A Department of Ecology Report

Loon Lake Class II Inspection Ground Water, Permit No. ST 8019

Summary

A Class II inspection was conducted at the Loon Lake Wastewater Treatment Plant August 23-25, 1994. The inspection consisted of two parts: 1) an engineering evaluation of the effectiveness of treatment, and 2) an evaluation of the ground water monitoring program. This document describes the methods and findings of the ground water evaluation.

Treated wastewater at Loon Lake is land applied with a center pivot sprinkler to a 65-acre spray field. Ground water adjacent to the spray field is monitored by three wells. This inspection evaluated the adequacy of the monitoring network and ground water sampling procedures.

With the current monitoring network, it is not possible to verify the ground water flow direction and to assess the adequacy of well placement. The screened interval of two wells is appropriate; the screened interval of the third well needs to be verified. The wells do not meet current sealing requirements. Recommendations are made to address deficiencies. The most significant deficiency is that the ground water flow direction has not been defined.

The facility's sampling procedures were adequate for general chemistry parameters. However, the sampling program should be upgraded to include a written Sampling and Quality Assurance Plan, field quality assurance samples, and sampling equipment modifications to reduce the potential for sample contamination.

by Denis R. Erickson
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Recommendations

1. The ground water flow direction must be defined at the spray field. Only with an understanding of the ground water flow direction is it possible to evaluate the adequacy of the monitoring network. The ground water flow direction probably can be defined by using water level elevations from monitoring wells and vicinity private wells measured about the same time. Based on a consultant's well survey (Century West Engineering Corporation, 1985) a sufficient number of private wells may exist in the area to define the ground water flow direction. However, private wells should only be included in the water-level monitoring network if the well construction is known and the well is screened in the uppermost aquifer.

   The staff gage at the north end of Loon Lake and wellhead elevations should be surveyed to a common datum and recorded to 0.01 feet. Water levels in Loon Lake and wells should be measured quarterly for one year and water-table contour maps should be constructed for each quarter to determine if seasonal changes occur.

2. If the ground water flow direction can be defined with the existing private and monitoring wells, the monitoring network should be evaluated to determine if additional wells are needed. At least one well should be upgradient of the spray field to provide samples of the upgradient water quality. A sufficient number of wells, usually three or four, should be downgradient of the spray field to detect contamination. All new wells should meet the requirements of Minimum Standards for Construction and Maintenance of Wells (Chapter 173-160 WAC).

   If the ground water flow direction cannot be defined with the existing private and monitoring wells, additional monitoring wells should be installed to adequately depict the ground water flow direction.

3. The depth and construction of MW2 must be verified if the well is to be used in the monitoring network.

4. The facility should prepare and implement an approved Sampling and Quality Assurance Plan. The plan should describe sampling methods, decontamination procedures, field test equipment and calibration, test methods, and field quality assurance samples. The plan should be sufficiently detailed so that a person unfamiliar with the site could conduct the sampling consistent with previous sampling events.

5. Discharge of final effluent to the spray field should be metered or the existing estimation method verified periodically (e.g. every five years).

6. If turbidity recurs in well samples, the wells should be re-developed until the discharge is sediment free. This work should be done by a qualified well contractor.

7. Vadose zone monitoring could provide an early warning of excess contaminant loading. But, considering the current low nitrogen loading rates, the difficulty of designing and installing a vadose monitoring program, and the difficulty of interpreting results, vadose zone monitoring should be considered optional.

Introduction

A Class II inspection was conducted at the Loon Lake Wastewater Treatment Plant August 23-25, 1994. The inspection consisted of an engineering evaluation of the effectiveness of treatment and an assessment of the ground water monitoring program.

This document describes the methods and findings for the ground water monitoring program assessment. The assessment consisted of three parts:

1. Evaluation of the adequacy of the monitoring well network
2 Audit of ground water sampling procedures
3. Comparison of Ecology and facility split sample results

In addition, Ecology's Eastern Regional Office requested that Environmental Investigations and Laboratory Services (EILS) Program assess the need and suitability for vadose zone monitoring at the site.

The Ecology inspection team consisted of Lisa Olson, site inspector from the Eastern Regional Office; and Guy Hoyle-Dodson and Denis Erickson, EILS Program. The inspection team was assisted by Jean Russell and Keith Van Etten with the Loon Lake Sewer District.

