FACILITIES PLAN ADDENDUM REPORT
LAKE VIEW TOWNSHIP, MINNESOTA

EVALUATION OF LAND APPLICATION BY SPRAY IRRIGATION

JUNE 29, 1984

June 29, 1984

Mr. Dale Hagen, Chairman
and Members of the
Lake View Township Board
P.O. Box 69
Detroit Lakes, MN 56501

In accordance with our contract for engineering services, we have completed the enclosed "Facilities Plan Addendum Report" which supplements the "Wastewater Treatment Facilities Plan Summary Report" presented in August, 1981.

This report further evaluates the central stabilization ponds with spray irrigation system, (Alternative 2) which was presented in the facilities plan. Included in this report is a soil investigation study of the pond and spray irrigaiton sites, an evaluation of the allowed application rate, and an updated construction cost estimate.

We await the opportunity to review this report with you and finalize your Step 1 facility planning activities.

Respectfully submitted,

RIEKE CARROLL MULLER ASSOCIATES, INC.

Michael A. Zagar

Michael A. Zagar, P.E.
Project Manager

Gary P. Dorn

Gary P. Dorn, P.E.
Project Engineer

MAZ:mt

Enc.

les, inc.
ts
rs
veyors

st street south
fice box 130
s, minnesota 55343
5-6901

FACILITIES PLAN ADDENDUM REPORT

LAKE VIEW TOWNSHIP

BECKER COUNTY, MINNESOTA

JUNE 1984

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly Registered Professional Engineer under the laws of the State of Minnesota.

Gary P. Dorn

Gary P. Dorn, P.E. Minnesota Reg. No. 16502

RIEKE CARROLL MULLER ASSOCIATES INC.

FACILITIES PLAN ADDENDUM REPORT
FOR
LAKE VIEW TOWNSHIP, MINNESOTA

TABLE OF CONTENTS

LIST OF TABLES

I. INTRODUCTION

On August 7, 1981 a "Wastewater Treatment Facilities Plan Summary Report" was submitted to the Lake View Township Board and a public hearing was held to present the findings on August 22, 1981. Following the hearing, the Lake View Township Board passed a resolution accepting Alternative 1, construction of cluster systems with individual septic tanks and community drainfields, as the recommended alternative. The facilities plan was then submitted to the Minnesota Pollution Control Agency (MPCA) for review.

Following a lengthy review and several meetings with MPCA, the Lake View Township Board decided to pursue the concept of a centralized stabilization pond with spray irrigation (Alternative 2) as the recommended alternative because of the following reasons; 1) the high cost of conducting detailed soils and groundwater tests on the cluster drainfield sites, 2) the elimination of grant money for alternative collection systems, thereby increasing the local costs and 3) the difficulty in finding approvable drainfield sites without going through condemnation.

This addendum to the facilities plan further evaluates the stabilization pond with spray irrigation alternative and provides an updated cost estimate for the recommended alternative.

Additional soils investigations were conducted at the two cluster treatment sites and at the spray irrigation site prior to completing this report, and are appended to the back.

II. DESCRIPTION OF RECOMMENDED ALTERNATIVE

A. General

As described in the facilities plan summary report, this alternative consists of a conventional collection system conveying wastewater by way of lift stations and forcemain to a central treatment facility, (stabilization ponds w/spray irrigation). Two areas around Lake Sallie would be served by cluster treatment systems. For a proposed layout of the alternative, see Figure 1. Table 1 presents preliminary design data for the recommended alternative.

B. Stabilization Pond

The stabilization pond facility will consist of two primary cells of 13 acres each and one secondary cell of 13 acres. Control structures will be designed to permit bypassing any cell, if the other cell must be taken out of service for emergency repairs, maintenance, or sludge removal.

Due to the sandy soils in the Lake View Township area, an artificial liner will be used in the ponds to minimize leakage. On the side slope of the dikes, the earth would be riprapped to prevent erosion. The tops and outer side slopes of the dikes would be seeded with a suitable grass cover to prevent erosion.

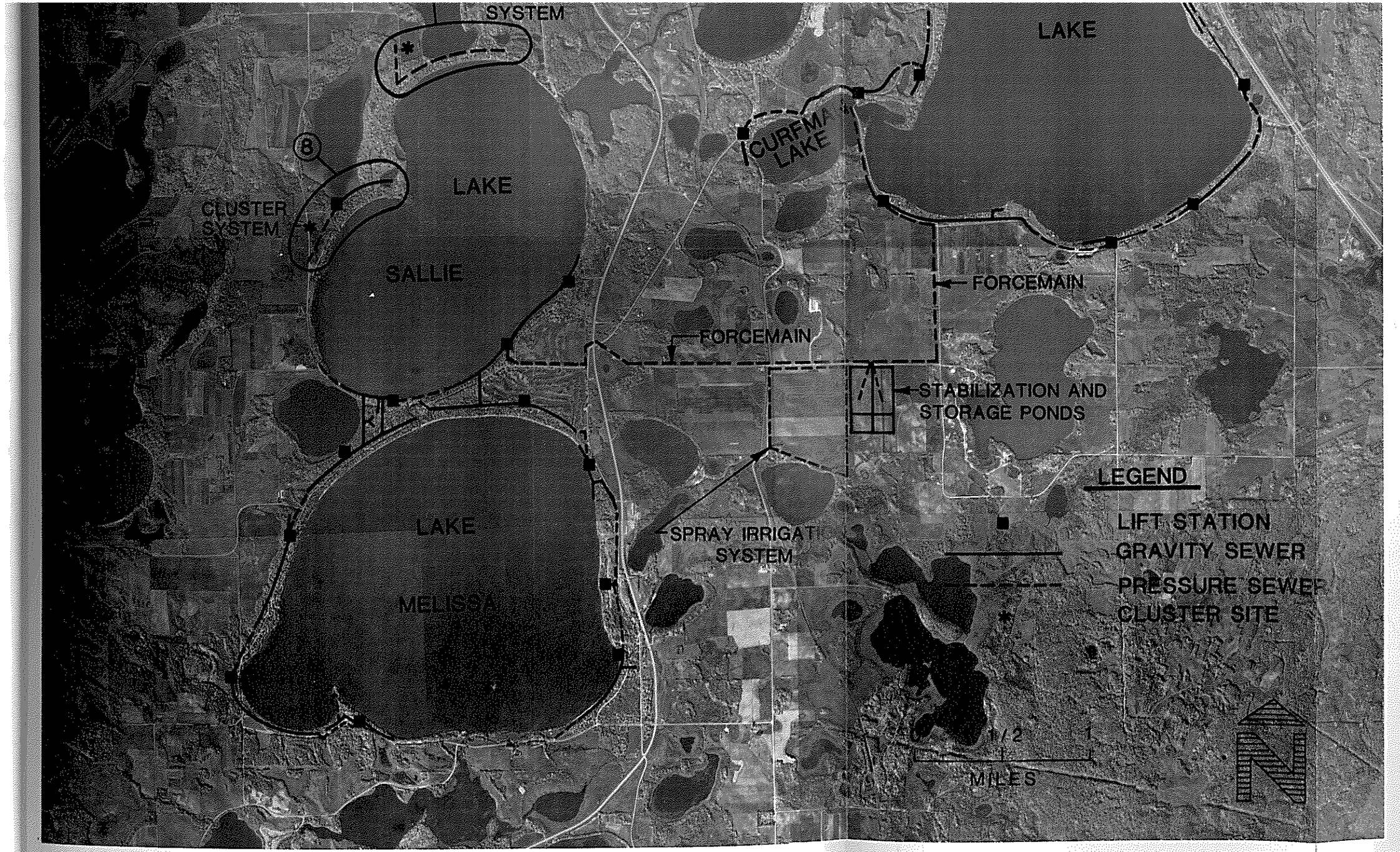

SYSTEM
LAKE
8
CLUSTER SYSTEM
LAKE
SALLIE
CURFM/ LAKE
FORCEMAIN
FORCEMAIN
STABILIZATION AND STORAGE PONDS
LAKE
MELISSA
SPRAY IRRIGAT SYSTEM
LEGEND
LIFT STATION
GRAVITY SEWER
PRESSURE SEWER
CLUSTER SITE
0
1/2
1
MILES
N

Table 1. Preliminary design data for recommended alternative

Basis of Design	
Design year	2010
Design service population	3,550
Summertime wastewater flow, gpd	366,000
Collection System	
Gravity	
Pipe material	Polyvinyl chloride
Pipe diameter, inches	8
Total sewer length, ft	58,400
Number of lift stations	20
Diameter of forcemain, inches	4
Total forcemain length, ft	35,600
Cluster Systems	
Number of septic tank/drainfield systems	2
Number of lift stations	2
Length of 4" forcemain, ft	6,200
Length of 4" gravity sewer, ft	4,300

Table 1. Preliminary design data for recommended alternative (continued)

Stabilization Ponds	
Number of cells	3
Total storage capacity, days	240
Total storage capacity, gallons	57,600,000
Total water surface area at mid-depth, acres	44.2
Water surface area, each cell, acres	14.73
Maximum depth, ft	6
Minimum operation depth, ft	2
Freeboard, ft	3
Width of top of dikes, ft	10
Slope of dikes (interior)	3:1
Sludge management	Storage in bottom 2 ft
Spray Irrigation	
Pumping Station	
Number of pumps	2
Capacity, gpm	800
TDH, ft	200
Chlorinator capacity, lb/day	50
Irrigation rigs	
Type	Center Pivot
Number	1
Length, ft	1,300
Spray nozzle pressure, psi	30-40
Typical application rate, inches/wk	1.17
Land application	
Total area irrigated, acres	168
Average annual application, inches	21
Principal crop	Corn

Flow would normally enter the primary cell and be discharged into the center of the cell through the inlet structure. Wastewater from the primary cell would be discharged to the secondary cell.

The pond area will be enclosed by a field fence to discourage trespassing and to prevent animals from entering. Warning signs will be provided along the fence to advise against trespassing. A tractor with mower attachment will be provided for mowing grass. The tractor and other maintenance equipment would be housed in a small shed.

Monitoring wells will be provided at the periphery of the pond facility, as well as the spray irrigation area. Periodically, in accordance with state requirements, these wells will be sampled and analyzed to detect any possible changes in groundwater quality which could be attributable to the ponds, i.e. a leak. In the event this should occur, early detection enables a rapid response by the City to dewater, inspect, and repair each pond cell as necessary.

No laboratory facilities will be provided. Wastewater and well testing would be done by an independent laboratory.

C. Spray Irrigation System

Wastewater effluents can be applied to crops by surface techniques, such as ridge and furrow and surface flooding, and by sprinkler systems. Sprinkler systems have the following advantages: (1) less susceptible to topographic constraints; (2) well suited to soils of varying permeability; (3) simulates rainfall, i.e. application rate is flexible; (4) runoff control is unnecessary; (5) adaptable for most crops without special site

preparation; and (6) lower operation and maintenance costs, with little operator attention required. Of the various sprinkler systems available, center pivot units have been selected because they are adaptable to slopes as steep as 15-20 percent and are highly automated, which is desirable to the farmer.

Various types of spray nozzles are available. Spray nozzles which minimize aerosol transmission while minimizing soil erosion are desirable. Low pressure (30 to 40 psi nozzle pressure) spray nozzles appear to be the most appropriate. These nozzles are compatible with different soils and crops. Water droplets are fairly large, minimizing aerosol transmission without posing a significant erosion or soil compaction problem. Nozzles will be oriented downward and application will be limited to days when wind velocity is low, which will minimize aerosol transmission.

