

Final Project Report

**Long-Term Hydrogeological Research  
and Educational Test Site**

KCHE 51 - 611851

Aug. 15, 1991 - Aug. 14, 1992

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Nov. 13, 1992

## INTRODUCTION:

This report covers the research activity of the KCHE-funded hydrogeological project entitled "**Long-Term Hydrogeological Research and Educational Test Site**" which was conducted on Western Michigan University property in SW Kalamazoo. The report will make reference to three different but contiguous parcels of land. The Asylum Lake area is that north of Parkview Ave. and east of Drake Rd., in Kalamazoo Township. Colony Farm Orchard is west of Drake Rd., in Oshtemo Township. The Lee Baker Farm is here referred to as all the remaining property lying south of Parkview Ave., also in Kalamazoo Township. A base map of the area is shown as Figure 1.

Funding of \$59,000 from the Kalamazoo Consortium for Higher Education was approved on Aug. 15, 1991, for the initial year. This report summarizes activities from that date through the end of August, 1992. The project was initially proposed for three years, with \$37,200 and \$27,150 budgeted for the second and third years conditional on merit and availability of funds. By September, the Governor announced that no more resources would be allocated to KCHE, and the project was down-sized to a one-year program. On Aug. 20, 1992, an additional \$10,000 grant from the CEO Council of Kalamazoo was also applied to this project. This sum had been given to the Dept. of Geology and IWS to cover some of the costs of the Hydrogeology Field Course taught during the month of July and was totally expended for that end.

## PROJECT ACTIVITY (second semester):

Activity during the first semester of the project was summarized in the "Semi-Annual Progress Report" of Feb. 14, 1992. Continuing work during the spring and summer of 1992 is as follows.

- ▶ Another multi-port gas sampling well was installed near AL-1 (John Ring thesis) to investigate the natural soil gas composition from the surface down to the water table, approximately 60 feet at this location. This brings to three the number of these special installations.
- ▶ Graduate assistants Bryan Allen and Vince Buening completed installation of protective steel covers and locking caps on all wells. They also completed the surveying required to establish the elevation at the top of each well (surface elevation and height of riser above ground level). These data allowed a contour map of static water levels to be produced.
- ▶ Bryan Allen completed the granulometry (sieve) analyses of all the split-spoon samples from the project and produced one-page graphical and numerical reports for each sample.

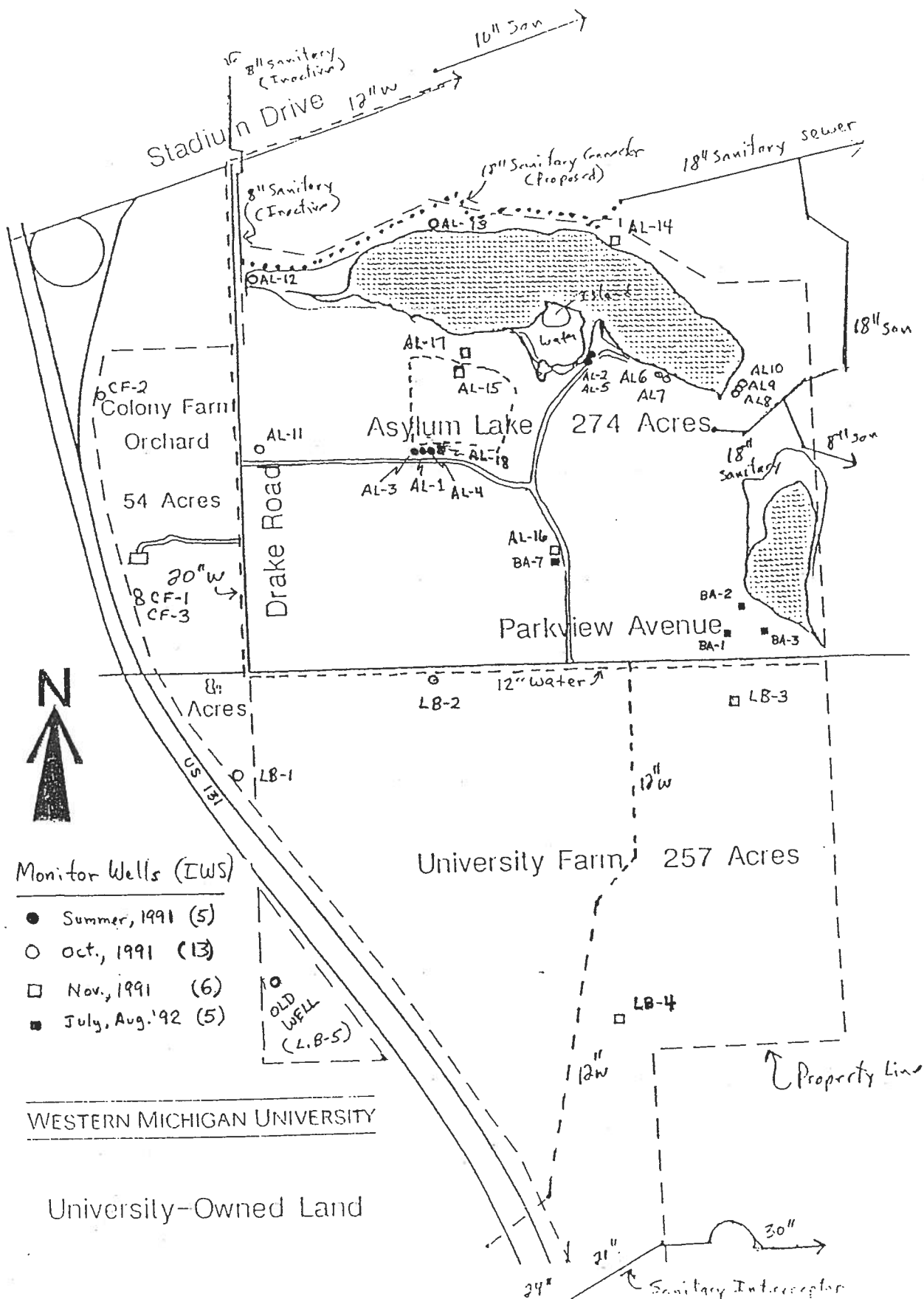


Figure 1 : Base map of the project area showing the monitor wells installed as of Aug. 31, 1992. (City of Kalamazoo utilities also shown.)