Facility Description

Wastewater Application

The Loon Lake community is located in Stevens County about 35 miles north of Spokane, Washington (Figure 1). The treatment plant consists of an aerated lagoon, two storage ponds, and a land application spray field (Figure 2). The spray field is the focus for the ground water inspection. Wastewater is applied to land with a center-

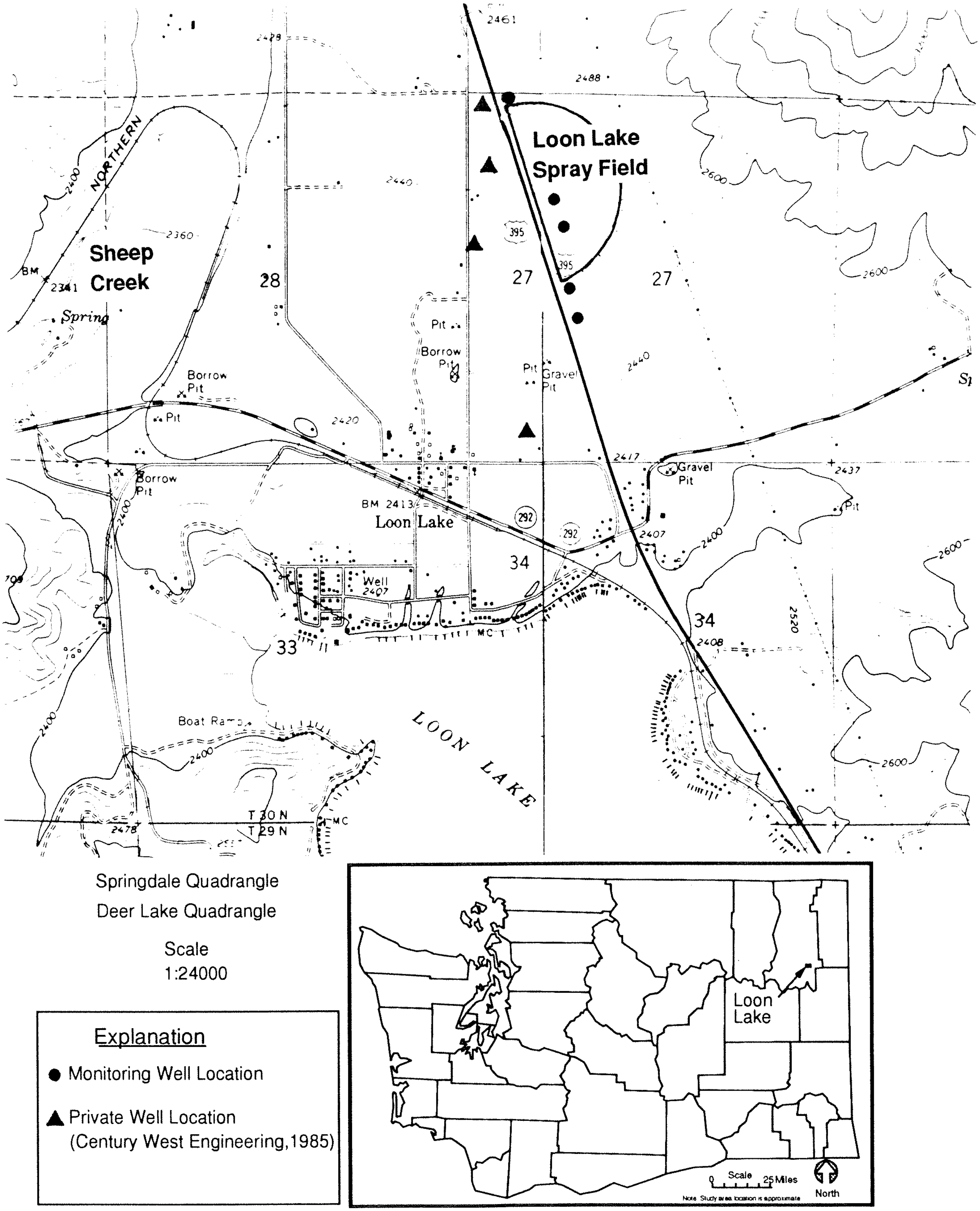

Figure 1. Location and Vicinity Map.

