	0.54E3	1.60E3	1.52E3	1.22E3	0.91E3
pH	6.92	6.89	7.20	6.96	6.84	6.80	7.05	7.08
TOTAL ORGANIC CARBON	3.949	15.195	9.803	1.157	10.007	10.877	7.969	12.253
CHLORIDE	71.7	103.8	52.4	8.7	104.2	117.7	58.0	14.2
AMMONIA-N	0.89	0.37	0.02	0.00	0.99	1.3	0.03	0.
NITRATE-N	15.55	10.26	10.74	0.91	27.39	9.29	12.64	1.41
NITRITE-N	0.20	0.30	0.00	0.00	0.27	0.09	0.00	0.00
WATER LEVEL-feet	894.99	894.60	894.62	894.07	894.91	894.22	894.17	893.51

(Concentration = mg/L except as
.oted, Conductivity @ 25 Celsius)

Appendix C.3

Groundwater Data for Maplewood, WI

The composition of the groundwater in the vicinity of the wastewater absorption beds was determined through sampling of 4 groundwater monitoring wells (Figure 15 and 16). The general flow pattern was to the southeast, the surface topography also sloped to the southeast of the site. The water table surface varied approximately two feet during the investigation (see Table C.3-2 for elevations).

The monitoring wells located closest (MWMW 2, 3 & 4) to the absorption beds revealed significant increases of measured parameters in the groundwater relative to background levels (MWMW1) (Table C.3-1). In particular samples from monitoring wells 2, 3 and 4 exhibited mean concentrations of total solids, chlorides and conductivity comparable to the concentrations in the applied STE. These concentrations of conservative parameters indicated that the monitoring wells were installed so that the samples were withdrawn within the effluent plume. The mean ammonia concentration measured in well 2 was approximately 4 times greater than the background levels (MWMW1). The concentrations of nitrate in the vicinity of the beds were approximately 2 to 4 times the background levels.

This data also indicates that the groundwater monitoring wells 2 and 3 were installed so that sample from these wells were representative of the water quality in the effluent plume.

Table C.3-1
Mean Concentrations of Conservative Parameters Measured in Groundwater at Maplewood, Wisconsin

	MWMW1	MWMW2	MWMW3	MWMW4
TOTAL SOLIDS	424	850	709	747
TOTAL VOLATILE SOLIDS	245	610	617	675
CONDUCTIVITY (umhos/cm)	.732E3	1.22E3	1.27E3	1.18E3
TOTAL ORGANIC CARBON	2.470	5.619	7.167	5.942
CHLORIDE	11.4	146.0	160.0	135.7
AMMONIA-N	0.03	0.10	0.02	0.03
NITRATE-N	4.71	19.24	7.71	8.79
NITRITE-N	<0.05	<0.05	<0.05	<0.05

(Concentration = mg/L except as noted, Conductivity @ 25 Celsius)

Table C.3-2
Results of Groundwater Monitoring for Conventional Parameters at Kingston, Wisconsin

	MWMW 1	MWMW 2	MWMW 3	MWMW 4	MWMW 1	MWMW 2	MWMW 3	MWMW 4
DATE	8-18-86	8-18-86	8-18-86	8-18-86	10-4-86	10-4-86	10-4-86	10-4-86
TOTAL SOLIDS	338	MISS	662	MISS	401	556	648	900
TOTAL VOLATILE SOLIDS	201	MISS	471	MISS	223	393	495	787
TEMPERATURE (Celsius)	-	-	-	13.5	10.0	8.5	10.0	10.0
CONDUCTIVITY (umhos/cm)	.89E3	.86E3	1.14E3	.99E3	0.72E3	1.05E3	1.29E3	1.55E3
pH	7.09	7.53	7.68	7.55	7.39	7.23	7.19	7.07
TOTAL ORGANIC CARBON	2.548	8.91	6.551	4.349	3.863	3.568	12.000	8.537
CHLORIDE	11.7	122.3	163.7	114.3	12.2	141.7	173.8	261.7
AMMONIA-N	0.02	0.10	0.03	0.03	0.09	0.30	0.07	0.07
NITRATE-N	1.06	9.89	7.63	10.92	1.81	10.00	4.31	10.73
NITRITE-N	0.01	0.09	0.01	0.02	0.04	0.08	0.04	0.04
WATER LEVEL-feet	695.12	693.30	694.22	694.03	694.49	693.27	693.52	695.34

Table C2-2 (continued)