▶ Continued efforts were made to clean and develop those wells for which this activity was halted earlier by winter weather. The delay between drilling and cleaning contributed to the loss of one well, LB-1, as the bentonite used in the mud-rotary drilling process had gelled and was impossible to remove from the area around the intake screen. This well was also compromised by the presence of very fine sand which also passed through the screen.

▶ Well CF-1 was also abandoned after further work showed that it was not completed in a shallow intermittently saturated formation, as reported by the driller. Geophysical work (resistivity soundings) adjacent to the well failed to show the presence of any clay-rich aquitard or saturated material shallower than 60 feet.

▶ Well LB-3 was completed at an insufficient depth, so there was question as to whether the few inches of water in the bottom was representative of the water table. This has been considered a dry well and it will not be used for sampling purposes.

▶ The 2" galvanized steel well S of Parkview and W of US 131 (dating from 1972) was successfully cleaned of debris and purged. It will serve as a monitor well.

▶ All the wells, including those defective for sampling purposes, were profiled with a down-hole geophysical tool, the gamma-ray logger, which discriminates between sand and clay.

▶ The microbiology sub-project, conducted by Jerry Johnson of KVCC, began regular weekly sampling of surface waters at four sites in May, 1992.

▶ Several days of surface geophysical work was done using the Ground Penetrating Radar (GPR), electrical resistivity, and electromagnetic (EM) methods to obtain approximate locations of buried utility lines connecting the former Asylum Lake buildings with those west of Drake Road.

▶ The M.S. thesis of Vince Buening is nearly complete. He focused his efforts on the interaction between the aquifer and the waters of Asylum Lake. John Ring's thesis work is continuing with more soil gas sampling and analysis. A third M.S. thesis has been initiated by Bryan Allen with separate support. This work builds upon his work and experience to date with the wells of this project. He will be monitoring any changes in ground water quality resulting in leaf composting practices at two sites on the Asylum Lake property.

▶ The initial water sampling campaign was done in the first half of June, 1992. Many of the determinations were made in the field and others were made in the IWS Water Quality Lab under the supervision of Ms. Dannette Shaw.

### CONSORTIUM PARTICIPATION:

Jerry Johnson of KVCC has been a key person in the microbiology sub-project. He has made weekly collections and analyses for coliform bacteria of surface waters in the project area.

### SUMMARY INFORMATION OF ALL WELLS ON THE SITE:

#### **Well Completion Data-**

The geotechnical logs noted for each well during the drilling and sampling process are shown in Appendix A. The blow counts required to drive in the standard split-spoon sampler are shown for each 6" interval are noted, as is the interval for which sample material was actually recovered.

The principal completion facts for all wells on the property as of the end of the project year are shown in tabular form in Appendix B. There are two wells on the Colony Farms Orchard area, three on the Lee Baker Farms, and the remainder are on the Asylum Lake parcel. The concentration on the latter parcel is due to ease of access without interference in farming activities, and to the development of the three M.S. thesis research projects in the area with potential anthropogenic impacts on the Lake and wetlands.

#### **Geologic Samples, Granulometry Data-**

Geologic samples were taken during the well drilling phase for most wells, those drilled using the hollow-stem-auger and the mud-rotary methods. These were taken by driving a cylindrical sampler ("split spoon") by percussion ahead of the drill tool, generally at 5 foot and sometimes at 10 foot depth intervals. This resulted in the retrieval of typically 4 to 16 inches of sample, which is then opened and the sample transferred to a sealed plastic bag for later analysis. The single page reports for grain size analysis of each sample are shown in Appendix C. The first page of this Appendix is a description of the procedure followed for the grain-size analysis. Almost all the samples were in the fine to coarse sand size range, with very minor silt and clay materials. Only the deep well had some samples dominated by clay-sized particles, those from 150 feet and deeper. Material from the surface to this depth are typical of those to be expected in the glacial outwash fan environment, ie, material deposited by streams emanating from the ice margin.

#### **Borehole Geophysical Data-**

Most of the wells were profiled with WMU's gamma ray logger, a geophysical well-logging tool which measures the natural gamma-ray activity as it is slowly lowered and then raised in a well. The deep well, AL-3, was logged several times. Before installation of the 5" PVC riser, it was

logged by Keck, Inc. with the natural gamma, the electrical resistivity, and the caliper tools. After completion, the well was again logged with the WMU logger, also manufactured by Keck. The gamma logs in this environment show deflection to the left indicating sand, while deflection to the right (higher gamma ray activity) shows silts and clays. In this geological environment, the potassium isotope ( $^{40}\text{K}$ ) resides almost exclusively in the fine sediment fraction. Thus, the field logs provide a semi-quantitative indicator of silt-clay content recorded continuously along the borehole. The split-spoon sampling, by comparison, represents about a foot of material sampled every 5 to 10 feet during drilling. These logs are included as Appendix D. For most of the shallow wells the gamma response is low and similar between wells, as the outwash sands have very little silt-clay content. Only in the deep well, AL-3, were clay-rich layers penetrated, and they show clearly on the logs as deflections to the right. Note that the log defines their upper and lower boundaries with much more precision than can be determined by sampling every 5 or 10 feet. Another feature of all the logs is the higher gamma ray activity caused by the concentrated bentonite clay products used to isolate and protect the aquifer from surface waters which would otherwise percolate down the annular space outside the casing or riser. These products were sometimes emplaced near the water table, but always from the surface down to about 6 to 10 feet. This is the reason for the high gamma values at the tops of most wells. Comparisons can be made as to the relative quantities of bentonite seals (typically "Enviroplug" pellets or chips) emplaced by the different drilling and completion methods, particularly where the wells are near each other as is the case for AL-1, AL-3, and AL-4. Well AL-3 had a suite of 4 logs run before installation of the well casing, in the open 8" diameter borehole filled with drilling mud. These were the caliper, short normal resistivity, long normal resistivity, and natural gamma ray logs. After the 5" PVC riser was installed, another gamma ray log was run in the well. These logs clearly define the water table and the clay-rich layers deeper than 140 ft.