Analysis of the soils data, available land, crops now grown by farmers, and climatic data have been utilized to determine a wastewater application rate. The water balance approach has been utilized to determine allowable wastewater application rates. The EPA Design Manual was consulted initially. The Manual uses a water balance approach considering precipitation, evapotranspiration, percolation and runoff. However, insufficient information is provided to utilize the water balance equation effectively. Therefore, a more comprehensive water balance approach has been used, based on the "Irrigation Guide for Minnesota", published by the Soil Conservation Service.

The SCS approach considers many factors affecting irrigation, such as available water holding capacity of a soil, soil depth and crop rooting depth, water intake rate of a soil, consumptive water use by crops, effective rainfall, carryover moisture, irrigation

efficiency, and application rate. The following is a brief description of the method used to calculate an allowable application rate.

Consumptive water use by the crop, i.e. evapotranspiration, and gross average rainfall are tabulated by month for the crop growing season. During a typical rainfall there will be some loss of water via runoff and percolation into the groundwater table below the crop rooting zone. This water is unavailable to the crop and is a function of rainfall intensity, volume of previous rainfalls, and volume of previous irrigation applications. The rainfall which remains available to crop roots in the soil is called net rainfall. Net rainfall for the site has been calculated using the net to gross rainfall relationships extracted from the Minnesota Irrigation Guide. The net irrigation requirement is computed as follows:

Net irrigation requirement = Consumptive use - net rainfall - carryover moisture

Carryover moisture is the moisture stored in the soil within root zone depths before the crop is planted. Net irrigation requirement must be adjusted for the fact that spray irrigation also experiences water losses, such as evaporation and percolation.

Table 2 illustrates monthly moisture balances for two sets of climatological conditions, a normal year which produces approximately 27.4 inches of precipitation, and the wettest year in ten years, which is calculated to produce approximately 33 inches of rainfall. Based upon this table, a gross application of 21 inches of wastewater could be applied to a corn crop during a normal growing season, but this would be reduced to 17.5 inches during a wet year. Assuming an application period of 18 weeks per year, the application rate would be 1.17 inches per week.

Table 2. Monthly moisture balance for spray irrigation, Lake View Township, Minnesota

Month	Total Rainfall[1] (inches) Normal Year	Total Rainfall[1] (inches) Wettest in 10 Years	Effective Rainfall (Inches) Normal Year[2]	Effective Rainfall (Inches) Wettest in 10 Years[3]	Consumptive Use[2] Field Corn (Inches)	Net Irrigation[4] (Inches) Normal Year	Net Irrigation[4] (Inches) Wettest in 10 Years	Gross Irrigation[5] (Inches) Normal Year	Gross Irrigation[5] (Inches) Wettest in 10 Years
January	0.80	0.96	—	—	—	—	—	—	—
February	0.58	0.66	—	—	—	—	—	—	—
March	1.28	1.55	—	—	—	—	—	—	—
April	2.74	3.30	—	—	—	—	—	—	—
May	3.39	4.09	0.81	1.39	1.46	0	0	0	0
June	4.65	5.61	2.49	3.01	4.09	1.15	0.05	1.53	0.07
July	3.91	4.72	2.37	2.85	7.69	5.32	4.84	7.09	6.45
August	3.86	4.65	2.38	2.86	7.65	5.27	4.79	7.03	6.39
September	2.52	3.04	1.07	1.30	4.22	3.15	2.92	4.20	3.89
October	1.68	2.01	0.50	0.60	1.24	0.74	0.64	0.99	0.85
November	1.07	1.29	—	—	—	—	—	—	—
December	0.94	1.12	—	—	—	—	—	—	—
Season Totals:	27.42	33.00	9.62	12.01	26.35	15.63	13.24	20.84	17.65

[1]Based on Wadena weather station

[2]SCS "Irrigation Guide For Minnesota", 1976

[3]Pro-rated based on ratio of total rainfall to normal rainfall

[4]Assuming carryover moisture of 1.10 inches at start of growing season

[5]Assuming 75% efficiency of irrigation equipment

The annual volume of treated effluent to be applied to the land in the design year would amount to approximately 78 million gallons (240 acre feet). In a normal year, this means the City would require a net or irrigated land area of 138 acres to accommodate their wastewater treatment needs. In a year when greater than average rainfall was received (represented in this analysis by the ten year precipitation, or put differently, a year when this quantity of precipitation has only a ten percent probability of occuring) the land requirement would be increased to 165 acres.

Since quarter section center pivot irrigation rigs typically irrigate 132 acres out of the 160 acre tract on which they are installed, a gross land area of 168 acres would be required during a normal year and 200 acres would be necessary during a wet year. As a result, one quarter section rig (nominally 1,300 feet long) would be required.

Three double-ring infiltrometer tests were performed at the proposed irrigation site to determine the infiltration rate of the soil. (A copy of the "Report of Soil Investigation" is included in the Appendix.) The results of the tests indicated percolation rates ranging from three to seven and one-half inches per week would be available. An infiltration rate of at least three inches per week is well above the MPCA's maximum allowable application rate of two inches per week and the prescribed application rate of 1.17 inches per week.

Farmers that irrigate field corn in the Lake View Township area typically apply a net of 12 inches of moisture annually. Yields of corn without irrigation are typically 40 bushels/acre and with irrigation increase to 100-125 bushels/acre.

Table 3 presents monthly nitrogen balances for a normal and wet year for field corn. These calculations indicate that nitrogen additions from the applied effluent will not be sufficient to supply the needs of a corn crop expected to yield 100 bushels/acre, but would apply approximately 57 percent of the normal nitrogen requirements.

D. Cluster Treatment Systems

As mentioned in the "Summary Report", it would be more cost effective to serve areas just to the north and west of Lake Sallie with cluster treatment systems rather than extending the collection system. A detailed description of the cluster systems is presented in the "Summary Report".

As part of the soils investigation work performed by Midwest Testing Laboratory, piezometers were installed at the two cluster sites and the soils were anlayzed. (Results of the soils investigation is included in the appendix.) The soils encountered at both sites consisted of primarily clean and free draining sand of various textures. The groundwater depths at the north and west sites varied between 8 and 20 feet, and 13 and 14 feet, respectively.

Table 3. Monthly nitrogen balance for spray irrigation, Lake View Township, Minnesota

Month	Applied Effluent (inches) Normal Year	Applied Effluent (inches) Wettest in 10 Years	Applied Nitrogen (lb/acre) Normal Year[2]	Applied Nitrogen (lb/acre) Wettest in 10 Years[3]	[1]Crop[2] Nitrogen Uptake (lb/acre)	Nitrogen Deficiency[3] (lb/acre) Normal Year	Nitrogen Deficiency[3] (lb/acre) Wettest in 10 Years
May	0	0	0	0	8	8	8
June	1.15	0.05	6	0	22	16	16
July	5.32	6.45	28	25	41	13	16
August	5.27	6.39	27	25	41	14	16
September	3.15	3.89	16	15	22	6	7
October	0.74	0.85	4	3	7	3	4
Season Totals:	15.63	13.24	81	68	141[4]	60	67

[1]Assuming 23 mg/l total nitrogen in pond effluent

[2]Assuming nitrogen uptake corresponds to consumptive use

[3]Nitrogen from other sources required at these quantities

[4]Assuming 100 bushel/acre corn on medium to coarse textured soils

III. COST CONSIDERATIONS

An updated preliminary construction cost estimate and salvage value for Alternative 2 is presented in Table 4. The estimate is based on May 1984 construction costs and the Engineering News Record Construction Cost Index at the time the estimate was prepared was 4142. The updated operation and maintenance costs are presented in Table 5.

Table 6 summarizes the equivalent annual costs for Alternative 2 for the 20-year planning period. The interest rate used for the cost-effective analysis was 8.125% as prescribed by the EPA, which results in a capital recovery factor of 0.0972 and a present worth factor for the 20-year period of 0.2096.

Revised local costs are presented in Table 7. Since the "Facilities Plan Summary Report" was prepared in 1981, the Federal share in the construction grants program has changed from 75 percent to 55 percent of eligible costs. For innovative/alternative (I/A) treatment technologies the program may provide for a 75 percent Federal grant.

At the present, the State has not determined its level of participation in the construction grants program under the new regulations. Therefore, the local costs developed in Table 7 do not include any grant assistance from the State. It is anticipated that the State will provide some assistance, thereby reducing the estimated local costs.

ble 4. Summary of construction cost estimates for wastewater collection and central ponds and spray irrigation facility (Alternative 2), Lake View Township, Minnesota[a]

Item	Construction Cost	Salvage
ollection and Conveyance System	$ 5,120,000	$ 1,633,000
aw Wastewater Pumping	293,000	145,000
luster Treatment Systems (Areas 7 & 8)	688,000	150,000
astewater Treatment and Storage Ponds	1,427,000	701,000
pray Irrigation System	254,000	41,000
lectrical and Portable Standby Power	71,000	--
elemetry	118,000	12,000
ffice, Storage and Maintenance Building	83,000	27,000
aintenance Vehicles and Equipment	30,000	--
UBTOTAL	$ 8,084,000	$ 2,709,000
Construction Contingencies (10%)	808,000	--
Engineering, Legal and Administrative (15%)	1,334,000	--
Land (63 acres @ $2,300/acre)	145,000	261,000
Interest During Construction	632,000	--
OTAL ESTIMATED CONSTRUCTION COST	$ 11,003,000	$ 2,970,000

Cost estimate revised May 1984, ENR = 4142

ble 5. Estimated annual operation and maintenance costs for wastewater collection and central ponds and spray irrigation facility (Alternative 2), Lake View Township, Minnesota[a]

ITEM	COST, $/YR
abor	$ 30,000
ower	7,000
arts/Supplies	4,000
ruck Mileage	5,000
ab Services	2,000
ontract Sludge auling	1,000
Replacement Cost	26,000
otal Annual & M Costs, $/yr	$ 75,000

[a] May 1984, ENR = 4142

ble 6. Estimated total equivalent annual cost for wastewater collection and central ponds and spray irrigation facility (Alternative 2), Lake View Township, Minnesota

ITEM	COST
Total Estimated Construction Cost, $	$11,003,000
Estimated Salvage Value at 20 years, $	2,970,000
Estimated Equivalent Annual Construction Cost, $/yr(a)	1,069,000
Estimated Equivalent Annual Salvage, $/yr(a)	61,000
Estimated Annual O & M Cost, $/yr	75,000
Estimated Total Equivalent Annual Cost, $/yr (Line 3 - Line 4 + Line 5)	1,083,000

(a) Based on 20-year amortization @ 8.125% interest

ble 7. Estimated local costs for wastewater collection and central ponds and spray irrigation facility (Alternative 2), Lake View Township, Minnesota (a)

	ITEM	COST
	Total Estimated Construction Costs, $	11,003,000
	Non-Grant Eligible Construction Costs, $	1,476,000
	Grant-Eligible Construction Costs:	
	I/A Technology, $	4,562,000
	Conventional Technology,	4,965,000
	Federal Grant:	
	@ 75% of Line 3, $	3,422,000
	@ 55% of Line 4, $	2,731,000
	Local Share of Construction Costs, $ (Line 1 - (Lines 5 + 6))	4,850,000
	Local Annualized Construction Costs, $/yr(b)	471,000
	Annual O & M Costs, $/yr	75,000
	Total Local Annual Costs, $/yr (Line 8 + Line 9)	546,000
	Estimated Monthly Costs per Household, $/Household/Month(c)	40.00

(a) Based on ENR construction index of 4142, salvage values not considered

(b) Based on 20-year amortization at 8.125% interest rate

(c) Based on 1,037 houses, and 91 commercial units @ 300 gpd/unit

IV. CONCLUSIONS AND RECOMMENDATIONS

It can be concluded from this addendum report that a wastewater collection system followed by a wastewater stabilization pond and spray irrigation facility is a technically feasible treatment alternative for Lake View Township. Two areas to the west and north of Lake Sallie would be serviced by cluster treatment systems. However, grant assistance from the State of Minnesota would be necessary to reduce local treatment costs and additional assistance from other state or federal agencies would be desirable to reduce the cost of constructing the collection system.