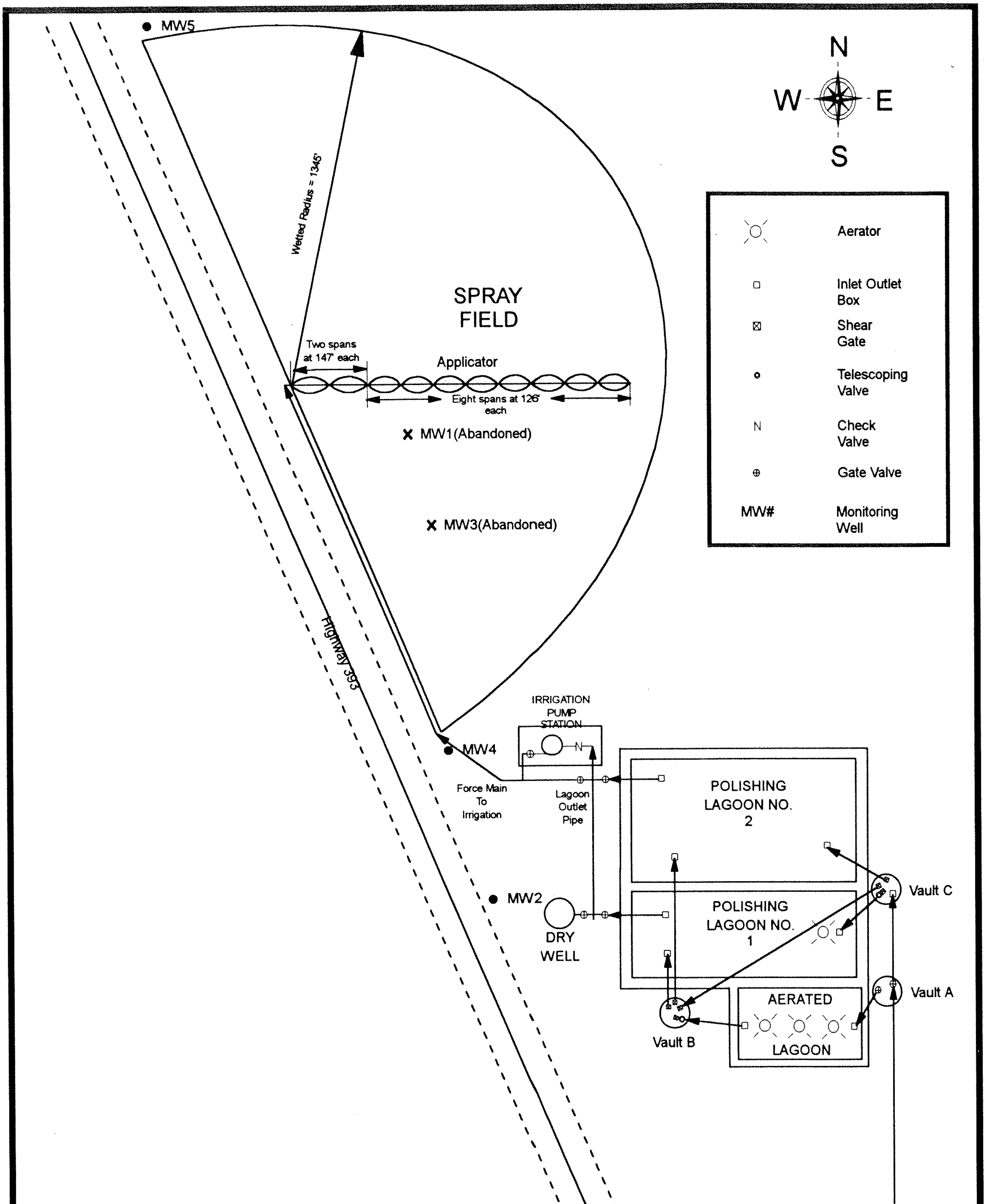

Figure 2 - Compliance Inspection, 1994
Loon Lake Sanitary Treatment Facility
Groundwater Monitoring & Plant Schematic

pivot sprinkler. The center pivot operates over a half circle that covers 65 acres. The wastewater application is subject to the requirements of Permit No. ST 8019. The permit specifies that the average amount of effluent discharged to the spray field not exceed 212,400 gallons per day over the irrigation season (a maximum of 210 days from April through October). The amount of wastewater applied to the spray field between April and October generally ranges from 189,000 to 220,000 gallons per day. Discharge to the spray field is determined based on the time that the pump motor runs.

