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INVESTIGATION OF TWO LARGE SCALE SUBSURFACE SOIL ABSORPTION SYSTEMS FOR WASTEWATER TREATMENT

by Anthony G. Hendricks

Introduction

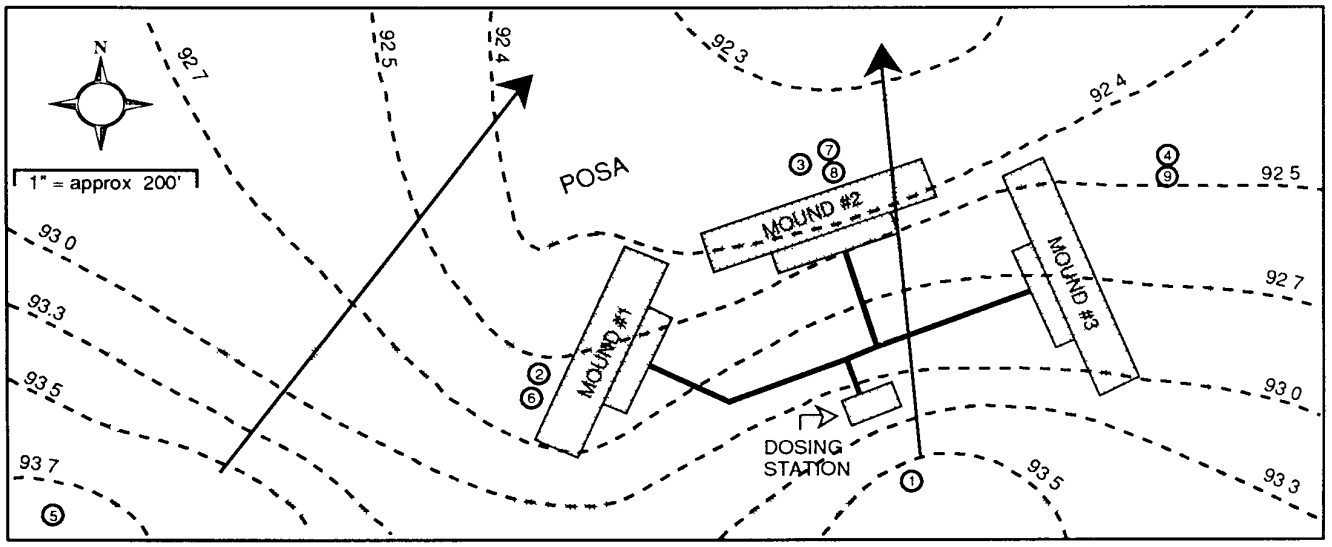
This investigation studied the impact on groundwater quality of two large scale subsurface soil absorption wastewater treatment systems. In Wisconsin, systems which have design flows greater than 8,000 gallons per day (gpd), must have a Wisconsin Pollution Discharge Elimination System (WPDES) permit from the Wisconsin Department of Natural Resources (DNR) for discharge to groundwater. Historically, criteria for evaluating subsurface soil absorption system suitability was based on the ability of the soils to assimilate the wastewater without ponding on the surface. In 1985, Chapter NR 140, Wis. Adm. Code, was promulgated to protect the groundwater resources of the state. NR 140 establishes standards for groundwater quality based on public health and welfare standards for drinking water. Wastewater discharges to groundwater must now meet the standards established in NR 140.

Currently about 150 of these large scale subsurface absorption systems exist in Wisconsin. This Findings summarizes an evaluation of the affect of two of these systems on groundwater quality. The Village of Wyeville (population 163; Monroe County) is served by a community septic tank/dosing chamber from which effluent is pumped to either of three mounds. The system has a design flow rate of 17,600 gpd and a current flow rate of 7,000 gpd. The Town of Scott Sanitary District #1 (population 200; Sheboygan County) is served by individual septic tanks which discharge into a central sewer system. The collected effluent is pumped to a dosing chamber equipped with an automatic syphon which controls the discharge to three absorption beds. The design flow rate is 29,500 gpd and the current flow rate is 12,500 gpd.