#### **Water Levels, Piezometric Surface-**

Water level measurements were made various times in most of the wells. Figure 2 is a typical map of such data derived from measurements in early June, 1992. Only measurements from wells screened in the water table aquifer were used for this map. The water table elevation contours vary smoothly and show a gradient to the east (of approximately 1:380), and locally to the NE as the Lake is approached. Ground water flow directions are perpendicular to these contour lines and hence indicate general flow to the ENE beneath the WMU farms property. Water levels at clusters of wells which are screened at different depths are not the same. For example, at the time the static water elevation in the deep well AL-3 (screen 215-240') was 873.91', the corresponding elevation in the adjacent shallow well,

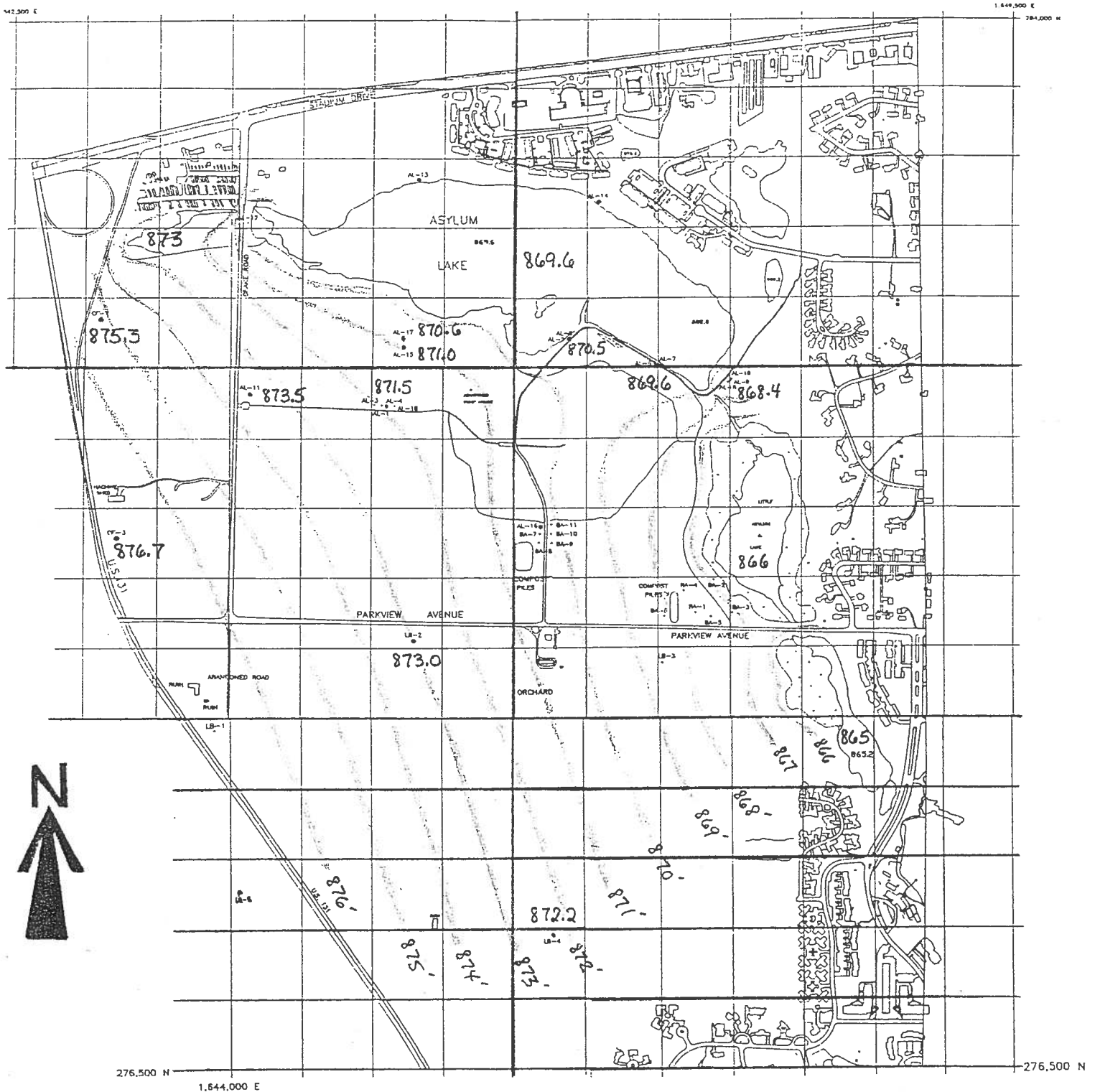


Figure 2 : Contour map of water table elevations (in feet above m.s.l.) for early June, 1992.

AL-1, (screened at 80-95') was 871.51'. This difference in hydraulic head of 2.4' indicates that at the location of these wells there is an upward component of flow, ie, there should be a tendency for water to flow from the deeper aquifer to the shallower aquifer. It can also suggest that one or both of the clay layers encountered between 150 and 210 ft are laterally extensive and effectively serve as aquicludes.

## SUBSURFACE WATER SAMPLING:

### **Methodology-**

The first systematic collection of ground water from most of the wells was in early June, 1992. The wells were purged by removing a volume of water several times the amount of the standing column in the well. Next a low-flow pump was used to draw water through a flow cell in the portable field laboratory which is mounted in the IWS van. When the measured parameters stabilized, the dissolved oxygen, electrical conductivity, pH, and temperature were recorded. At that time, samples were drawn for immediate analysis in the field of the following constituents:  $\text{NH}_3\text{-N}$ , Iron, Nitrite, Nitrate ( $\text{NO}_3\text{-N}$ ), Phosphate, Silica, Total Alkalinity (as equivalent  $\text{CaCO}_3$ ), Sulfide, and Chloride. The field analyses were made using a Chemetrics Field Kit which uses the photometric analysis technique. Then, two sample bottles were filled and preserved for later analysis in the IWS Water Quality Laboratory for the following:  $\text{Ca}^{++}$ ,  $\text{Mg}^{++}$ ,  $\text{Na}^+$ ,  $\text{K}^+$ , Fe, Mn, Cu, Cd, Pb, Zn, and  $\text{SO}_4^{-2}$ .