	MWMW 1	MWMW 2	MWMW 3	MWMW 4	MWMW 1	MWMW 2	MWMW 3	MWMW 4
DATE	1-6-87	1-6-87	1-6-87	1-6-87	3-20-87	3-20-87	3-20-87	3-20-87
TOTAL SOLIDS	466	964	857	642	491	1030	989	697
TOTAL VOLATILE SOLIDS	282	677	653	537	277	762	852	588
TEMPERATURE (Celsius)	8.0	8.0	8.0	9.0	8.0	9.0	8.5	9.5
CONDUCTIVITY (umhos/cm)	0.65E3	1.37E3	1.20E3	0.98E3	0.63E3	1.60E3	1.35E3	1.19E3
pH	7.23	6.87	6.96	7.37	6.80	6.71	6.73	7.06
TOTAL ORGANIC CARBON	2.294	6.259	2.723	6.538	1.173	3.740	7.3945	4.342
CHLORIDE	12.9	141.4	149.5	87.1	9.0	107.6	152.9	79.8
AMMONIA-N	0.00	0.00	0.00	0.00	0.02	0.02	0.0	0.0
NITRATE-N	9.68	22.68	10.04	2.54	6.26	34.38	8.06	10.98
NITRITE-N	0.00	0.01	0.00	0.00	0.00	0.02	0.00	0.00
WATER LEVEL-feet	694.45	693.33	693.41	694.60	693.33	697.80	697.30	693.46

(Concentration = mg/L except as noted, Conductivity @ 25 Celsius)

Appendix C.4

Groundwater Data for Wyeville, WI

The composition of the groundwater in the vicinity of the wastewater absorption beds was determined through sampling of 4 groundwater monitoring wells (Figure 17 and 18). Representative groundwater surface contours near the system were depicted in Figure 19. The general flow pattern was to the north, the surface topography also sloped to the north of the site. The water table surface varied approximately two feet during the investigation (see Table C.4-2 for elevations).

The monitoring wells located closest (WVMW 2, 3 & 4) to the absorption beds revealed significant increases of measured parameters in the groundwater relative to background levels (WVMW1) (Table C.4-1). In particular, samples from monitoring wells 2, 3 and 4 exhibited mean concentrations of total solids, chloride and conductivity comparable to the concentrations in the applied STE. These concentrations of conservative parameters indicated that the monitoring wells were installed so that the samples were withdrawn within the effluent plume. The mean ammonia concentration measured in wells 2,3 and 4 was approximately 3 to 100 times greater than the background levels (WVMW1). The concentration of nitrate in the vicinity of the beds was significantly higher than background levels.

This data also indicates that the groundwater monitoring wells 2, 3 and 4 were installed so that samples from these wells were representative of the water quality in the effluent plume.

Table C.4-1
Mean Concentrations of Conservative Parameters Measured in Groundwater at Wyeville, Wisconsin

	WVMW1	WVMW2	WVMW3	WVMW4
TOTAL SOLIDS	228	401	457	429
TOTAL VOLATILE SOLIDS	116	280	294	270
CONDUCTIVITY (umhos/cm)	.069E3	0.527E3	0.580E3	0.628E3
TOTAL ORGANIC CARBON	2.348	12.036	6.257	6.099
CHLORIDE	3.6	122.6	125.3	116.9
AMMONIA-N	<0.03	0.12	1.24	5.43
NITRATE-N	<0.05	4.27	16.57	24.79
NITRITE-N	<0.05	0.10	<0.05	<0.05

(Concentration = mg/L except as noted, Conductivity @ 25 Celsius)

Table C.4-2
Results of Groundwater Monitoring for Conventional Parameters at Wyeville, Wisconsin

	WVMW 1	WVMW 2	WVMW 3	WVMW 4	WVMW 1	WVMW 2	WVMW 3	WVMW 4
DATE	8-23-86	8-23-86	8-23-86	8-23-86	10-11-86	10-11-86	10-11-86	10-11-86
TOTAL SOLIDS	230	535	486	587	517	377	437	397
TOTAL VOLATILE SOLIDS	165	345	311	376	456	309	301	260
TEMPERATURE (Celsius)	-	-	-	-	15.5	15.5	13.5	13.5
CONDUCTIVITY (umhos/cm)	.60E3	.48E3	.38E3	.66E3	0.075E3	0.558E3	0.62E3	0.64E3
pH	5.05	4.09	4.39	4.53	5.22	4.61	4.09	4.29
TOTAL ORGANIC CARBON	2.98	19.15	12.40	4.231	2.408	4.035	5.038	6.934
CHLORIDE	2.0	120.1	112.6	120.1	10.4	130.5	141.7	119.2
AMMONIA-N	0.07	0.09	0.04	0.12	0.06	0.07	0.80	4.49
NITRATE-N	0.05	7.58	16.43	47.74	0.03	2.19	13.20	22.80
NITRITE-N	0.01	0.08	0.02	0.01	0.04	0.09	0.04	0.04
WATER LEVEL-feet	909.81	909.42	909.35	909.58	912.35	910.75	909.67	910.39