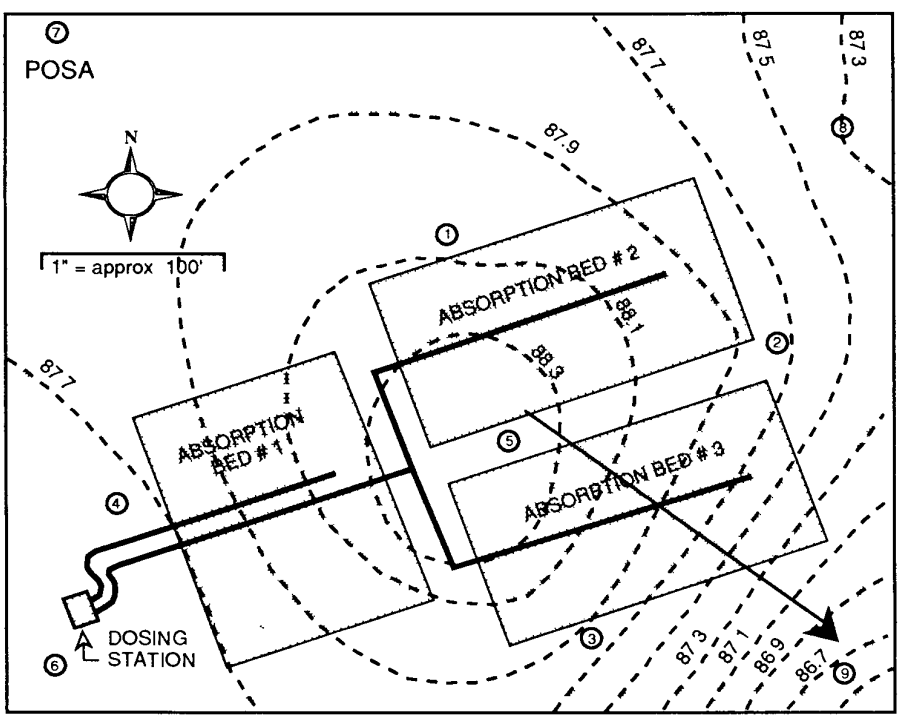
This study was based on the standards established in NR 140. Key terms in the Code are: Point of Standards Application (POSA) which is the specific location, depth, or distance from a facility at which the concentration of a substance in groundwater is measured to determine WPDES permit compliance; Enforcement Standard (ES) which is the standard established to protect public health or public welfare; Preventative Action Limit (PAL) which is the concentration of a substance, based on a percentage of the ES, that indicates WPDES permit compliance may be threatened; and Alternate Concentration Limit (ACL) which is a site-specific groundwater concentration of a substance, based on background levels, that replaces a PAL, an ES, or both, when an exemption is granted by the DNR.

Methods

From November 1986 through June 1988, groundwater was sampled on ten occasions at each study site. The samples were collected from wells established to monitor the quality of groundwater moving through each site. Grab samples of the septic tank effluent were also obtained at each site. The locations of the monitoring wells and the groundwater flow patterns are illustrated in Figure 1.



Village of Wyeville



Town of Scott

Monitoring wells
Ground water contours in feet (relative values)
General direction of ground water flow
Dosing Stations
POSA = Point of Standards Application

FIGURE 1. Location of monitoring wells, mounds/absorption beds and general groundwater flow patterns for the two study sites.

Evidence of effluent ponding above the absorption beds and mounds was noted. For each sample, the depth to groundwater was recorded and field data for pH, temperature, and specific conductance were obtained. Sampling was conducted in accordance with DNR groundwater sampling procedures. The samples were filtered in the field, cooled, and delivered to the State Laboratory of Hygiene, where the following analyses were conducted:

- 5-day Biochemical Oxygen Demand (BOD)
- Chlorides (Cl^-)
- Total Dissolved Solids (TDS)
- Total Suspended Solids (TSS)
- Ammonia-Nitrogen (NH_3-N)
- Nitrate+Nitrite-Nitrogen (NO_3^-+NO_2^--N)
- Total Kjeldahl-Nitrogen (TKN)

Results and Discussion

Investigation of these large scale soil absorption systems indicates that both systems are functioning hydraulically at the current loading rates, which are well below the design loading rates. Evidence of groundwater mounding beneath both sites was observed, although it was most pronounced at the Town of Scott site.

While these systems appear to be functioning adequately from a hydraulic standpoint, evaluation of the monitoring data at both sites indicates that the groundwater quality is negatively impacted by the operation of these systems. The most significant impacts on groundwater quality were elevated levels of Cl^-, TDS, and nitrogen compounds in monitoring wells downgradient of the discharge points. No significant impacts were observed for BOD, pH, or temperature.

The downgradient groundwater Cl^- concentrations were substantially higher than the background levels at both facilities. However, only one well (Town of Scott #4) exceeded the PAL for Cl^-. The groundwater monitoring for nitrogen compounds at both facilities indicates that exceedances of both the PAL and the ES are occurring downgradient of the facilities as a result of the effluent being discharged.

All downgradient wells at the Village of Wyeville site exceeded the PAL for TDS. An ACL for TDS, based on background concentrations, would result in exceedances occurring at only one well, located about 44 ft from one of the mounds. Since dissolved solids are not adsorbed readily to soil particles or attenuated by microbial activity, the elevated TDS concentration in the groundwater downgradient of the facilities appears to be a direct result of the effluent.