Typically, the major concern with municipal land application systems is nitrate contamination of ground water. Based on facility monitoring results from December 1991 through August 1994, total nitrogen concentrations of the final effluent ranged from 5 to 40 mg/L with a mean of 19 mg/L (Water Quality Permit Life Cycle System, 1994). Facility estimates for the wastewater nitrogen application rate range from about 40 to 80 pounds/acre total nitrogen.

The primary crop in the spray field is alfalfa, which is managed and harvested by a local farmer. Since 1992 about 25 acres of barley have been rotated on the 65 acres to improve soil conditions for alfalfa production (Loon Lake Sewer District #4, 1992). Supplemental commercial fertilizers (including nitrogen) have been applied to the barley and alfalfa to stimulate production (Loon Lake Sewer District #4, 1992, 1993, and 1994).

Ground Water Monitoring Network

Ground water monitoring has been conducted at the facility since 1985. The ground water monitoring network consists of three wells (MW2, MW4, and MW5). The locations of the wells are shown in Figure 2. MW5 is intended to be an upgradient well, and MW2 and MW4 are intended to be downgradient wells. Two monitoring wells located within the land application area (MW1 and MW3), were decommissioned in 1986 at the request of Ecology.

Site Conditions

The following section describes the site hydrogeology, soils and climate.

Hydrogeology

The site hydrogeology is known from soil borings, well logs and test pits advanced by the facility (Century West Engineering, 1985 and 1986). Sand and gravel glacial deposits underlie the spray field. The deposits range in thickness from about 50 to

150 feet and overlie granitic bedrock. The deposits are shallowest (about 50 feet deep) beneath the eastern portion of the spray field. These deposits are saturated typically at a depth of 80 to 100 feet and represent the target aquifer for ground water monitoring. For this report the aquifer is designated as the sand and gravel aquifer.

The sand and gravel aquifer is not continuous beneath the site. It is only present beneath the western part of the spray field. Under the eastern part of the spray field the glacial deposits are less than 80 to 100 feet thick and, therefore, are not deep enough to be saturated. In this area granitic bedrock underlies the glacial deposits. Because granite transmits water poorly it is not considered part of the target aquifer.

The sand and gravel aquifer is primarily unconfined. However, a fine-grained, silt and clay layer was reported at a depth interval of 85 to 95 feet in one soil boring (B-2). The aquifer is recharged by surface water and by infiltration of precipitation and irrigation. The ground water flow direction was assumed to be southerly (Washington State Department of Ecology, 1991) or toward the southwest (Century West Engineering, 1985). However, with the existing well configuration, the ground water flow direction cannot be verified (See Results and Discussion Section for additional detail).

The hydraulic conductivity (the ease with which water moves through the deposits) of the sand and gravel aquifer is probably high. Century West Engineering (1985) estimated the hydraulic conductivity to be about 500 feet/day based on visual descriptions of the drill cuttings. Using specific capacity data from well logs for four vicinity wells, I estimated the hydraulic conductivity of the uppermost aquifer to range from about 40 to 260 feet per day (See Methods Section below).

Soils

The predominate soil type is the Bonner silt loam (Donaldson *et al*, 1982). This very deep, well-drained soil is on terraces and is formed over glacial outwash and mantled with volcanic ash and loess. The water capacity is moderate, and the rooting depth is 60 inches or more. The permeability is moderately rapid through the subsoil and very rapid through the substratum.

Climate

Climate data for the Loon Lake is summarized in Table 1. The average annual precipitation is about 22 inches at Deer Park, located about 10 miles southeast of Loon Lake (Phillips, 1965). The data is based on 30 years of records from 1931 to 1960. Annual pan evaporation at Spokane between 1965 and 1993 averaged about 48 inches (Atmospheric Sciences Center, 1994). About 22 inches of wastewater was applied at the spray field in 1993 (Washington State Department of Ecology, 1994). Using a simple water balance (and assuming the consumptive use of alfalfa was 0.76 times the pan evaporation) the annual recharge to ground water beneath the spray field is about 7 inches. Recharge occurs primarily from October through March.

Table 1. Loon Lake Climate Summary. (Units in inches.)