### **Results-**

The results of this series of measurements, which took about two weeks to complete are shown here as a series of maps, and in tabular form (Appendix E). (Some of these maps also include data from near-surface samples on Asylum Lake, in cases where it was appropriate to compare constituents in ground water and lake water.) Figure 3 shows the distribution of aquifer temperatures, which average  $10.4^\circ\text{C}$  and range between  $8.3^\circ\text{C}$  and  $12.4^\circ\text{C}$ . These temperatures are representative of the shallow aquifer even though some wells are considerably deeper than others. The flow cell temperatures are made with low pump rates and the water rising in the sample tubing equilibrates with the water in the standing column of water in the well as well as the soil and air temperature. The small range of variations and lack of systematic pattern does not permit any profound conclusions to be drawn from this data set, although it stands as a reference for comparisons in the future.

The map of ground water conductivity (Figure 4) is a useful overview of water quality. It is approximately proportional to the total dissolved ion content (anion and cation) of the water. The rather large variations are probably due primarily to road salting practices. The two wells just east of US 131 (CF-2 and CF-3) show the greatest values, while LB-5 further south and west of US 131 shows





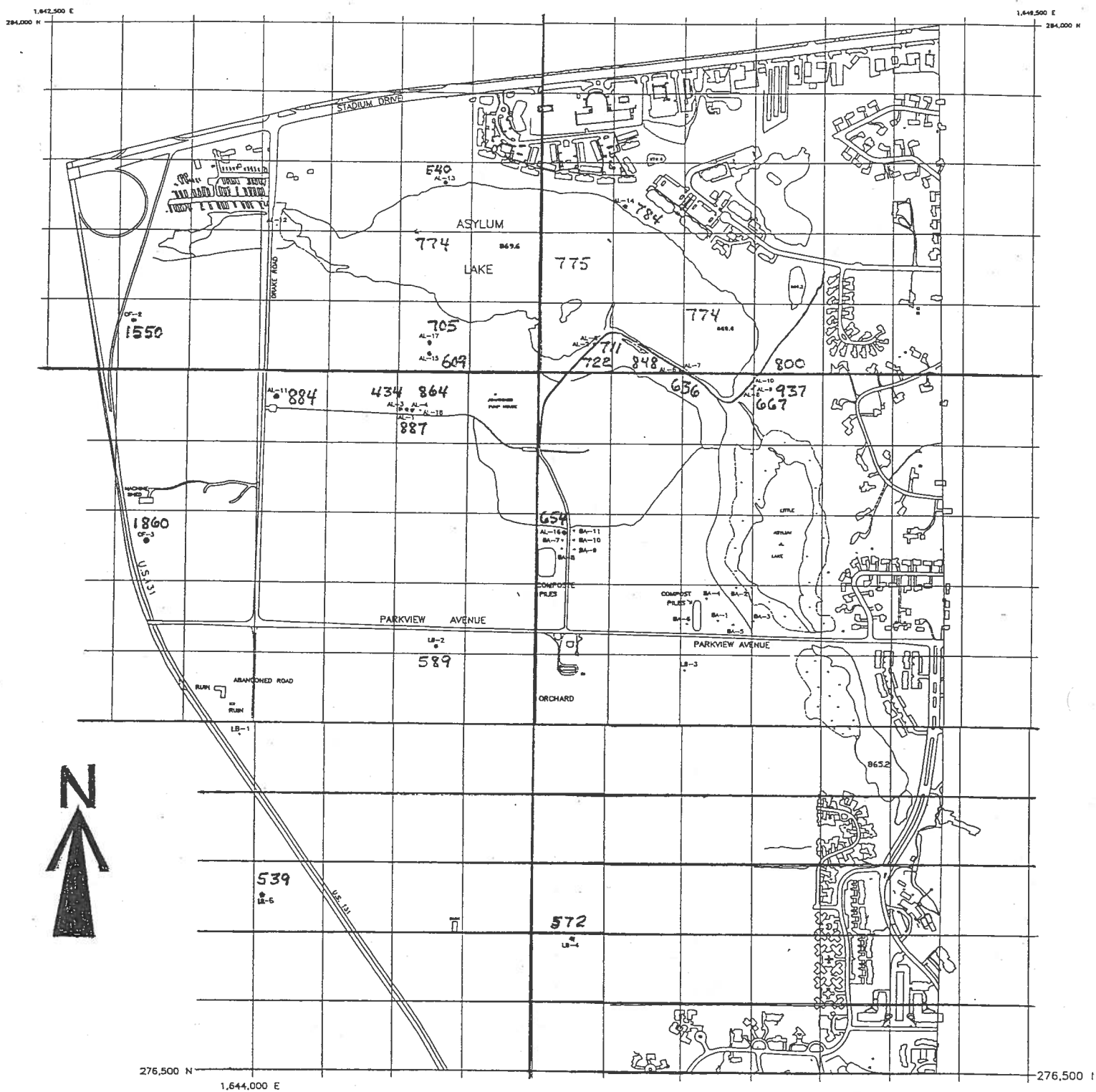


Figure 4 : Map of water conductivity (specific electrical conductance) in IWS/KCHE monitor wells, WMU farms property; June, 1992 sampling period. Units are micro-mhos/cm or micro-Siemens/cm.

the second lowest value. The ground water flow directions from Figure 2 are clearly from W to E, and hence the greatest effect of salting should be to the east of the most heavily salted portion of the highway, near curves and the interchange with Stadium Drive. Dilution effects (lateral and downward spreading, with infiltrating rainfall superposed) diminish the conductivity in wells further to the east. The maximum value of  $1860\mu\text{S}/\text{cm}$  occurs in a well located in a gentle topographic depression adjacent to US 131. Salt-contaminated runoff from the highway accumulates in such areas during the winter, and then infiltrates after the Spring thaw. Wells south of Parkview, LB-2, LB-4, and LB-5, probably represent background conductivities for the area. The deep well, AL-3, shows the lowest value in the entire survey area,  $434\mu\text{S}/\text{cm}$ . This indicates that shallow ground water flow lines from the area of US 131 do not reach the screened depth interval of 215-240 ft. of this well 2000 ft. east of US 131. The implication is that the clay materials at 150 ft. and 200 ft. depth have considerable lateral continuity, ie, this lower aquifer is somewhat protected from surface contamination. The three values for near-surface samples of Asylum Lake are slightly higher than for most adjacent shallow wells. These more elevated values can probably be attributed to street and parking lot runoff originating from the Stadium Drive area and flowing south along Drake Rd. and entering the Lake at its western extremity.