Based upon the information presented herein, the following recommendations are submitted:

1. The facilities plan addendum report should be submitted to the Minnesota Pollution Control Agency for approval.

2. Lake View Township should request to be put on the Minnesota Pollution Control Agency's Fiscal Year 1985 Municipal Project List.

3. Additional grant assistance should be sought.

APPENDIX

"Report of Soil Investigation"

by Midwest Testing Laboratory

REPORT OF SOIL INVESTIGATION

Proposed Wastewater
Treatment Facilities
Lake View Township
Becker County, Minnesota
Project Number 2984

MIDWEST TESTING LABORATORY

MIDWEST TESTING LABORATORY

P. O. BOX 3042 • FARGO, NORTH DAKOTA 58108 • 701-293-0814

November 10, 1983

Lake View Township
P.O. Box 69
Detroit Lakes, MN 56501

Re: Soil Investigation
Proposed Wastewater Treatment
Facilities
Lake View Township
Becker County, Minnesota

Gentlemen:

The attached report covers the soil investigation we conducted for the above project. Two copies of our report are being furnished for your use, with one copy being sent directly to Rieke, Carroll, Muller Associates, Inc. in Hopkins, Minnesota. The work was conducted in accordance with your instructions and authorization.

Approximately 50 percent of the soil samples obtained will be held at our office for two months and will then be discarded unless we are notified to hold them for a longer period of time.

Should any questions arise pertaining to the soil conditions or unexpected conditions develop during construction, please do not hesitate to contact us.

Very truly yours,

MIDWEST TESTING LABORATORY, INC.

Theodore J. Engelstad

Theodore J. Engelstad, P.E.

TJE:sfm

Proj. No. 2984

cc: R.C.M. Assoc., Inc.

REPORT OF SOIL INVESTIGATION

Proposed Wastewater Treatment Facilities
Lake View Township
Becker County, Minnesota
Project Number 2984

INTRODUCTION:

The proposed wastewater treatment facilities will serve resorts and home owners that are situated around portions of Detroit Lake, Lake Sallie, and Lake Melissa in Lake View Township. Most of the project area will send their wastewater along collection lines to a central waste stabilization pond site. Pond effluent will be disbursed by spray irrigating adjacent cropland. Two area on the west and north sides of Lake Sallie will be served by off site cluster treatment systems. The main portion of our work was conducted on October 19 and 20, 1983. This work included installing piezometers at the two cluster sites and performing three double-ring infiltrometer tests at the spray irrigation site. The following report will provide factual information of the investigation and evaluate the soil conditions encountered in relation to the proposed construction.

SITE AND SOIL CONDITIONS

North Cluster Site (known as project area seven)

This site is located in the west portion of the northwest quarter of section eight in Lake View Township. Monson Lake is off to the east and Lake Sallie is to the south of the site. The site is within a tilled field and its topography is quite variable. Three piezometers were installed at locations near the north, west, and east edges of the field, and ground surface elevations at these locations vary by almost 12 feet.

Beneath a layer of dark organic topsoil, the soils encountered in our borings consist almost entirely of sand of various texture. One exception to this is a silt loam stratum that was found at the bottom of boring number five. The sand layers vary in texture from fine to very coarse and for the most part, are quite clean, that is, they contain very few very fine particles of the silt and clay categories.

South Cluster Site (known as project area eight)

This site is located in the west portion of the northeast quarter of section 18 in Lake View Township. An access road separates the site from cabins located along the west shore of Lake Sallie. At this proposed cluster site, piezometers were placed at three locations within a grassy area just west of this road. This area is relatively flat, with surface elevations at the three piezometer locations varying about 1.4 feet. Directly to the west is a low wooded area, with a very small stream winding through it. The fourth piezometer for this cluster site was installed at the west edge of the wooded area that runs adjacent a township or county road. The ground elevation at this location is roughly nine to ten feet lower than the ground elevations at the other piezometers at this site.

The soils encountered at the piezometer locations are once again primarily sand of various textures but generally quite clean and free draining. Exceptions to this are primarily seen within the first two to three feet of the surface and also in the lower portion of the second boring that was taken much deeper than the others. The soils nearest the surface are primarily loam of a black to very dark brown coloration. Beneath the surface loam, a layer of sandy loam is also generally found. The clean sand layers are then encountered and are found to extend to the final depths of the shallower borings and continue to about the 36-foot depth within the deeper boring. At this point, a dark brownish gray silty clay loam was encountered. This in turn is underlain by clay and silt loam layers that

continue to the 56-foot depth where our boring was terminated. Below about the 47-foot depth, lenses, laminations, and a layer of loamy sand are found within the silt loam and clay strata.

(Note: piezometer number three was installed very near to piezometer number two to determine the vertical hydraulic gradient in the area. Due to their close proximity to each other, boring number three was not logged.)

Waste Stabilization Pond and Spray Irrigation Site

This site is in the northeast quarter of section 21 in Lake View Township. In general, the north and east sides of the site are bordered by county or township roads number four and five, respectively and Meadow Lake borders the site at the southwest corner. The proposed waste stabilization pond is to be placed within the northeast corner of the site, with the remainder of the quarter section to be used for spray irrigation. The site has a rolling topography and is presently being used as farmland.

Three double-ring infiltrometer tests were performed on the spray irrigation site, with shallow auger borings also performed at each location. Test number one was located at a high point in the northeast portion of the northwest quadrant of the site. About the upper one-half foot at this location is a black sandy loam. This is underlain by a foot of brown loamy sand, which is then followed by a relatively coarse brown sand. The second test was performed in a very low area to the southwest of test number one. Here, a very dark brown silty clay loam is first encountered. This extends about one and one-half feet, where about a two-foot layer of grayish brown loam is found. This in turn is underlain by a brownish gray loamy sand. Test number three was performed in about the middle of the southeast quadrant of the site. At this location, about one foot of a black sandy loam is immediately underlain by a one-foot layer of brown loam, below which a medium textured brown sand is encountered.

Remarks

For a more complete description of the soils encountered at the three sites, please refer to the attached boring logs.

GROUND WATER

Ground water level readings at each piezometer location were taken on October 21, 1983, and the results are summarized on the data sheets, following the boring logs. From this information, at the north site, the ground water table is seen to slope downward to the south and east. At the south site, the water level readings also indicate a downward trend of the ground water table toward nearby Lake Sallie. The very small stream winding through the wooded area just to the west has a surface elevation that is consistent with the trend of the ground-water table. The ground water level found in piezometer number four is about eight inches lower than the levels established in the other piezometers. We would reserve judgment on this particular water level reading until further monitoring has been conducted. We understand these later water level checks will be performed by your representative.

Boring number two performed at the south site was taken to a depth that would establish the saturated thickness of the surficial aquifer. This thickness was found to be approximately 23 feet. The piezometer at this location was set at approximately the 35-foot depth. Piezometer number three was set a few feet to the south and about 15 feet below the surface. On October 21st, the ground water elevations at these locations were identical, suggesting no vertical movement of ground water within the surficial aquifer at this site.

LABORATORY INVESTIGATION

Five samples were selected for laboratory analysis. A grain size analysis was performed of each sample and is shown in tabular and graphical form at the back of the report.

Sample number one was taken from boring number five from about the 15½ foot depth. The test indicates a silt loam with a uniformity coefficient of 7.3. The surface soils at our test locations on the spray irrigation site range from sandy loam to silty clay loam. A grain size analysis was also performed on the material found directly below the surface soils at test location two. Sandy loam soils from test locations one and three do differ somewhat, with the material from test location one having a significantly higher sand content.

DOUBLE-RING INFILTROMETER TESTS

Three double-ring infiltrometer tests were performed at locations directed by Mr. Joe Magner of the Minnesota Pollution Control Agency and are shown on an attached sketch. At each location, the test area was stripped of about one inch of topsoil to remove the surface vegetation. To perform the tests, rings of 12 inches and 24 inches in diameter were hydraulically pressed into the soil a distance of four inches. Water was then added to both sides of the inside ring. After a period of time when the soils were allowed to soak, the water levels were adjusted to about two and one-half to three inches above the surface and periodic readings were then taken until a uniform infiltration rate had been established.

Test number one and three established infiltration rates of three inches per hour and five-eighths inch per hour, respectively. Both these tests were performed in sandy loam materials. These materials do differ significantly, however, in grain size distribution, and this is reflected in the infiltration rates that were obtained. An added factor that may be involved in the slower rate of test number three is the one-foot layer of loam that was found below the topsoil. Test number two was performed in a low grassy wet spot. After soaking for a period about 18 hours, readings that were taken showed virtually no infiltration taking place. At this location, the soils were quite cohesive to a depth about 3½ feet, and a check of our shallow auger

boring the day after it was performed showed a water level 33 inches below the surface.

DISCUSSION (spray irrigation site)

The double-ring infiltrometer test results indicate infiltration rates ranging from zero to three inches per hour. We recommend spray irrigation be avoided in the low area represented by the zero infiltration rate. This appears to be an isolated case at this site. The entire site has a quite variable topography but is generally much higher than this low spot.

The double-ring infiltration test provides an infiltration rate of the soil. A study that has been conducted with regard to such tests indicates that the test results using small diameter cylinders overestimate the true vertical infiltration rate by about 40 percent. We will use this factor in our analysis. Experience of others has shown that the maximum design percolation rate should be no more than four to ten percent of the minimum soil hydraulic conductivity. As a very low head of water is used in the double-ring infiltrometer test, the infiltration rate obtained can be taken as the saturated soil hydraulic conductivity. Using an infiltration rate of five-eighths inch per hour as obtained in our third infiltrometer test and based on other factors given above, a field percolation rate ranging from three to seven and one-half inches per week would be available.

The application rate for spray irrigation is determined by the water balance equation:

precipitation + applied wastewater = evapotranspiration + percolation

Although we are not aware of exact figures, we understand the evapotranspiration rate is greater than the precipitation rate in the Detroit Lakes area. From the figures and assumptions given above, an application rate of at least three inches per week is indicated. We understand M.P.C.A. regulations call

for a maximum allowable application rate of two inches per week. Our figures indicate that the soil will easily be able to accept this rate of application and still allow for the possibility of the presence of soils with slower infiltration characteristics.

FIELD INVESTIGATION PROCEDURES

Seven piezometers were installed and three double-ring infiltrometer tests were performed at the sites on October 19 and 20, 1983. The work was performed at the locations shown on the attached sketches. Surface elevations at the south and north cluster sites were referenced to the top of piezometers number one and five, respectively. These reference points were taken as assumed elevations of 100.0.

Soil Sampling

The borings were advanced with 3-3/8 inch hollow stem auger, with split barrel samples obtained at regular intervals. Using this procedure, a two-inch O.D. split barrel sampler is driven by a 140-pound weight falling 30 inches. The number of blows required to drive the sampler twelve inches after a six-inch initial set is the standard penetration resistance and will be referred to as N value, an index related to the consistency of cohesive soils and the relative density of cohesionless soils.