Month	Precipitation (Deer Park)	Pan Evaporation (Spokane 1965-93)	Alfalfa Consumptive Use	Loon Lake 1993 Irrigation	Recharge Estimate
January	2.90	0.00	0.00	0.00	2.90
February	2.11	0.00	0.00	0.00	2.11
March	1.86	0.00	0.00	0.00	1.86
April	1.50	4.66	3.54	0.75	-1.29
May	1.40	7.32	5.56	3.32	-0.85
June	1.60	8.58	6.52	3.39	-1.53
July	0.50	11.13	8.46	3.72	-4.24
August	0.50	10.23	7.77	3.69	-3.59
Sept	1.20	6.39	4.86	3.75	0.09
October	2.30	0.00	0.00	3.69	5.99
November	2.60	0.00	0.00	0.00	2.60
December	3.24	0.00	0.00	0.00	3.24
Annual Total=	21.71	48.31	36.72	22.31	7.30

Note: Alfalfa Consumptive Use= 0.76 x Pan Evaporation (SCS, 1991).
Preciptation Source: Phillips, 1965
Pan Evaporation Source: Atmospheric Sciences Center, 1994.
Irrigation Source: Washington State Department of Ecology, 1994.

Methods

Monitoring Network Adequacy

To evaluate the adequacy of the ground water monitoring network, I considered the well placement (plan view), depth of screened interval, and monitoring well construction. These factors are discussed below.

Well Placement

Guidelines to determine well placement include:

- The network defines the ground water flow direction
- Upgradient well(s) provide samples representative of ground water quality unaffected by the facility
- Downgradient wells of the facility are located where there is a high likelihood they would detect contamination if it occurred

Depth of Screened Interval

Wells must be screened in the uppermost aquifer and along potential contaminant pathways. Because of the low recharge rate at Loon Lake, the vertical downward component of ground water flow will be small, and dissolved contaminants entering ground water will move predominately in a horizontal direction. Therefore, to be properly situated, monitoring wells should be screened near the top of the uppermost aquifer.

Well Construction

Wells should meet the Minimum Requirements for Construction and Maintenance of Wells, Chapter 173-160 WAC.

Hydraulic Conductivity

I estimated hydraulic conductivity from specific capacity data for four vicinity wells. Specific capacity is the ratio of well discharge rate to drawdown. I used a method described by Bradbury and Rothschild (1985). The method is an iterative solution to the Theis equation with modifications for partial penetration. Specific capacity and well construction information were available for four private well logs from Century West Engineering (1985).

Facility and Ecology Split Samples

Split samples were obtained at all three wells on August 24, 1994 by alternately filling portions of both the facility's and Ecology's sample bottles. The wells were purged the previous day. The facility purged and sampled using PVC bailers. Bottles were filled in one-third increments. Ecology sample bottles were furnished by Ecology's Manchester Environmental Laboratory (MEL). Samples were stored on ice in coolers. To meet holding time requirements nitrite and orthophosphate samples were sent to MEL via air freight the same day samples were obtained . Other samples were transported to Olympia on August 25 with the EILS sampling team and from Olympia to MEL by Ecology courier. Chain-of-custody was maintained for all samples. The target parameters, test methods and quantitation limits for Ecology samples are listed in Table 2.

Table 2. Parameters, Test Methods, and Practical Quantitation Limits for Loon Lake Compliance Inspection – Ground Water.

Parameter	Test Method EPA Methods/Standard Methods	Quantitation Limit
pH (Field)	Orion Model 250A	0.1 Std Units
Temperature	Orion Model 250A	0.1°C
Specific Conductance (Lab)	EPA 120.1/2510	10 micromhos/cm
Ammonia-N	EPA 350.1/4500 NH3 D	0.01 mg/L
Nitrate+Nitrite-N	EPA 353.2/4500 NO3 F	0.01 mg/L
Nitrite-N	EPA 353.2/4500 NO3 B	0.01 mg/L
Ortho-Phosphate-P	EPA 365.3/4500-P F	0.01 mg/L
Total Persulfate Nitrogen	EPA 353.2 (Modified)/4500	0.01 mg/L
Chloride	EPA 330.0/4110B	0.1 mg/L
Total Organic Carbon	EPA 415.1/5310B	0.1 mg/L
Metals:		
Arsenic, Total	Graphite Furnace AA, EP1-206.2	1.5 ug/L
Cadmium, Dissolved	EP1-213.2	3.0 ug/L
Chromium, Dissolved	ICAP, EP1-200.7	5.0 ug/L
Copper, Total	ICAP, EP1-200.7	3.0 ug/L
Lead, Dissolved	EP1-239.2	20 ug/L
Mercury, Total	Graphite Furnace AA, EP1-245.1	0.05 ug/L
Nickel, Total	ICAP, EP1-200.7	10 ug/L
Zinc, Total	ICAP, EP1-200.7	4.0 ug/L

ICAP=Inductively Coupled Argon Plasma.