The map of dissolved oxygen content of the monitoring well samples (Figure 5) is relatively simple. The bulk of the values between 6.6 and 8.8 ppm indicate waters in contact with the atmosphere. The single very low value at well AL-3 (215 - 240 ft screen depth) supports the conclusion that water from this lower aquifer has not been in contact with the atmosphere for a long period of time, and it is well isolated from the upper aquifer. The lower values at wells at the SE end of the Lake can be explained by the observation that all these wells yielded reducing waters (with finely divided black particles which settled out of samples or could be filtered out) resulting from passage through organic-rich sediments. The oxygen demand of the decaying organic material caused the lowered oxygen values in the ground water.

The map of pH values (Figure 6) shows that the aquifers are slightly basic, as is normal in this region for glacial aquifers. The pH values for Asylum Lake near-surface waters have been added to this map for comparison. These waters are significantly higher, reflecting the result of biological (photosynthesis) and chemical (carbonate mineral equilibrium) processes acting on the water composition in the lake.

Figure 7 is the map of total alkalinity, which shows a range of 160 to 340 (mg/l as  $\text{CaCO}_3$ ) over the area. Increases in total alkalinity are caused by carbonate mineral dissolution from soils, and microbial respiration of organic matter in the subsurface.

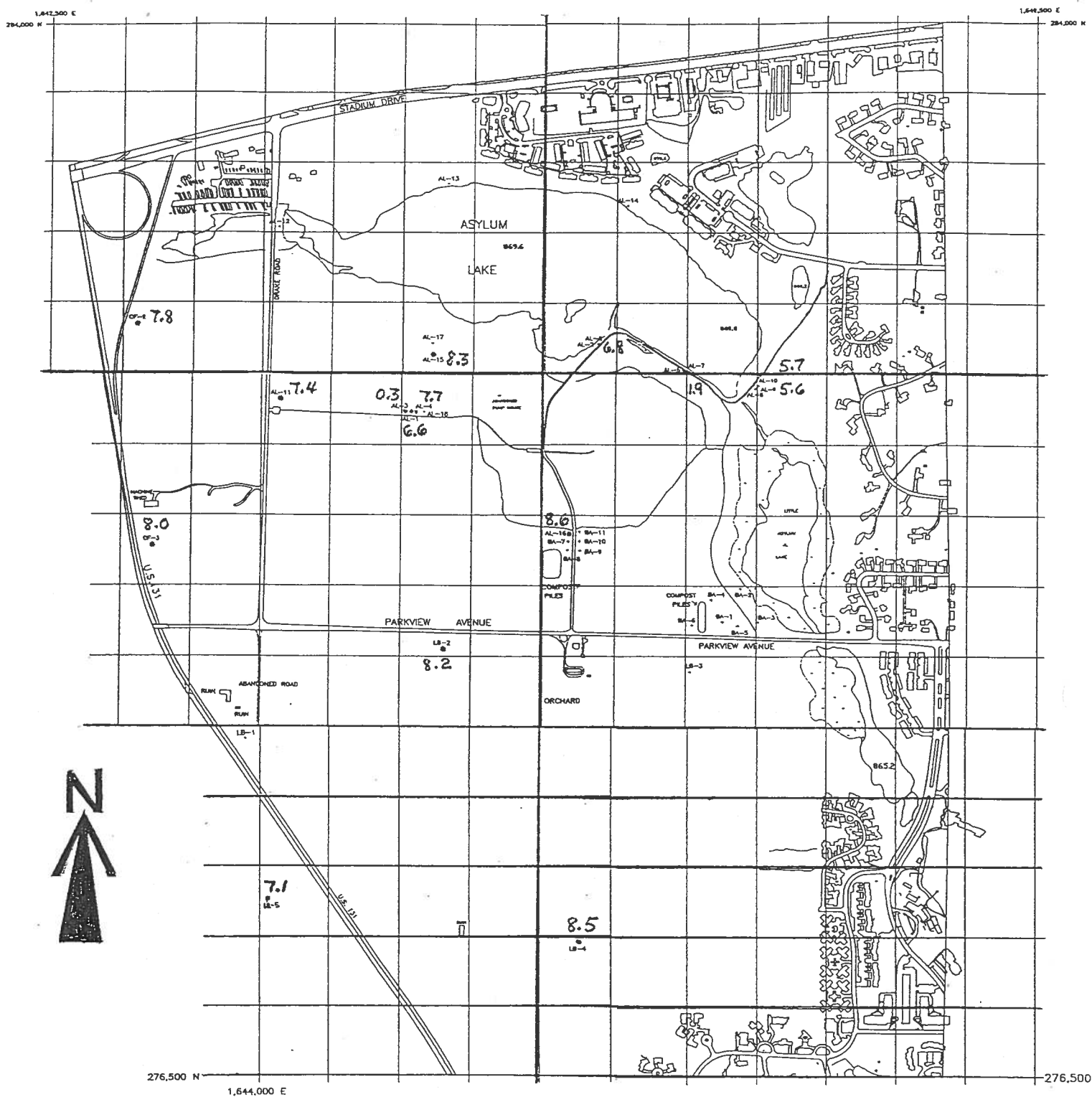


Figure 5 : Map of Dissolved Oxygen content in IWS/KCHE monitor wells, WMU farms property; June, 1992 sampling period. Concentrations in ppm.

Figure 7 : Map of Total Alkalinity in IWS/KCHE monitor wells and surface waters of Asylum Lake; WMU farms property, June, 1992 sampling period. Units are ppm as  $\text{CaCO}_3$ .