Soil Classifications

As the borings were advanced in the field and samples obtained, they were visually and manually classified in accordance with the U.S. Department of Agriculature Soil Classification System. Representative portions of all samples were returned to the laboratory for verification of the field classifications. Selected samples were submitted to a program of laboratory tests to aid in determining the characteristics of the soil. Logs of the borings, laboratory test results, and charts illustrating

the soil classification procedures and descriptive terminology are attached.

LIMITATIONS OF INVESTIGATION

The area of the borings in relation to the entire sites are relatively small and therefore, should not be assumed to be necessarily typical of the entire areas of the sites. Also, this investigation cannot warrant soil conditions below the depths of our borings. Because of these and other reasons, we recommend close observation during construction for soil conditions not typical of the strata logged.

I hereby certify that this re...
was prepared by me or under my
direct supervision and that I am a
duly Registered Professional Engineer

Theodore J. Engelstad

Theodore J. Engelstad

Date Nov. 10, 1983 Reg. No. ND 2317

MIDWEST TESTING LABORATORY

2984 LOG OR TEST BORING NO. 1 VERTICAL SCALE 1" = 3'

Proposed Wastewater Treatment Facs., Lake View Township, Becker Co., Minn.

SOIL DESCRIPTION SURFACE ELEV. 98.6	SAMPLE NO.	SAMPLE TYPE	N VALUE	LABORATORY TESTS: MOISTURE	DENSITY	LL/PL	Qu
FILL-sandy clay loam and sand, black, dark brown and grayish brown	1	SS	10				
SAND-light grayish brown, very coarse to fine, with a trace*	2	SS	23				
SAND-light grayish brown, medium to fine, dry to moist							
SAND-grayish brown, very coarse to medium, with a little gravel, moist	3	SS	17				
	4	SS	25				
SAND-brown, coarse, with a trace of gravel, moist	5	SS	24				
SAND-brownish gray, very coarse to coarse, with a little gravel, wet to water-bearing	6	SS	14				
	7	SS	6				
SAND-gray, very coarse to medium, with a little gravel, waterbearing	8	SS	9				
SAND-gray, very coarse, with some gravel, waterbearing	9	SS	14				
END OF BORING							

*of gravel, dry to moist (may be fill)

WATER LEVEL DATA

TIME	CAVE IN DEPTH	WATER LEVEL
(see attached data sheet)		

BORING DATA

STARTED 10-19-83 COMPLETED 10-19-83 @ 1730

METHOD USED: 3-3/8" HSA 0-19½'

CREW CHIEF M. Larson

MIDWEST TESTING LABORATORY

2984 LOG OR TEST BORING NO. 2 - page 1 VERTICAL SCALE 1" = 4'

CT Proposed Wastewater Treatment Facs., Lake View Township, Becker Co., Minn

SOIL DESCRIPTION SURFACE ELEV. 97.2	SAMPLE NO.	SAMPLE TYPE	N VALUE	LABORATORY TESTS: MOISTURE	DENSITY	LL/PL	Qu
LOAM-black to very dark brown*	1	SS	16				
SANDY LOAM-brown, w/a trace of gravel							
LOAMY SAND-grayish brown, very coarse to fine, with a little**	2	SS	30				
SAND-light brown, medium to fine, dry to moist	3	SS	32				
SAND-grayish brown, very coarse to medium, with a trace of gravel, moist	4	SS	26				
	5	SS	20				
SAND-brownish gray, very coarse to coarse, with a little gravel, wet to waterbearing	6	SS	15				
SAND-gray, medium to fine, with a trace of gravel, waterbearing	7	SS	10				
SAND-grayish brown to gray, very coarse, with some gravel, waterbearing	8	SS	14				
	9	SS	12				
SAND-gray, very coarse to medium, with a trace of gravel, waterbearing	10	SS	34				
(continued on next page) *(may be fill) **gravel, dry							

MIDWEST TESTING LABORATORY

2984 LOG OR TEST BORING NO. 2 - page 2 VERTICAL SCALE 1" = 4'

CT Proposed Wastewater Treatment Facs., Lake View Township, Becker Co., Minn.

SOIL DESCRIPTION SURFACE ELEV.	SAMPLE NO.	SAMPLE TYPE	N VALUE	LABORATORY TESTS: MOISTURE	DENSITY	LL/PL	Qu
(continued from page 1)							
SAND-gray, very coarse to coarse, with some gravel, waterbearing	11	SS	18				
SILTY CLAY LOAM-dark brownish gray, with a trace of gravel	12	SS	19				
CLAY-gray	13	SS	11				
SILT LOAM-brownish gray, with lenses and laminations of loamy sand	14	SS	17				
CLAY-gray, with a 3-inch layer of loamy sand at about 55 feet	15	SS	17				
END OF BORING							

ER LEVEL DATA

	TIME	CAVE IN DEPTH	WATER LEVEL
(attached data sheet)			

BORING DATA

STARTED 10-20-83 COMPLETED 10-20-83 @ 1130

METHOD USED: 3-3/8" HSA 0-54½'

CREW CHIEF M. Larson

MIDWEST TESTING LABORATORY

2984 LOG OR TEST BORING NO. 4 VERTICAL SCALE 1" = 2'

Proposed Wastewater Treatment Facs., Lake View Township, Becker Co., Minn.

SOIL DESCRIPTION (SURFACE ELEV. 88.8)	SAMPLE NO.	SAMPLE TYPE	N VALUE	LABORATORY TESTS: MOISTURE	DENSITY	LL/PL	Qu
LOAM-black to very dark brown	1	SS	9				
SANDY LOAM-brown, with a little gravel	2	SS	13				
SAND-gray to brownish gray, coarse to fine, with a trace of gravel, shaley, water-bearing	3	SS	8				
	4	SS	3				
SAND-gray, very coarse to coarse, with a little gravel, waterbearing	5	SS	2				
END OF BORING							

WATER LEVEL DATA

	TIME	CAVE IN DEPTH	WATER LEVEL
(see attached data sheet)			

BORING DATA

STARTED 10-20-83 COMPLETED 10-20-83 @ 1545

METHOD USED: 3-3/8" HSA 0-9½'

CREW CHIEF M. Larson

MIDWEST TESTING LABORATORY

2984 LOG OR TEST BORING NO. 5 VERTICAL SCALE 1" = 3'

Proposed Wastewater Treatment Facs., Lake View Township, Becker Co., Minn.

SOIL DESCRIPTION (SURFACE ELEV. 97.9)	SAMPLE NO.	SAMPLE TYPE	N VALUE	LABORATORY TESTS: MOISTURE	DENSITY	LL/PL	Qu
LOAMY SAND-dark brown to brown, coarse to very fine, with a*	1	SS	2				
SAND-brown, medium to very fine, moist	2	SS	8				
SAND-light grayish brown, coarse to medium, with a trace of gravel, moist	3	SS	20				
	4	SS	26				
SAND-grayish brown, very coarse to coarse, with some gravel, wet to waterbearing							
SAND-brown, fine, waterbearing	5	SS	20				
SAND-grayish brown, very coarse to medium, with a little gravel, waterbearing	6	SS	22				
	7	SS	34				Hyd.**
SILT LOAM-grayish brown							
END OF BORING							

*trace of gravel

**See attached summary sheet and curve.

WATER LEVEL DATA

DATE	TIME	CAVE IN DEPTH	WATER LEVEL
(See attached data sheet)			

BORING DATA

STARTED 10-20-83 COMPLETED 10-20-83 @ 1720

METHOD USED: 3-3/8" HSA 0-14½'

CREW CHIEF M. Larson

MIDWEST TESTING LABORATORY

2984 LOG OR TEST BORING NO. 6 VERTICAL SCALE 1" = 4'

PROJECT Proposed Wastewater Treatment Facs., Lake View Township, Becker Co., Minn

SOIL DESCRIPTION SURFACE ELEV. 109.5	SAMPLE NO.	SAMPLE TYPE	N VALUE	LABORATORY TESTS: MOISTURE	DENSITY	LL/PL	Qu
(sampling began at 5 feet) SAND-light brown, medium, moist	1	SS	34				
SAND-grayish brown, very coarse to medium, with a little gravel, moist	2	SS	23				
	3	SS	34				
SAND-grayish brown, coarse to medium, with a trace of gravel, wet to waterbearing	4	SS	38				
	5	SS	23				
END OF BORING							

WATER LEVEL DATA

DATE	TIME	CAVE IN DEPTH	WATER LEVEL
(see attached data sheet)			

BORING DATA

STARTED 10-20-83 COMPLETED 10-20-83 @ 1825

METHOD USED: 3-3/8" HSA 0-24½'

CREW CHIEF M. Larson

MIDWEST TESTING LABORATORY

2984 LOG OR TEST BORING NO. 7 VERTICAL SCALE 1" = 4'

Proposed Wastewater Treatment Facs., Lake View Township, Becker Co., Minn.

SOIL DESCRIPTION SURFACE ELEV. 106.8	SAMPLE NO.	SAMPLE TYPE	N VALUE	LABORATORY TESTS: MOISTURE	DENSITY	LL/PL	Qu
(sampling began at 5 feet)							
SAND-light grayish brown, very coarse to medium, with a trace of gravel, dry to moist	1	SS	24				
SAND-light brown, medium, dry to moist	2	SS	26				
SAND-light brown, fine, moist to wet to waterbearing	3	SS	26				
LOAMY SAND-grayish brown, fine, waterbearing	4	SS	22				
SAND-brown, very coarse to coarse, with a little gravel, waterbearing	5	SS	30				
END OF BORING							

WATER LEVEL DATA

	TIME	CAVE IN DEPTH	WATER LEVEL
(see attached data sheet)			

BORING DATA

STARTED 10-20-83 COMPLETED 10-20-83 @ 1930

METHOD USED: 3-3/8" HSA 0-24½'

CREW CHIEF M. Larson

MIDWEST TESTING LABORATORY

B NO. 2984 PROJECT Proposed Wastewater Treatment Facs., Lake View Township, Becker County, Minnesota

BORING NO.: D.R. #1

LAYER	SOIL DESCRIPTION	SURFACE ELEV.
0-½'	SANDY LOAM-black	
½-1½'	LOAMY SAND-brown	
1½-4'	SAND-brown, coarse to medium, with a trace of gravel, dry	

WATER LEVEL DATA

DATE	TIME	W.L.	CAVE-IN

BORING DATA

STARTED	
COMPLETED	
CREW CHIEF	

BORING NO.: D.R. #2

LAYER	SOIL DESCRIPTION	SURFACE ELEV.
0-1½'	SILTY CLAY LOAM-very dark brown	
1½-3½'	LOAM-grayish brown	
3½-4'	LOAMY SAND-brownish gray, waterbearing	

WATER LEVEL DATA

DATE	TIME	W.L.	CAVE-IN

BORING DATA

STARTED	
COMPLETED	
CREW CHIEF	

BORING NO.: D.R. #3

LAYER	SOIL DESCRIPTION	SURFACE ELEV.
0-1'	SANDY LOAM-black	
1-2'	LOAM-brown	
2-4'	SAND-brown, medium, dry	

WATER LEVEL DATA

DATE	TIME	W.L.	CAVE-IN

BORING DATA

STARTED	
COMPLETED	
CREW CHIEF	

MIDWEST TESTING LABORATORY

2501 Main Ave. / P. O. Box 3042 / Fargo, North Dakota 58108 / Dial (701) 293-0814

REPORT OF: ELEVATION DATA

JECT: Proposed Wastewater Treatment Facs., Lake View Township Becker County, Minnesota

DATE: November 10, 1983

ORTED TO: Lake View Township
P.O. Box 69
Detroit Lakes, MN 56501

COPIES: R.C.M. Assoc., Inc.