Table C.4-2 (continued)

	WVMW 1	WVMW 2	WVMW 3	WVMW 4	WVMW 1	WVMW 2	WVMW 3	WVMW 4
DATE	1-13-87	1-13-87	1-13-87	1-13-87	3-17-87	3-17-87	3-17-87	3-17-87
TOTAL SOLIDS	137	368	454	381	28	324	453	351
TOTAL VOLATILE SOLIDS	46.	216.	280	236	0.	252	284	203
TEMPERATURE (Celsius)	5.5	8.0	8.0	7.0	4.5	7.0	7.0	6.0
CONDUCTIVITY (umhos/cm)	.065E3	0.54E3	0.66E3	0.54E3	.075E3	0.53E3	0.66E3	0.67E3
pH	5.62	4.63	4.46	4.01	5.07	4.46	4.05	4.66
TOTAL ORGANIC CARBON	1.568	7.977	5.149	0.653	2.438	17.263	2.439	4.579
CHLORIDE	0.6	70.9	80.0	65.1	0.6	161.0	166.7	161.0
AMMONIA-N	0.00	0.26	1.03	6.29	0.01	0.07	2.29	10.02
NITRATE-N	0.02	4.04	25.10	6.45	0.02	3.2	11.46	22.10
NITRITE-N	0.01	0.12	0.04	0.03	0.00	0.13	0.06	0.02
WATER LEVEL-feet	910.73	909.90	909.37	909.73	911.35	910.15	909.33	909.78

(Concentration = mg/L except as noted, Conductivity @ 25 Celsius)

Table C.4-3
Results of Septage monitoring for Conventional Parameters

	WV-SS	WV-SS	WV-SS
DATE	10-11-86	1-13-87	3-17-87
TOTAL SOLIDS	2570	3001	2150
TOTAL VOLATILE SOLIDS	636.	871	856
TOTAL SUSPENDED SOLIDS	3125	1470	2165
VOLATILE SUSPENDED SOLIDS	365	130	290
TEMPERATURE (Celsius)	16.0	7.0	6.0
CONDUCTIVITY (umhos/cm)	1.35E3	1.9E3	2.15E3

Table C.1-3 (continued)

pH	5.17	4.86	5.34
BIOLOGICAL OXYGEN DEMAND	1192	1580	1360
TOTAL ORGANIC CARBON	1000	1908.5	1041.3
CHLORIDE	173.8	183.2	204.2
AMMONIA-N	112.9	128.6	114.9
NITRATE-N	0.07	0.15	0.07
NITRITE-N	0.05	0.30	0.23

(Concentration = mg/L except as noted, Conductivity @ 25 Celsius)

APPENDIX D

VOC DETECTION LIMITS FROM THE WISCONSIN STATE LABORATORY OF HYGENE

Municipal Wastewater

Department of Natural Resources

VOLATILE ORGANIC — ~~SOLID WASTE PROGRAM~~
Form 4400-94 10-84

D-1

Bill To: ☐ Hazardous Waste ☐ Non-Hazardous Waste ☐ Spill Program

Facility Name ______ Lic. No. 0 __ __ __ __ Field No. ______

County ______ County Code __ __ DNR Point ID No. __ __ __

Collection Date: __ __ / __ __ / __ __ (M M D D Y Y)

Time (24-Hour Clock): __ __ / __ __ (H H M M)

Sample Location ______

Sample Description ______

Send Report To:
Name
Address
City, State, Zip Code

Collected by ______

Telephone ( )

Account Number 040060
For Lab Use Only

☐ Monitoring Well (W)
☐ Surface Water (W)
☐ Private Well (W)
☐ Wastewater (E)
☐ Lysimeter (W)
☐ Waste (B)
☐ Oil (O)
☐ Soil (S)
☐ Leachate (L)
☐ Other ______