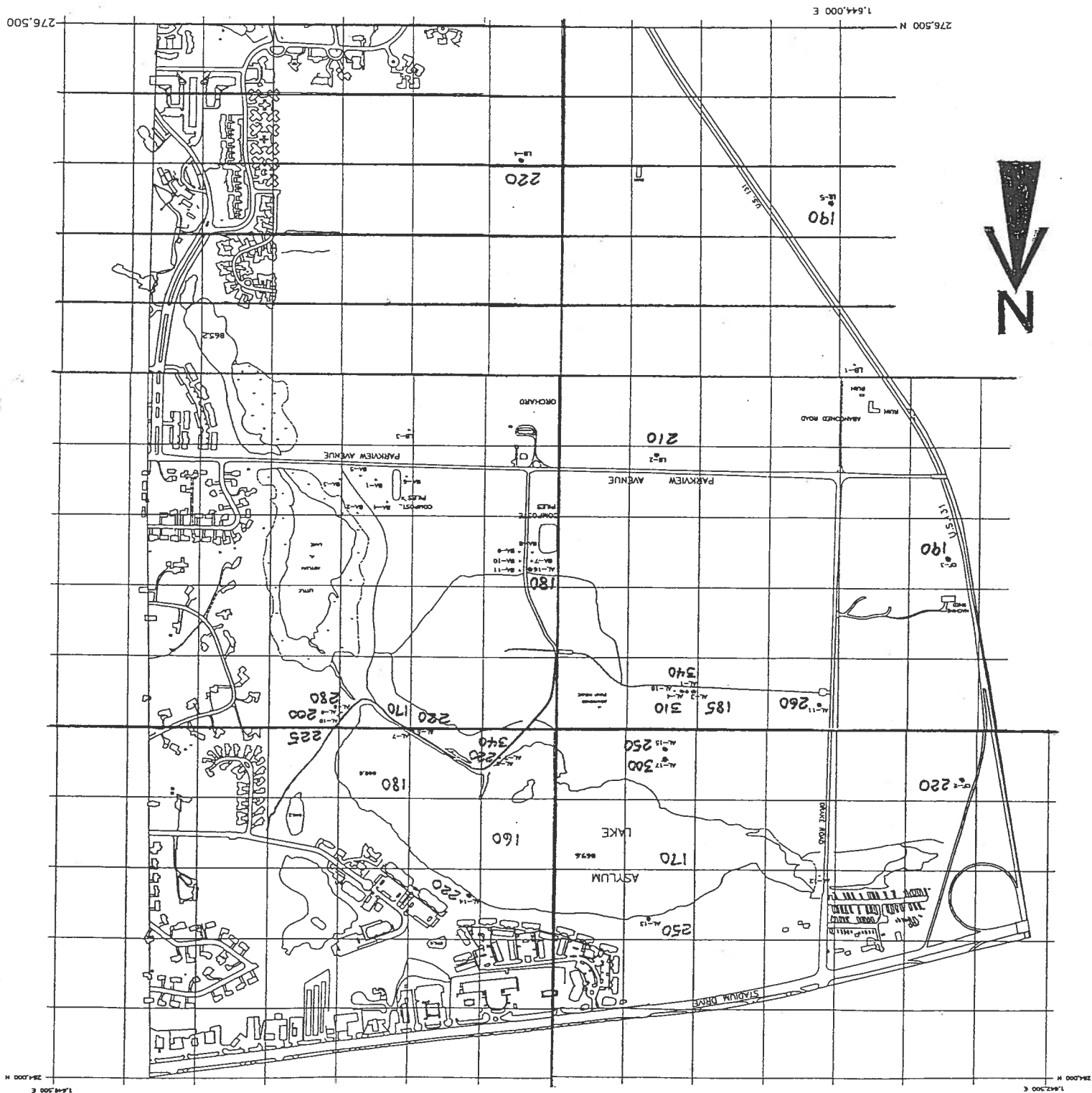
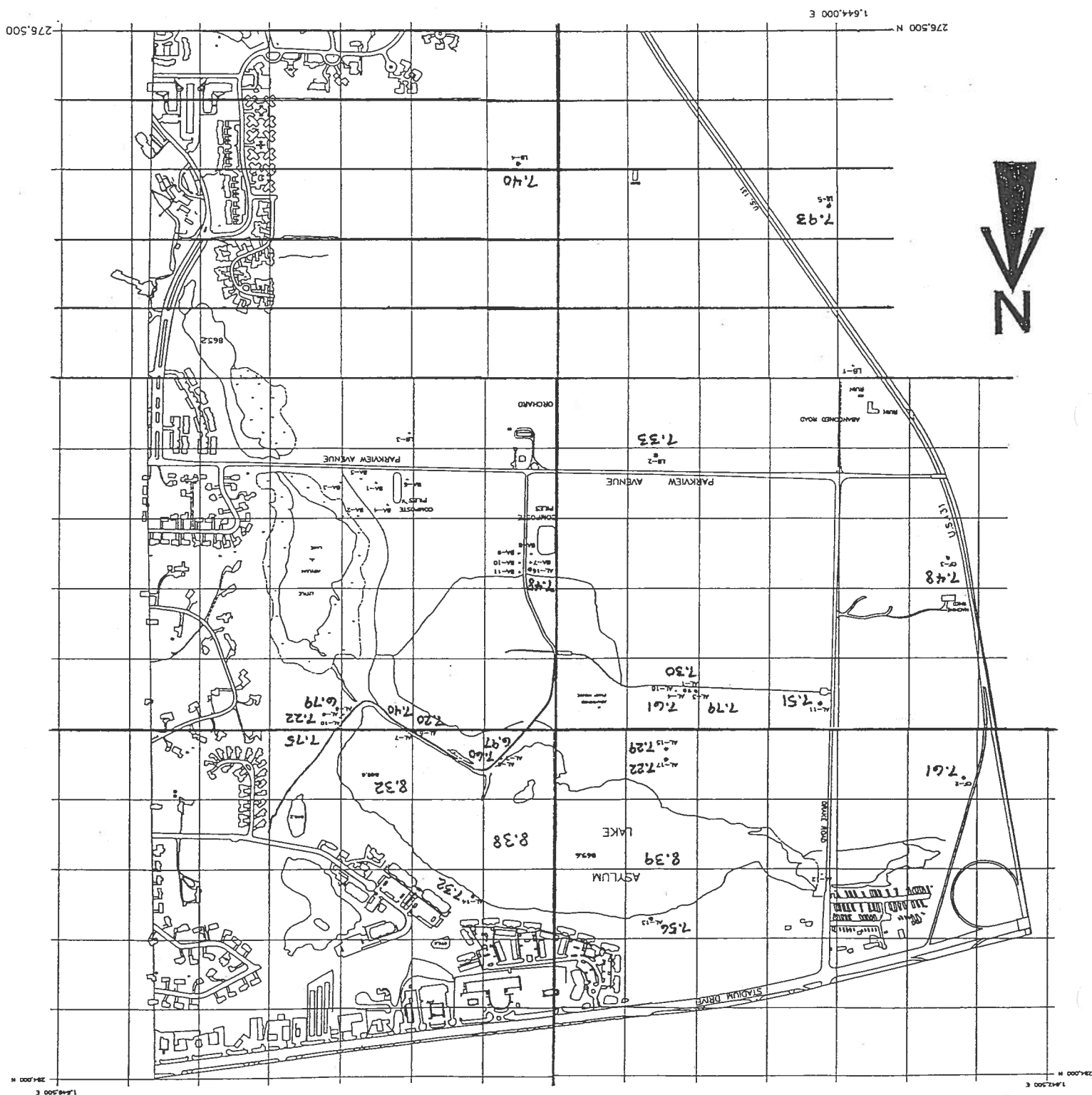