JECT NO: 2984

SOUTH CLUSTER SITE (Area 8)

Location	Elevation	Water Level Elevation*
of Pipe #1	100.00 (assumed)	84.08
und Surface at Pipe #1	98.61	
of Pipe #2	98.18	84.10
und Surface at Pipe #2	97.23	
of Pipe #3	98.52	84.10
nd Surface at Pipe #3	97.43	
of Pipe #4	90.99	83.45
nd Surface at Pipe #4	88.81	
l stream in wooded area		84.59
Sallie (just east of D.L. fire # S722)		83.74

d on measurements taken on October 21, 1983 by Midwest Testing
atory.

MIDWEST TESTING LABORATORY

2501 Main Ave. / P. O. Box 3042 / Fargo, North Dakota 58108 / Dial (701) 293-0814

REPORT OF: ELEVATION DATA

CT: Proposed Wastewater Treatment Facs., Lake View Township Becker County, Minnesota

DATE: November 10, 1983

TED TO: Lake View Township
P.O. Box 69
Detroit Lakes, MN 56501

COPIES: R.C.M. Assoc., Inc.

CT NO: 2984

NORTH CLUSTER SITE (Area 7)

Location	Elevation	Water Level Elevation*
of Pipe #5	100.00 (assumed)	89.17
nd Surface at Pipe #5	97.87	
of Pipe #6	111.55	89.65
nd Surface at Pipe #6	109.50	
of Pipe #7	109.10	89.68
d Surface at Pipe #7	106.80	
Monson (near pipe #5)		88.78

d on measurements taken on October 21, 1983 by Midwest Testing
atory.

MIDWEST TESTING LABORATORY

2501 Main Ave. / P. O. Box 3042 / Fargo, North Dakota 58108 / Dial (701) 293-0814

REPORT OF: TESTS OF SOILS

ECT: Wastewater Treatment Facilities
Lake View Township
Becker County, Minnesota

DATE: November 10, 1983

RTED TO: Lake View Township
P.O. Box 69
Detroit Lakes, MN 56501

COPIES: R.C.M.

ECT NO: 2984

LE NUMBER:	1	2	3
ATION:	Boring #5 @ 15½'-16'	D.R.I. #1 @ 0-½'	D.R.I. #2 @ 0-½'
SSIFICATION:	SILT LOAM-grayish brown	SANDY LOAM-black	SILTY CLAY LOAM-black

TICLE DISTRIBUTION: (See attached curves)

avel			
Coarse (76.2-12.7 mm)	0	0	0
Fine (12.7-2.0 mm)	0	1	0
nd (%)			
Very Coarse (2.0-1.0 mm)	trace	5	0
Coarse (1.0-0.5 mm)	½	21	trace
Medium (0.5-0.25 mm)	1	30	1
Fine (0.25-0.10 mm)	1½	12	2
Very Fine (0-10-0.05 mm)	27	3	5
nes (%)			
Silt (0.05-0.002 mm)	63	19	62
Clay (less than 0.002 mm)	7	9	30
efficient of Uniformity	7.3		

MIDWEST TESTING LABORATORY

2501 Main Ave. / P. O. Box 3042 / Fargo, North Dakota 58108 / Dial (701) 293-0814

REPORT OF: TESTS OF SOILS

ECT: Wastewater Treatment Facilities
Lake View Township
Becker County, Minnesota

DATE: November 10, 1983

RTED TO: Lake View Township
P.O. Box 69
Detroit Lakes, MN 56501

COPIES: R.C.M.

ECT NO: 2984

PLE NUMBER:	4	5
ATION:	D.R.I. #2 @ 1½'-2'	D.R.I. #3 @ 0-½'
SSIFICATION:	LOAM-grayish brown	SANDY LOAM-black

TICLE DISTRIBUTION: (See attached curves)

Gravel		
Coarse (76.2-12.7 mm)	0	0
Fine (12.7-2.0 mm)	½	1
Sand (%)		
Very Coarse (2.0-1.0 mm)	3	4
Coarse (1.0-0.5 mm)	6½	15
Medium (0.5-0.25 mm)	5	20
Fine (0.25-0.10 mm)	7	12
Very Fine (0.10-0.05 mm)	8	5
Fines (%)		
Silt (0.05-0.002 mm)	46	30
Clay (less than 0.002 mm)	24	13

MIDWEST TESTING LABORATORY

Project No. 2984

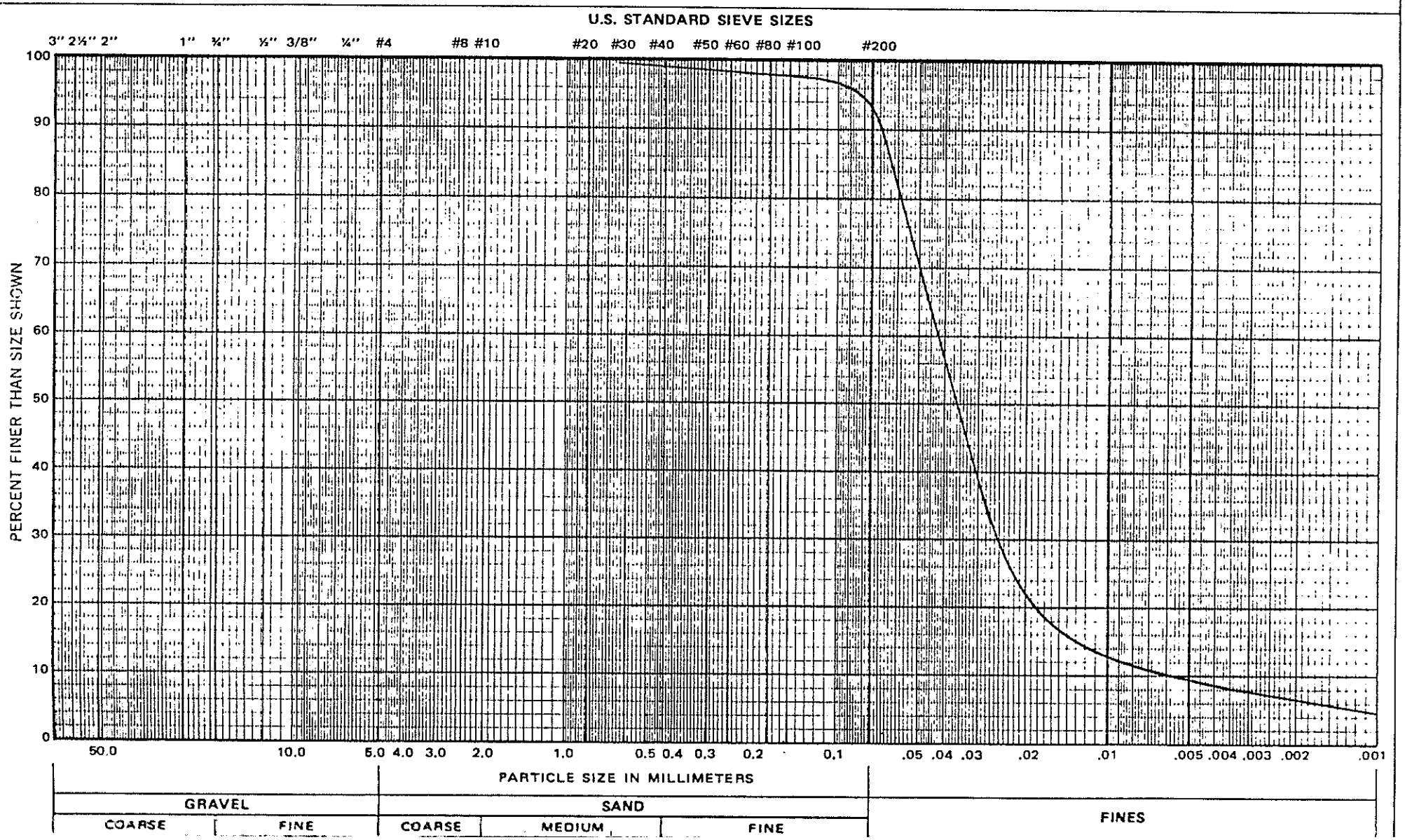
Sample Source Boring #5 @ 15½'-16'

Classification Silt Loam

Project: Proposed Wastewater Treatment Facs.
Lake View Township
Becker County, Minnesota

Reported To: Lake View Township

GRAIN SIZE DISTRIBUTION CURVE



MIDWEST TESTING LABORATORY

Project No. 2984

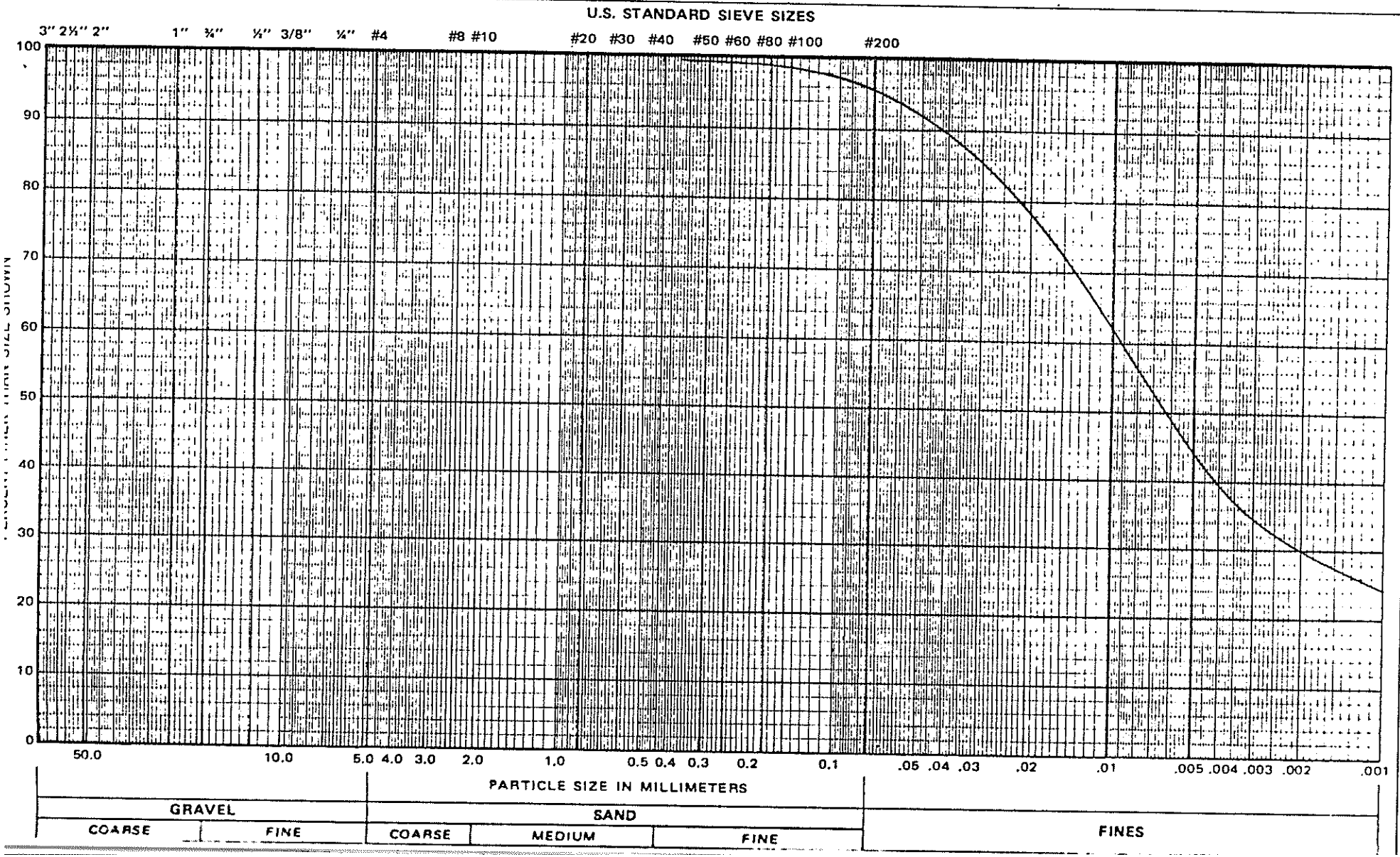
Sample Source Double-Ring Infiltrometer #2 @ 0-½'