Enforcement ☐ Yes ☐ No

Split Sample ☐ Yes ☐ No

Received by ______

Analysis Type (check (✓) one)
☐ GC-MS Screening
☐ Follow-up of GC-MS Screening Sample Number (fill in) ______
☐ GC-MS Screening and Quantification
☐ Other (explain) ______

Detection Limits (ug/l) are indicated in brackets [ ]

	Compound	Detected	Not Detected	(ug/l)
☐	007 Acrolein[50]	☐	☐	___ . __
☐	009 Acrylonitrile[20]	☐	☐	___ . __
☐	025 Benzene[1.0]	☐	☐	___ . __
☐	046 Bromobenzene[4.0]	☐	☐	___ . __
☐	051 Bromodichloromethane[1.5]	☐	☐	___ . __
☐	053 Bromoform[5.0]	☐	☐	___ . __
☐	055 Bromomethane[50]	☐	☐	___ . __
☐	063 n-Butylacetate[0.5]	☐	☐	___ . __
☐	071 Carbon Disulfide[5.0]	☐	☐	___ . __
☐	073 Carbon Tetrachloride[1.5]	☐	☐	___ . __
☐	083 Chlorobenzene[2.0]	☐	☐	___ . __
☐	087 Chloroethane[2.0]	☐	☐	___ . __
☐	093 2-Chloroethylvinyl Ether[4.0]	☐	☐	___ . __
☐	095 Chloroform[1.0]	☐	☐	___ . __
☐	108 o-Chlorotoluene[1.0]	☐	☐	___ . __
☐	110 p-Chlorotoluene[1.0]	☐	☐	___ . __
☐	147 Dibromochloromethane[2.0]	☐	☐	___ . __
☐	148 1,2-Dibromo-3-Chloropropane	☐	☐	[not quantified] ___ . __
☐	153 o-Dichlorobenzene[2.0]	☐	☐	___ . __
☐	155 m-Dichlorobenzene[2.0]	☐	☐	___ . __
☐	157 p-Dichlorobenzene[2.0]	☐	☐	___ . __
☐	165 1,1-Dichloroethane[1.0]	☐	☐	___ . __
☐	167 1,2-Dichloroethane[1.0]	☐	☐	___ . __
☐	169 1,1-Dichloroethylene[1.0]	☐	☐	___ . __
☐	171 1,2-Dichloroethylene[1.0]	☐	☐	___ . __
☐	174 Dichloroiodomethane	☐	☐	[not quantified] ___ . __
☐	181 1,2-Dichloropropane[1.0]	☐	☐	___ . __

	Compound	Detected	Not Detected	ug/l
☐	183 cis-1,3-Dichloropropene[2.5]	☐	☐	___ . __
☐	185 trans-1,3-Dichloropropene[2.5]	☐	☐	___ . __
☐	233 Ethylbenzene[1.0]	☐	☐	___ . __
☐	427 Fluorotrichloromethane[1.0]	☐	☐	___ . __
☐	298 Isopropylbenzene[1.0]	☐	☐	___ . __
☐	319 Methylethylketone (MEK)[12]	☐	☐	___ . __
☐	393 Styrene[2.0]	☐	☐	___ . __
☐	396 1,1,1,2-Tetrachloroethane[3.0]	☐	☐	___ . __
☐	397 1,1,2,2-Tetrachloroethane[3.0]	☐	☐	___ . __
☐	399 Tetrachloroethylene[1.0]	☐	☐	___ . __
☐	401 Tetrahydrofuran (THF)[200]	☐	☐	___ . __
☐	411 Toluene[1.0]	☐	☐	___ . __
☐	421 1,1,1-Trichloroethane[1.0]	☐	☐	___ . __
☐	423 1,1,2-Trichloroethane[1.5]	☐	☐	___ . __
☐	425 Trichloroethylene[1.0]	☐	☐	___ . __
☐	428 Trichlorotrifluoroethane[3.0]	☐	☐	___ . __
☐	434 Vinyl Chloride	☐	☐	[not quantified] ___ . __
☐	437 Xylenes[2.0]	☐	☐	___ . __
☐	______	☐	☐	___ . __
☐	______	☐	☐	___ . __

Comments ______

Date Received and Sample No. ______

Date Reported ______

R.H. Laessig, PhD, Director
Wisconsin State Laboratory
Madison, Wisconsin 53706

050838- Volatile Organic Compounds (VOCS) in Small Community Wastewater Disposal Systems Using Soil Absorption