Figure 6 : Map of pH in IWS/KCHE monitor wells and surface waters of Asylum Lake, WMU farms property; June, 1992 sampling period.



The map of sodium ion concentrations (Figure 8) shows an extremely wide range, with the up-gradient well on the west side of US 131 showing approximately 1% of the downgradient  $\text{Na}^+$  at wells CF-2 and CF-3. This reinforces the interpretation that winter salt applications are a cause of the ground water degradation along US 131 north of Parkview. Relatively unimpacted wells (LB-2, LB-4, LB-5, AL-3, AL-16) have sodium content ranging between 2 and 6 ppm. Asylum Lake shows higher Na values than adjacent wells due to surface runoff and evaporation from the lake surface.

The chloride concentrations shown in Figure 9 show a pattern similar to the sodium (and the conductivity in Figure 4). Values from apparently unimpacted wells give a background range of 2.6 to 8.0 ppm, while the maximum concentrations are just east of US 131 and reach 480 ppm. Asylum Lake shows concentrations (130 - 150 ppm) much greater than surrounding wells, again verifying that it suffers a heavy influx of runoff salts. For reference,  $\text{Cl}^-$  in excess of 100 ppm imparts a salty taste.

The map of calcium ion concentrations (Figure 10) shows little variation in the wells, between 50.6 and 97. ppm. The deep well, AL-3, shows markedly less than adjacent wells in the water table aquifer. Well AL-14, on the NE side of the Lake is anomalously low. An average calculated eliminating these two low values is 82.0 ppm. The near-surface samples from the Lake are systematically lower in  $\text{Ca}^{++}$  than the adjacent ground waters because of carbonate precipitation.

Figure 11 is a map of the nitrate concentrations found in the wells. This is usually a measure of contamination by agricultural fertilizers, and locally by domestic septic disposal systems. Wells in tilled fields or down gradient from them showed moderate  $\text{NO}_3^-$  levels (LB-2, LB-4, LB-5, AL-16, AL-17). Exceptions to this observation were found at AL-1, AL-4, and AL-15. The deep well, AL-3, showed very low values as expected for a protected aquifer. Conversely, the only anomalous high value in non-tilled areas was at well AL-5. This may be a biased data point, or it may point to possible nitrate loading by past sewage disposal practices of the residences which stood for many years in the adjacent wooded area. For reference, the Health Department limit for drinking water is 10 ppm. The low values on this property attest to, and recommend, the conservative farming practices of the leasee who has practiced low input, low tillage farming for at least the past five years on this property.

The final map of this series, Figure 12, shows sulfate ion concentration in waters of the area. The range of values, from about 13 to 40 ppm, is narrow and limited to concentrations which are of little concern. The spatial variability does not appear to show any consistent pattern.