Classification Silty Clay Loam

Project: Proposed Wastewater Treatment Facs.
Lake View Township
Becker County, Minnesota

Reported To: Lake View Township

GRAIN SIZE DISTRIBUTION CURVE



oject No. 2984

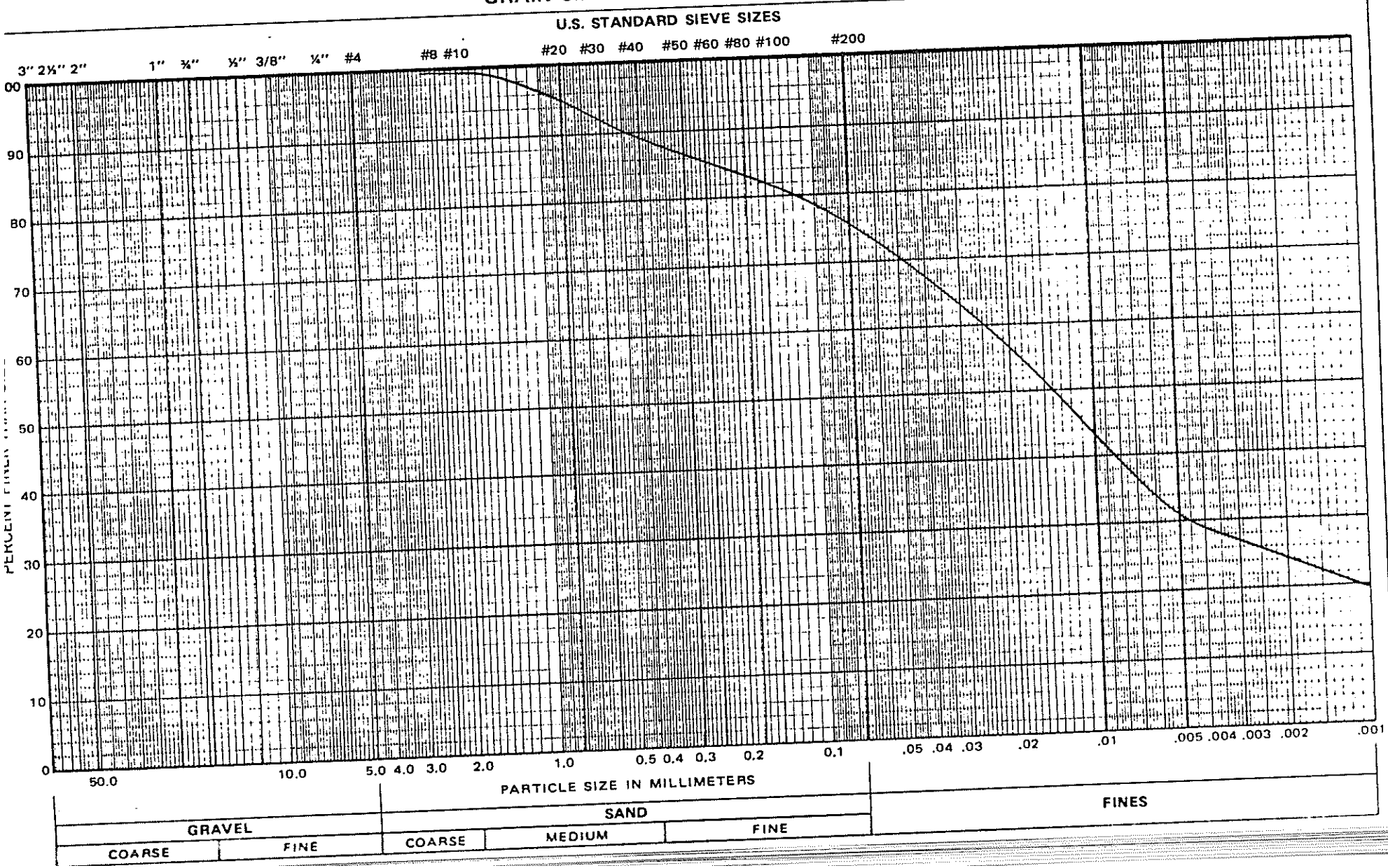
Project: Proposed Wastewater Treatment Facility
Lake View Township
Becker County, Minnesota

mple Source Double-Ring Infiltrometer #2 @ 1½'-2'

Reported To: Lake View Township

assification Loam

GRAIN SIZE DISTRIBUTION CURVE



Project No. 2984

Sample Source Double-Ring Infiltrometer #3 @ 0-½'

Classification Sandy Loam

Project: Proposed Wastewater Treatment Facs.
Lake View Township
Becker County, Minnesota

Reported To: Lake View Township

GRAIN SIZE DISTRIBUTION CURVE

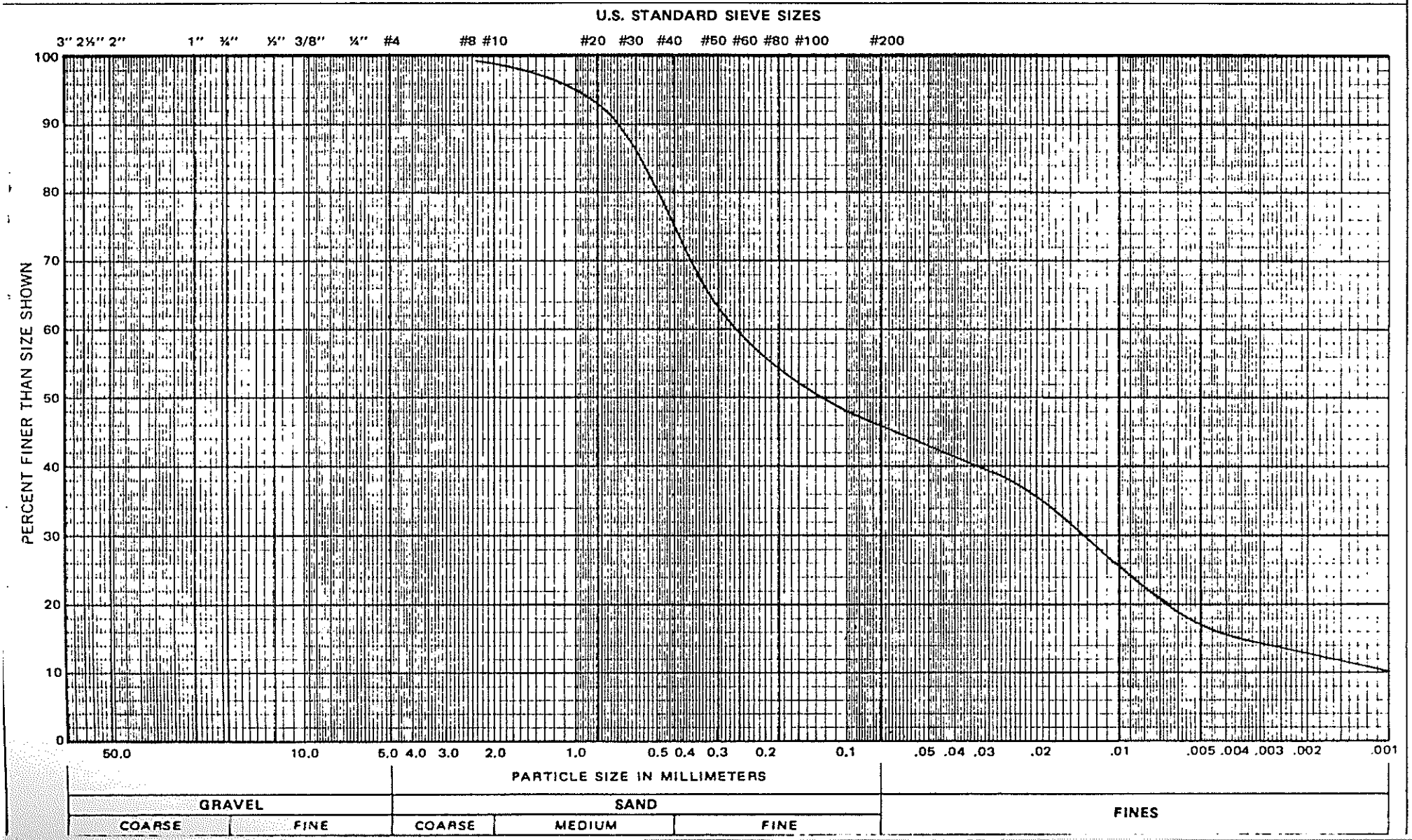
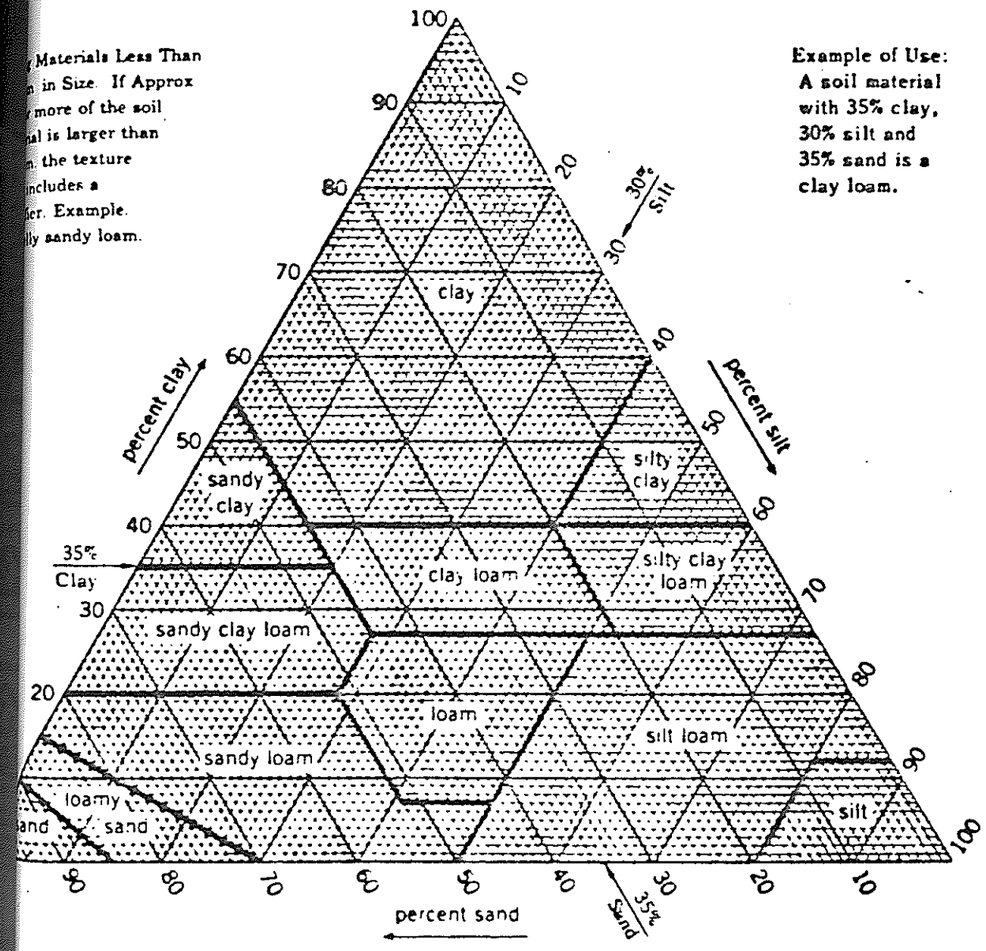