AA=Atomic Absorption.

References:

American Public Health Association, 1985. Standard Methods for the Examination of Water and Wastewater, 16th Edition, 1268 pgs.

US Environmental Protection Agency, 1983. Methods for Chemical Analysis of Water and and Wastes, EPA-600/4-79-020, Revised March 1983.

Quality Assurance of Ecology Samples

Laboratory quality assurance samples for nutrients consisted of method blanks, spikes, laboratory control samples and duplicates. All Ecology nutrient data are qualified with a "J" because the refrigeration unit failed over a weekend and sample temperatures were not maintained at 4°C at least part of the weekend. The extent that sample results are affected is unknown.

Quality assurance samples for metals included calibration standards in addition to quality assurance samples listed above for nutrients. All data are considered acceptable for use except zinc. Zinc was detected in the method blank at 13 ug/L. Concentrations less than 10 times this value are qualified with a "B".

Ecology field quality assurance for ground water samples consisted of one blind split sample. The split sample was obtained from well MW4 and was identical to the MW4 sample except that it was given a different sample identifier. The split sample provides an estimate of analytical precision. Relative percent differences (RPDs) were calculated for all detected parameters. An RPD is the ratio of the difference of duplicate results and their mean expressed as a percentage. For this study, RPDs were less than ten percent with the exception of mercury which was 16 percent.

Results and Discussion

Monitoring Network Adequacy

The evaluation of the ground water monitoring network considered well placement, depth of screened interval, and well construction. Each is discussed below.

Well Placement

The ground water flow direction must be known to evaluate the adequacy of the well placement. It is not possible with the existing monitoring well configuration to verify the ground water flow direction. Wells are located along a single line which does not allow for triangulation of water-level elevations. Initially, when the monitoring wells were installed, the ground water flow direction was assumed to be to the south or southwest. In my opinion, the ground water flow beneath the site may have a westerly component. Information that supports this view are:

- The water level in Loon Lake (2,381 feet above Mean Sea Level) appears to be about 30 feet higher than the ground water level at the site.

- Water level elevations in MW2 are about one foot higher than in MW4.

- Sheep Creek, located about one mile west of the spray field (Figure 1), is probably the regional discharge area for the sand and gravel aquifer.

If there is a westerly component to ground water flow, MW2 and MW4 may not be located downgradient of the spray field. Also, MW5 is located so close to the spray field that an accurate ground water flow direction must be determined to ensure that MW5 is unaffected by the facility.

Depth of Screened Interval

The screened interval for MW5 is adequate; the well is screened over the upper portion of the aquifer. MW4 is adequate most of the time but is occasionally dry when water levels are low. The well should have been screened deeper to account for water-level fluctuations.

The depth of the screened interval for MW2 must be verified. The as-built drawing shows a screened interval of 88 to 95 feet, but Table 1 in Century West Engineering (1986) reports a well depth of 85.5 feet. The log for boring B-2 shows a silt layer at a depth interval of 85 to 95 feet (Century West Engineering, 1985). If the as-built drawing for MW2 is correct, MW2 is screened over the silt layer which is not the target layer for monitoring.

Well Construction

Well construction is summarized in Table 3. The well depths should be considered approximate because they were measured from as-built drawings without depth labels. All wells were constructed using 2-inch PVC and 20-slot well screens. Each well has a locking outer protective steel casing. PVC casing is compatible with the parameters of interest.

The wells do not meet current sealing requirements for Resource Protection Wells (Chapter 173-160-550 WAC). Based on these requirements, the annular space along most of the well length must be sealed with bentonite or a bentonite/cement mixture. In 1985-86, when the wells were installed, the minimum surface seal requirement was 18 feet. The wells do not meet this minimum surface seal requirement.

Table 3. Loon Lake Monitoring Well Construction Summary (units=feet).

Well ID	Total Depth	Casing	Cement Grout Seal Interval	Bentonite Seal Interval	Screened Interval
MW2	95	2-Inch PVC	0-15	15-16.5	88-95
MW4	98.3	2-Inch PVC	0-15	15-17	88-98
MW5	112	2-Inch PVC	0-10.5	10.5-12	102-112

Sample turbidity and sediment was reported to be a problem occasionally (Van Etten, 1994). Sediment was not observed in samples during the site visit.