All but one of the wells at the Town of Scott site, including the background well, exceeded the PAL for TDS. This is likely due to the naturally higher TDS levels caused by the sandstone/limestone geology in the area. The downgradient TDS levels are further increased due to the effluent. If an ACL is calculated reflecting these high background concentrations, only the wells in close proximity to the absorption beds would have exceedances, while no exceedances would occur at wells located at the property boundary.

TABLE 1. Groundwater monitoring results (mean values), Village of Wyeville.

Well	GW Level (ft**)	Parameter (mg/L) Cl^-	$NO_3^-+NO_2^-$-N	TKN	NH_3	TDS
1*	91.3	1	<0.1	1.2	<0.1	45
2	91.6	75	20.5	5.4	5.0	332
3	92.4	78	28.7	8.0	7.3	326
4	91.2	61	30.7	2.5	2.3	322
5*	92.6	1	<0.1	0.3	<0.1	56
6	91.6	109	20.5	3.8	3.2	391
7	91.0	105	21.3	4.5	3.8	358
8	91.2	87	31.0	9.7	8.5	356
9	90.9	63	18.9	0.4	<0.1	288
PAL		125	2.0	(Bkgrd + 2.0)		250
ES		250	10.0	N.A	N.A.	500

* - Background Wells
** - Relative Values

TABLE 2. Groundwater monitoring results (mean values), Town of Scott

Well	GW Level (ft**)	Parameter (mg/L) Cl^-	$NO_3^-+NO_2^-$-N	TKN	NH_3	TDS
1	88.5	116	29.7	0.7	0.3	996
2	87.5	122	25.4	3.5	2.7	987
3	87.7	97	18.4	0.5	<0.1	775
4	87.6	129	35.9	2.4	1.8	1030
5	88.4	111	36.6	1.2	0.7	1031
6	87.4	55	15.7	0.4	<0.1	587
7*	86.8	21	1.5	0.3	<0.1	510
8	86.5	45	3.2	0.4	<0.1	491
9	85.9	11	4.3	0.5	<0.1	569
PAL		125	2.0	(Bkgrd + 2.0)		250
ES		250	10.0	N.A.	N.A.	500

* - Background Well
** - Relative Values

At the Village of Wyeville site, the PAL and the ES for $NO_3^-+NO_2^-$-N and the PAL for TKN are exceeded at all downgradient wells, and the PAL for NH_3-N is exceeded at four of the seven downgradient wells. These results indicate that most, but not all, of the organic-N and NH_3-N in the effluent is being nitrified to $NO_3^-+NO_2^-$N. $NO_3^-+NO_2^-$-N is highly soluble and not readily adsorbed to soil particles; thus it is detected at high levels downgradient of the facility. In addition, the detection of NH_3-N at the downgradient wells could be an indication of incomplete oxidation resulting from anaerobic conditions. These conditions could be the result of saturated soils caused by groundwater mounding beneath the absorption cells.

At the Town of Scott site, exceedances of the PAL and ES occurred for $NO_3^-+NO_2^-$-N at all downgradient wells, and PAL

exceedances for TKN and NH_3-N were detected at several downgradient wells. The causes of the exceedances are most likely the same as those described for the Village of Wyeville system.

Conclusions

The findings of the study indicate that:

- Neither system exhibited surface ponding at current loading rates. Subsurface mounding is occurring, but has not adversely affected the hydraulic performance of either system.

- The Village of Wyeville system exceeded the ES for NO_3^-+NO_2^--N and the PAL for TDS, conductivity, TKN, and NH_3-N. These exceedances were detected at the facility's POSA, which is the property boundary. The establishment of an ACL for TDS would reduce, but not eliminate, TDS exceedances.

- The Town of Scott system exceeded the ES for NO_3^-+NO_2^--N and TDS, and PAL for Cl^-, TKN, and NH_3-N. The POSA for this facility is the property boundary. Monitoring wells located at the POSA indicated exceedances of the ES for NO_3^-+NO_2^--N and the PAL for TKN and NO_3^-+NO_2^--N.

Therefore, we conclude that, although both facilities evaluated in this study have had adequate hydraulic performance, neither of these systems is meeting the groundwater quality standards in Chapter NR 140, Wis. Adm. Code, for the parameters monitored during this investigation.

Recommendations

In order to determine impacts on groundwater quality, a better understanding of how these systems function is needed. Modifications that can improve their performance should also be considered. We recommend the following:

- The data generated by this study should be used to develop pollutant transport models to predict the movement of contaminants through the groundwater.

- Criteria for improved design of these systems that will enable them to meet groundwater standards should be developed.

- Other technologies that could be used in conjunction with, or to replace, these systems should be evaluated as a means to achieve groundwater standards.

- Organic constituents that may exist in these wastewaters should be evaluated and their fate through the treatment process determined.

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