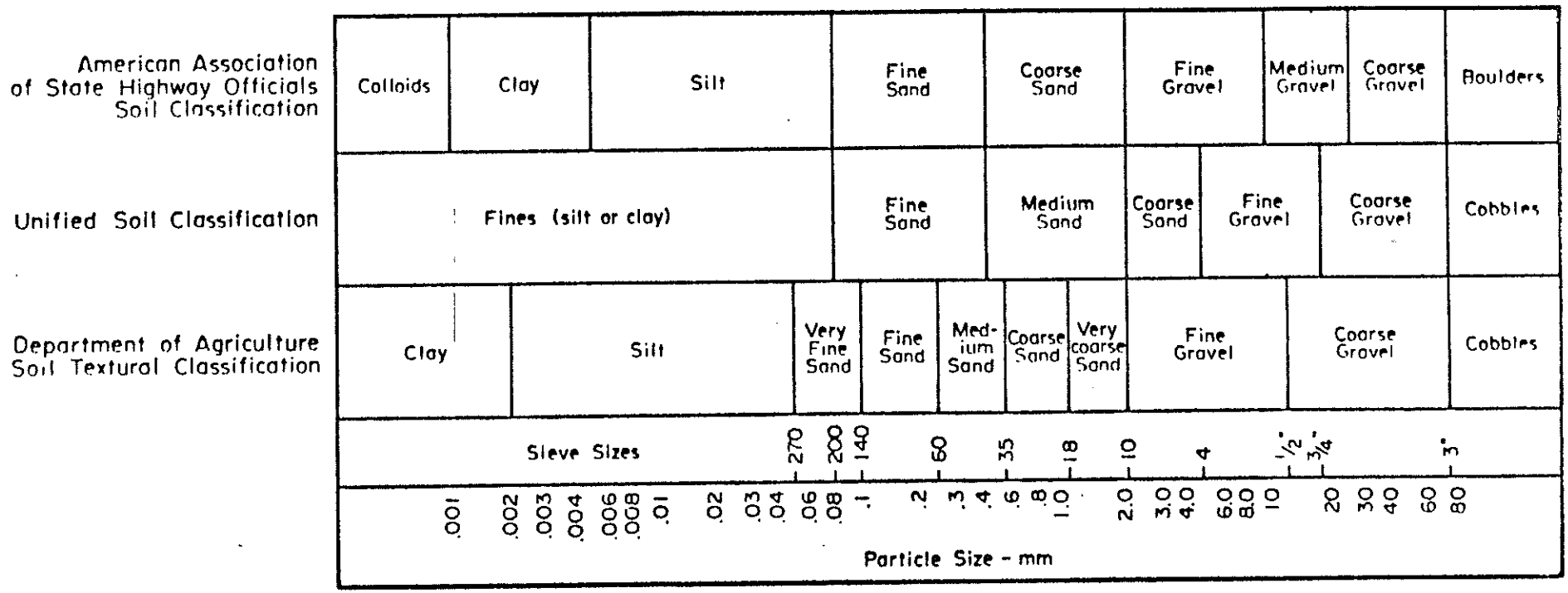
CHART 3 GUIDE FOR USDA SOIL TEXTURAL CLASSIFICATION.

...Materials Less Than
...in Size. If Approx
...more of the soil
...al is larger than
...the texture
...includes a
...er. Example.
...ly sandy loam.



Example of Use:
A soil material with 35% clay, 30% silt and 35% sand is a clay loam.

A COMPARISON OF PARTICLE SIZE LIMITS IN THREE CLASSIFICATION SYSTEMS



Modified from PCA Soil Primer

PARTICLE NAME	PARTICLE SIZE RANGE, IN mm	SIEVE NUMBERS
VERY COARSE SAND	2.0 – 1.0	10 – 18
COARSE SAND	1.0 – 0.5	18 – 35
MEDIUM SAND	0.5 – 0.25	35 – 60
FINE SAND	0.25 – 0.10	60 – 140
VERY FINE SAND	0.10 – 0.05	140 – 270

DESCRIPTIVE TERMINOLOGY

RELATIVE DENSITY OF COHESIONLESS SOILS

Term	"N" Value
Very Loose	0-4
Loose	5-8
Medium Dense	9-15
Dense	16-30
Very Dense	Over 30

CONSISTENCY OF COHESIVE SOILS

Term	"N" Value
Soft	0-4
Medium	5-8
Rather Stiff	9-15
Stiff	16-30
Very Stiff	Over 30

RELATIVE PROPORTIONS

Term	Range
Trace	0-5%
A Little	5-15%
Some	15-30%
With	30-50%

THICKNESS OF SOIL INTRUSIONS

Term	Range
Lense/Lamination	0-1/8"
Seam	1/8"-1"
Layer	1"-12"

PARTICLE SIZES

Term	Range
Boulders	Over 8"
Cobbles	3"-8"
Gravel	
Coarse	3/4"-3"
Fine	#4-3/4"
Sand	
Coarse	#4-#10
Medium	#10-#40
Fine	#40-#200
Silt and Clay	Determined by Plasticity Characteristics

NOTE: Sieve sizes shown are U.S. Standard

DRILLING & SAMPLING SYMBOLS

Symbol	Definition
FA	Flight Auger
SS	Split Spoon
TW	Thin-Walled Tube
HSA	Hollow Stem Auger
N	Penetration Resistance: blows required to drive a two-inch OD split spoon sampler one foot by means of a 140-pound hammer falling 30 inches.

LABORATORY TEST SYMBOLS

Symbol	Definition
LL	Liquid Limit, %
PL	Plastic Limit, %
Q_u	Unconfined Compressive Strength, psf
Additional insertions in Q_u column	
G	Specific Gravity
SL	Shrinkage Limit, %
pH	Hydrogen Ion Content - Meter Method
O	Organic Content, % - Combustion Method
M.A.	Grain Size Analysis - Mechanical Method
Hyd.	Grain Size Analysis - Hydrometer Method
C	One-Dimensional Consolidation
Q_c	Triaxial Compression

WATER LEVEL INFORMATION

Water levels shown on the boring logs are levels measured in the borings at the time and under the conditions noted. In sand, the indicated levels can be considered reliable. In clay soil, it is not possible to determine the ground water level within the normal scope of a test boring investigation, except where lenses or layers of more previous water-bearing soil are present. Even then, a long period of time may be necessary to reach equilibrium. Therefore, the position of the water level noted on the boring logs for cohesive or mixed-texture soils may not indicate the true level of the ground water table.