Two wells, MW1 and MW3, were installed within the spray field and were decommissioned at the request of Ecology. Details of the decommissioning were not available; therefore, I cannot evaluate whether it met Washington State standards.

Facility Sampling Procedures

Facility sampling procedures were observed when sample splits were obtained. Water samples are obtained from wells using PVC bailers and reusable polyethylene line. About one well volume was purged from wells having sufficient volume, otherwise they were purged dry. Samples were collected the following day.

The observed sampling procedures were adequate, but modifications are suggested, especially when sampling for trace metals.

1. Bailer line should not be allowed to touch the ground. This is especially important when sampling for low concentrations of metals. The bailer line should be attached to a reel or equivalent. A downrigger (commonly used for fishing) attached to a tripod and equipped with stainless steel cable is particularly useful. A monofilament line can be used to attach the cable to the bailer. This makes sampling easier and decreases the possibility of contaminating samples.

2. Current standard practice is to purge a minimum of three well volumes prior to sampling. Well volumes should be calculated based on the well diameter and the height of water in the well. Well volumes should be calculated for each sampling event. We recommend that field parameters (pH, temperature, and specific conductance) be measured and recorded at the wellhead for each well volume. Sampling should occur only after the field parameters are stable.

3. Whenever possible, samples should be obtained immediately after purging. The observed procedure was to sample the day after purging.

4. For general chemistry parameters, bailer decontamination should consist of tap water wash with non-phosphate detergent, a tap water rinse and a de-ionized water rinse. For metals, decontamination should also include a 10% solution nitric acid rinse followed by de-ionized water rinses.

5. Samples for metals analysis should be placed in a specially cleaned bottle at the wellhead rather than in a common bottle. The common bottle is a potential source of metals contamination.

The facility does not have a written Sampling and Analysis Plan. Sampling and Analysis Plans describe decontamination procedures, sample methods, test methods, and field quality assurance samples. The plans are especially useful because they result in consistent sampling procedures even if personnel change. The plan should be sufficiently detailed so that a sampler unfamiliar with the site can obtain samples consistently with previous sampling events.

Water Quality Results

The water quality results for Ecology and facility split samples from wells are shown in Table 4. In general, Ecology and facility results are similar. One minor difference is ammonia-N. The facility reported ammonia-N concentrations ranging from 0.13 to 0.33 mg/L but Ecology did not detect ammonia-N (less than 0.01 mg/L) in any of the samples. This difference in ammonia-N results is not considered significant to the monitoring program.

Facility chloride concentrations (4 mg/L) were about double the Ecology results (1.6 to 2.6 mg/L) but the concentrations are low and these differences also are not considered significant. The facility did not test for metals this sampling event so metals results cannot be compared.

Mercury was detected in all well samples at concentrations ranging from 0.12 to 0.20 ug/L. The presence of mercury in ground water is rare. Mercury does not migrate in ground because it has a low solubility in water and readily sorbs to soil particles (US EPA, 1979). The uniform concentrations suggest laboratory or sampling contamination. The laboratory did not detect mercury in method blanks; thus, it seems likely that the mercury is present due to sample contamination.

Table 4. Loon Lake Class II, Ground Water Inpection, Water Quality Results.

Analyte	Ecology MW5 34-8092	Loon Lake MW5 8/5/95	Ecology MW4 34-8093	Loon Lake MW4 8/5/95	Ecology MW2 34-8094	Loon Lake MW2 8/5/95	Ecology MW4 Dup 34-8096	Ecology RPD(%) (-8093 and -8096)
Specific Conductance (micromhos/cm @ 25°C)	400	NT	278	NT	208	NT	277	0.4
Conventionals (mg/L)								
Total Organic Carbon	1.2	NT	2.2	NT	1 U	NT	2.3	4.4
Ammonia-N	0.01 U	0.33	0.01 U	0.13	0.01 U	0.13	0.036	--
Nitrite-N	0.01 U	0.005	0.01 U	0.004	0.01 U	0.003	0.01 U	--
Nitrate+Nitrite-N	0.04 J	0.05 U	0.64 J	0.3	0.82 J	0.2	0.66 J	3.1
Orthophosphate-P	0.024	0.04	0.042	0.09	0.022	0.07	0.043	2.4
Total Persulfate N	0.57 J	NT	0.70 J	NT	0.85 J	NT	0.74 J	5.6
Chloride	1.6	4	2.0	4	2.6	4	1.9	5.1
Metals (ug/L)								
Arsenic, Total	1.7 P	NT	1.5 U	NT	1.5 U	NT	1.5 U	--
Mercury, Total	0.16 P	NT	0.17 P	NT	0.12 P	NT	0.20 P	16.2
Cadmium, Dissolved	3 U	NT	3 U	NT	3 U	NT	3 U	--
Chromium, Dissolved	5 U	NT	5 U	NT	5 U	NT	5 U	--
Copper, Total	14 P	NT	14 P	NT	11 P	NT	13 P	7.4
Lead, Dissolved	20 U	NT	20 U	NT	23 P	NT	20 U	--
Nickel, Total	10 U	NT	10 U	NT	10 U	NT	10 U	--
Zinc, Total	54.2 B	NT	75.3 B	NT	41.2 B	NT	69.1 B	8.6