LAKE VIEW TOWNSHIP
Becker County, Minnesota

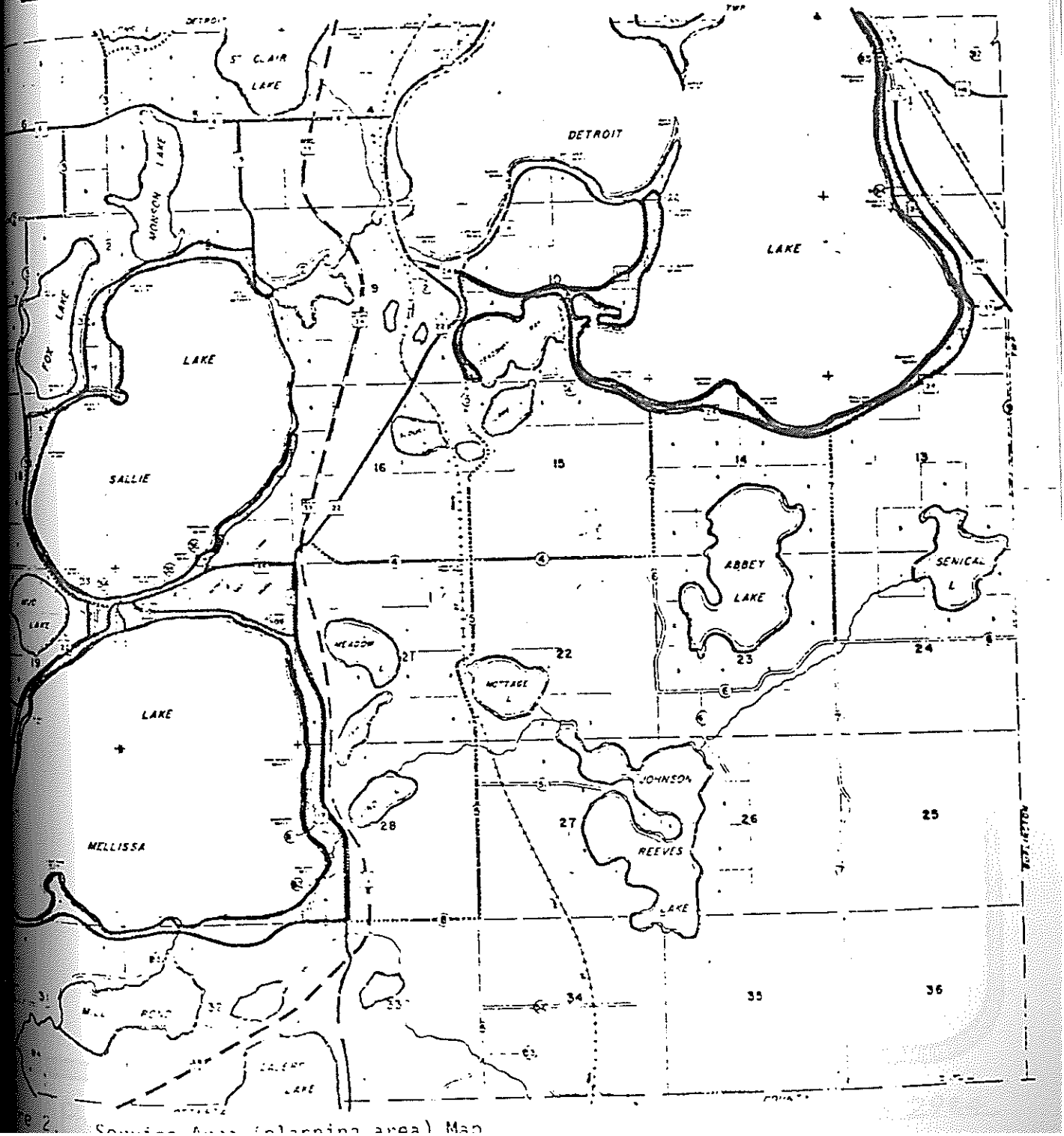
TOWNSHIP 138 NORTH RANGE 41 WEST

NORTH

SCALE

0 1/2 1/4 1 MILE

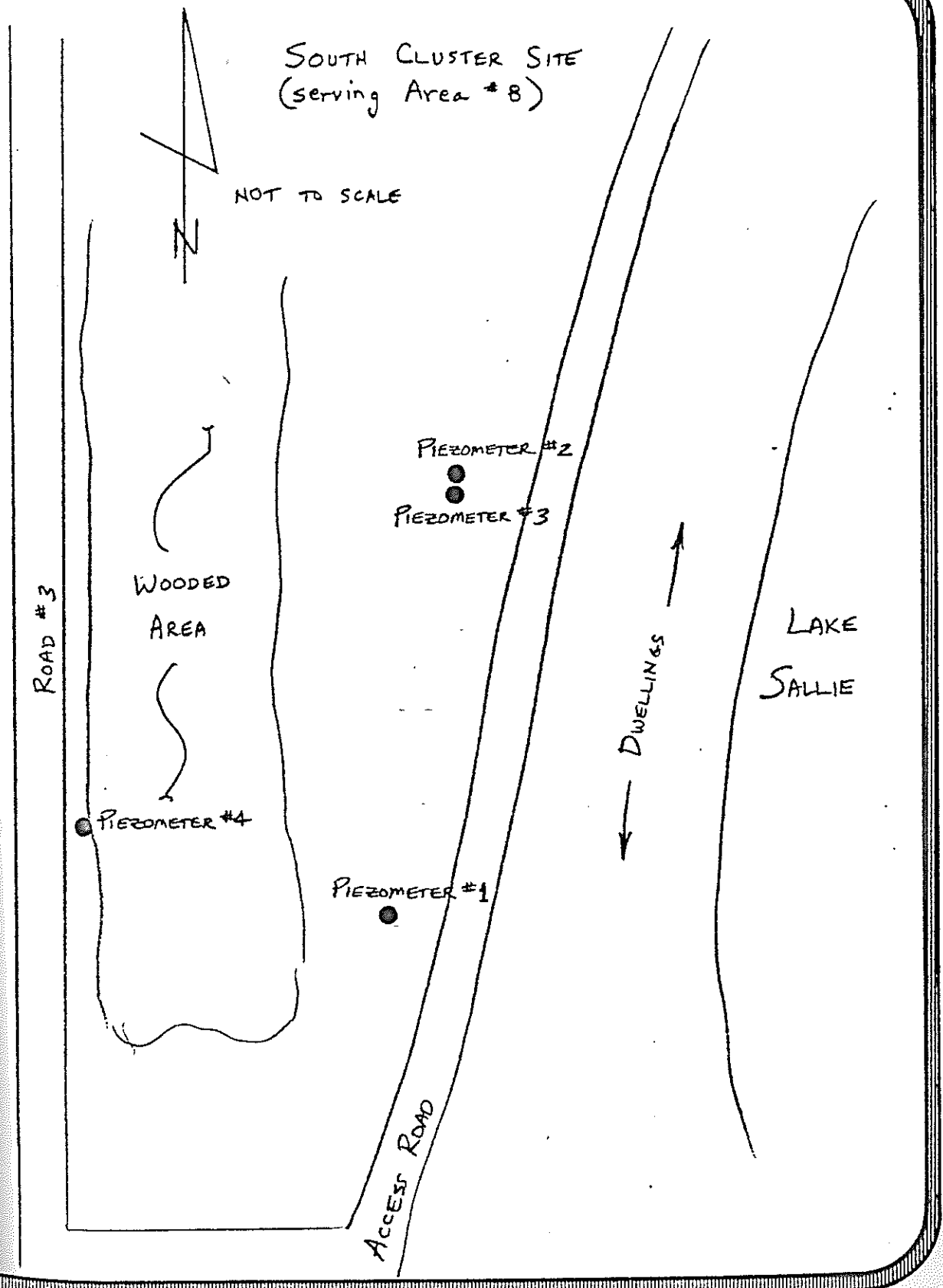
SERVICE AREAS



Sewing Area (planning area) Map

MIDWEST TESTING LABORATORY

TEST BORING LAYOUT

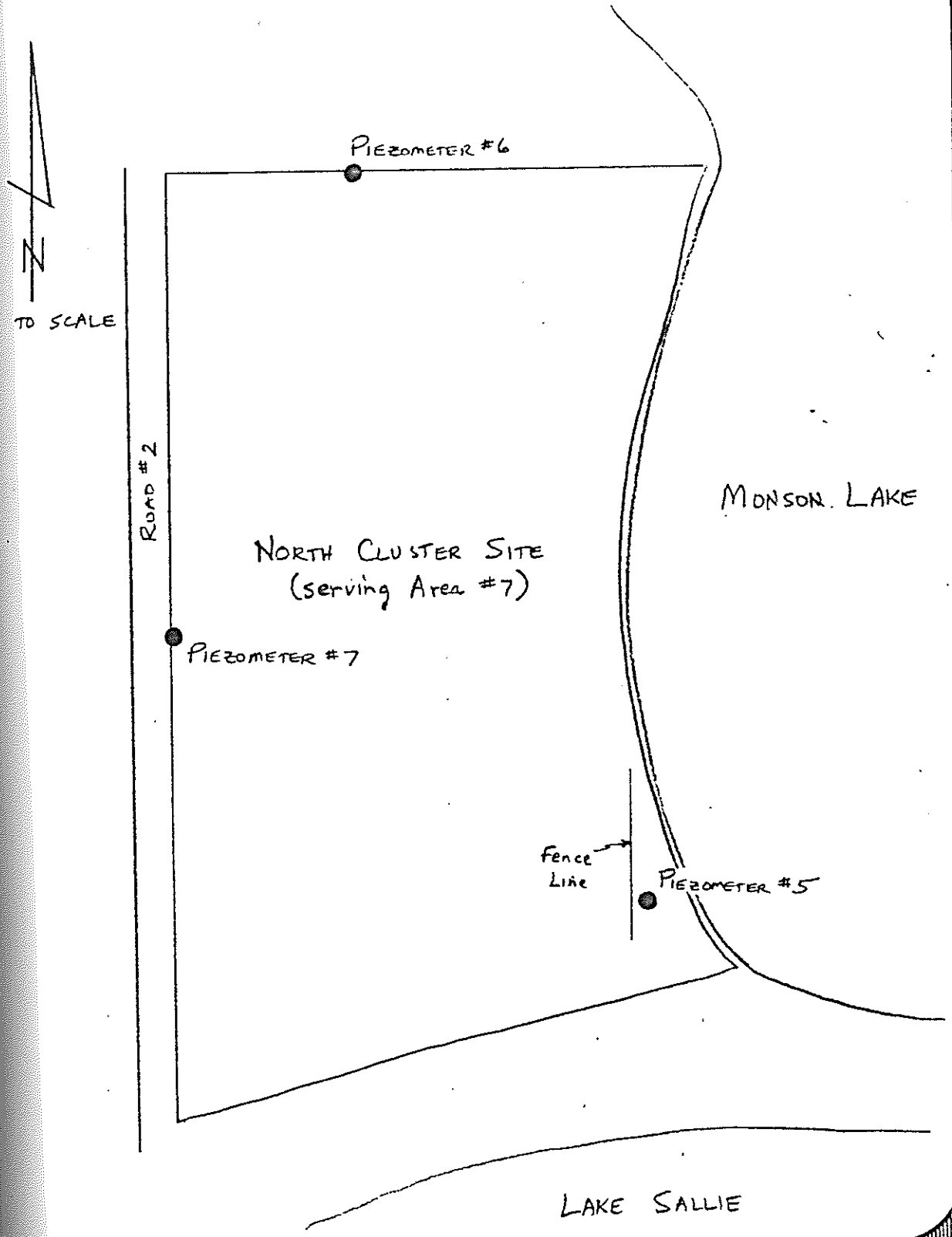


Proposed Wastewater Treatment Facilities

JOB NO. 2984

MIDWEST TESTING LABORATORY

TEST BORING LAYOUT

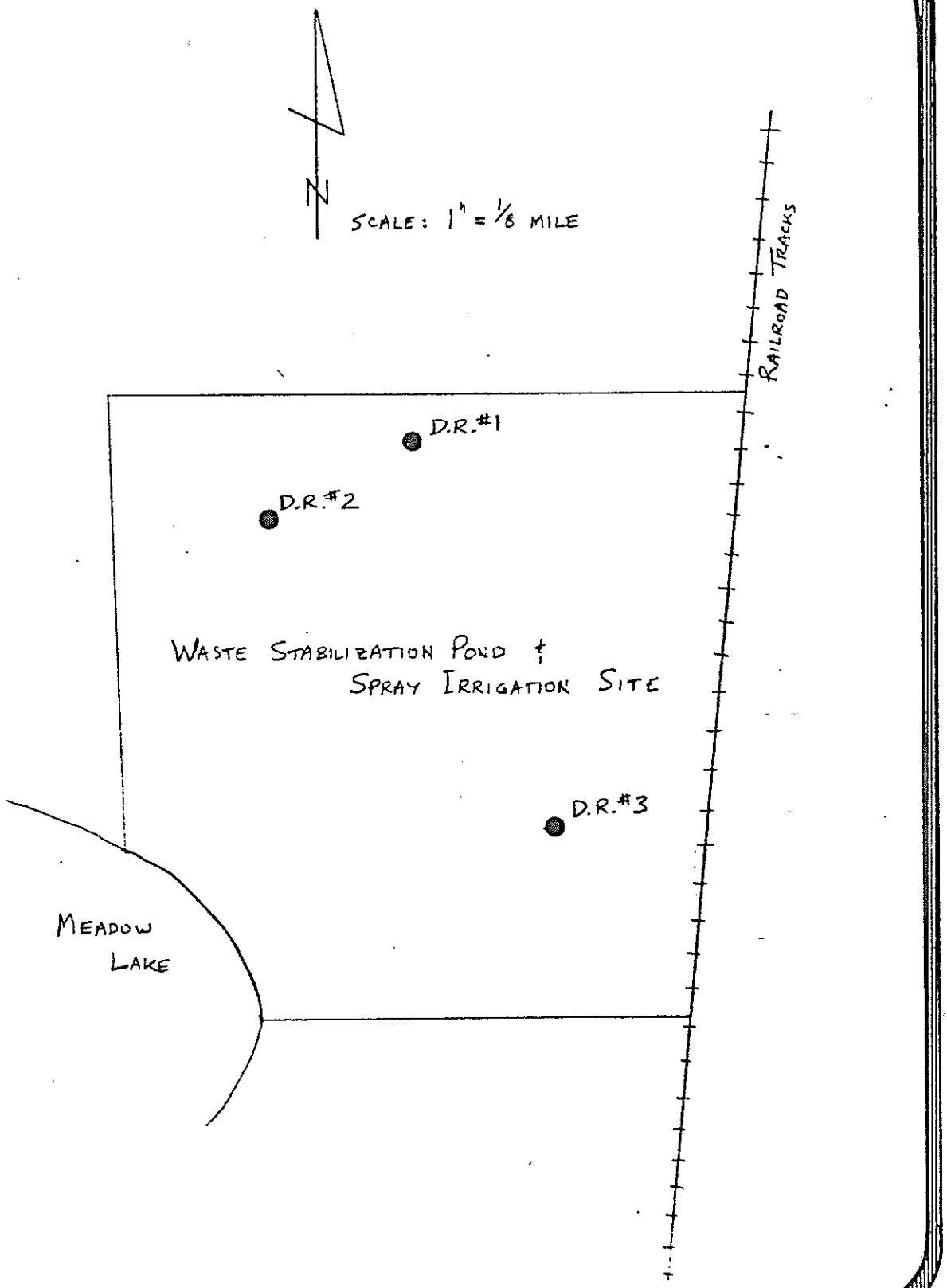


Proposed Wastewater Treatment Facilities

JOB NO. 2984

MIDWEST TESTING LABORATORY

TEST BORING LAYOUT



PROPOSED WASTEWATER TREATMENT FACILITIES

JOB NO. 2984