U= Analyte was not detected at or above the reported result.

UJ= Analyte was not detected at or above the reported estimated result.

P= Analyte was detected above the instrument detection limit but below the established minimum quantitation limit.

J= Analyte was positively identified; the numeral result is an estimate.

B= Analyte was found in method blank indicating the sample may have been contaminated.

RPD= Ratio of the difference and mean of split sample results expressed as a percentage.

NT= Not tested.

Site Suitability for Vadose Zone Monitoring

Vadose Zone Monitoring

The vadose zone is the unsaturated zone between the ground surface and the water table. At Loon Lake the thickness of the vadose zone is about 80 to 100 feet. Usually vadose zone monitoring consists either of 1) samples of pore water quality and/or 2) changes of moisture contents in soil with depth or time. The advantage of vadose zone monitoring is that it can provide an early warning of contaminant loading before contaminants reach ground water. Thus, waste application rates can be adjusted in response to vadose monitoring results. Because the movement of water and contaminants through variably saturated soil is complex and dynamic, a disadvantage of vadose zone monitoring is that it requires considerable experience and expertise, especially in the interpretation of results. The suitability of a site for vadose monitoring depends on a number of factors. Three of the most important are:

- Soil conditions
- Contaminant loading
- Travel time from the surface to ground water

These factors are discussed below.

Soil Characteristics

The cobbly soil at Loon Lake limits the types of vadose monitoring equipment that can be installed at the site. Caving would make it difficult to install equipment that require a trench below the root zone (wick and brick lysimeters). Also cobbly soils would make it difficult to drive equipment, such as barrel lysimeters, into place. The high permeability of the soil could translate to rapidly moving wetting fronts which would require carefully timed sampling.

Contaminant Loading

Vadose zone monitoring is especially useful at sites where contaminant loading is high. The nitrogen loading at Loon Lake is not high. Loon Lake Sewer District estimates the annual nitrogen loading at the spray field to be about 40 to 80 pounds per acre. This is based on an effluent nitrogen concentration of 39 mg/L, 50% volatilization of ammonia, and 15% denitrification of total nitrogen. The maximum permitted nitrogen loading -- assuming no losses to volatilization and denitrification and an average total nitrogen concentration of 19 mg/L (Water Quality Permit Life Cycle System, 1994) -- is 109 pounds per acre year. The potential nitrogen uptake for alfalfa ranges from 200 to 480 pounds per acre per year (Metcalf and Eddy, 1991).

Travel Time to Ground Water

In general, the longer the travel time to ground water, the more useful vadose zone monitoring is. The travel time from the Loon Lake spray field to the water table is unknown. The movement of water and contaminants through unsaturated soil is a complex process that depends on climatic factors, soil properties, application rates and contaminant mobility. The existing data is inadequate to estimate reliable travel times to ground water. Intuitively however, because the depth to water is 80 to 100 feet and application rates are low, vadose monitoring probably would be a useful tool for providing an early warning of excess contaminant loading.

Conclusions

1. The ground water flow direction at the spray field cannot be defined with the existing monitoring well configuration. The ground water flow direction must be known in order to evaluate the adequacy of well placement.

2. The monitoring wells do not meet current sealing standards for monitoring wells. Any new wells installed at the site should meet existing requirements.

3. The observed sampling procedures were adequate; however, modifications are needed to ensure that samples are not inadvertently contaminated, especially trace metals.

4. Vadose zone monitoring could provide an early warning of excess contaminant loading. But considering the current low nitrogen loading rates, the difficulty of designing and installing a vadose monitoring program, and the difficulty of interpreting results, vadose zone monitoring should not be a permit requirement.

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