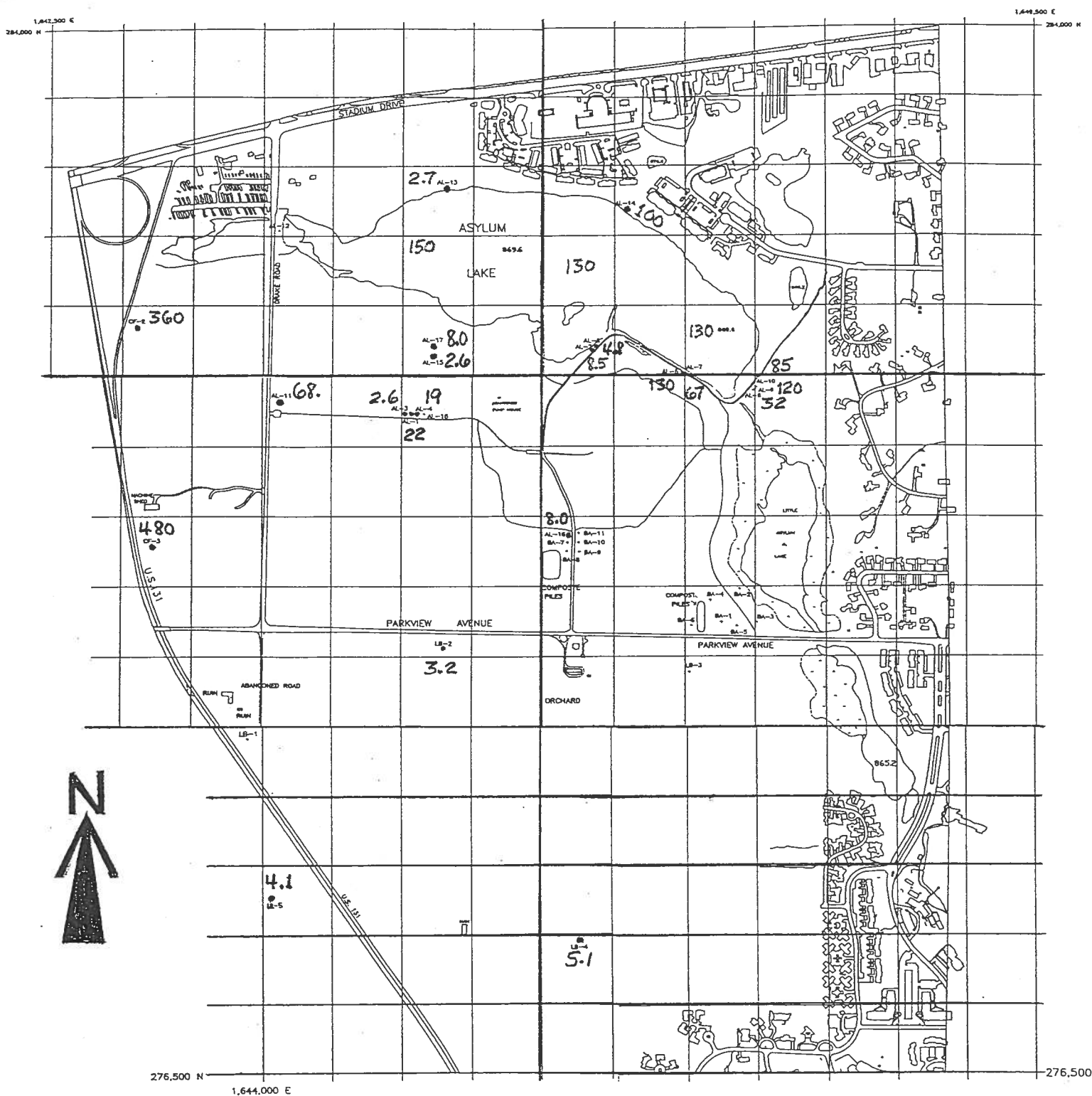


Figure 9 : Map of Chloride concentration in IWS/KCHE monitor wells, WMU farms property; June, 1992 sampling period. Concentrations in ppm.

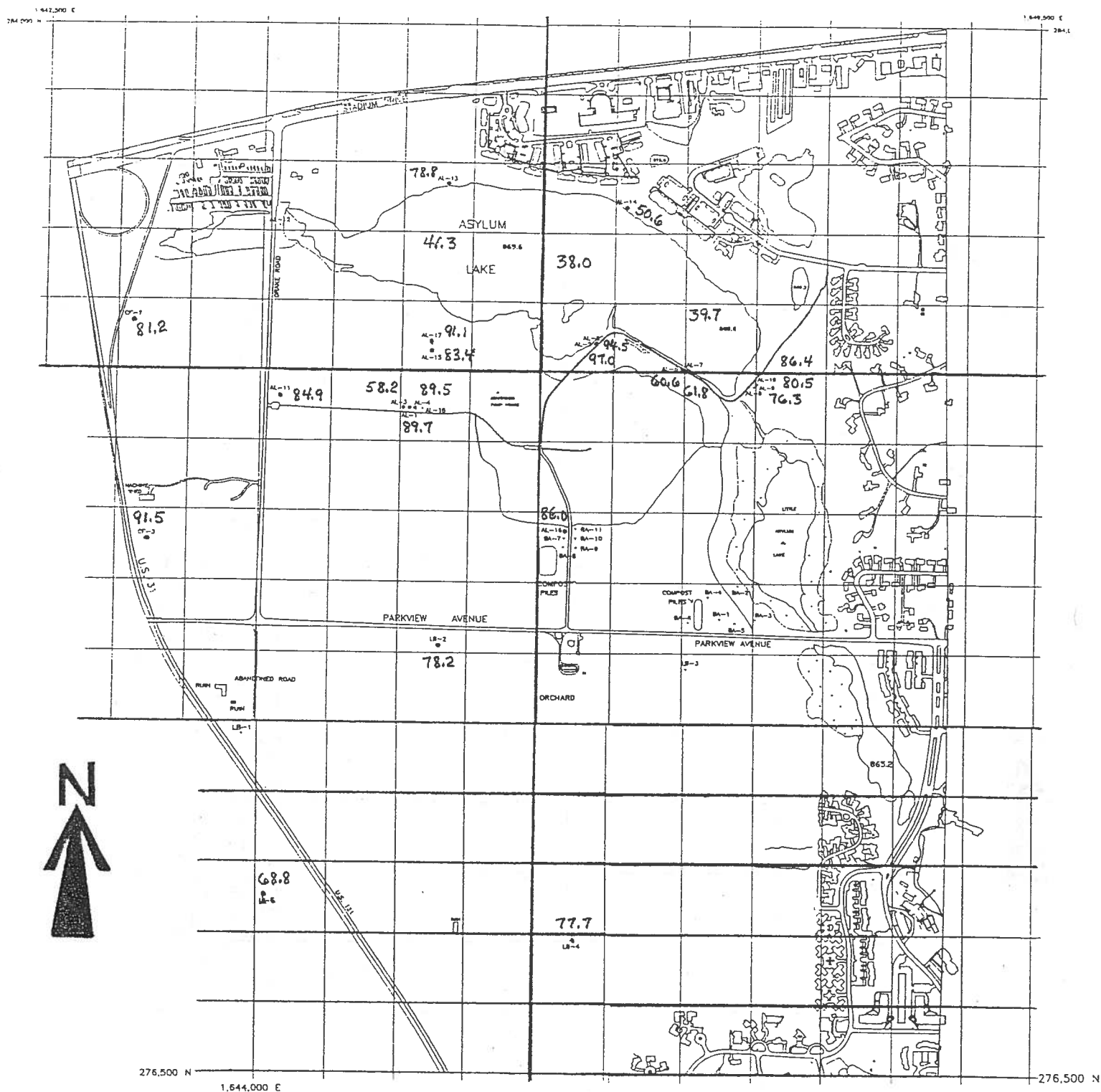


Figure 10 : Map of Calcium (Ca<sup>++</sup>) concentration in IWS/KCHE monitor wells and surface waters of Asylum Lake, WMU farms property; June, 1992 sampling period. Units are ppm.

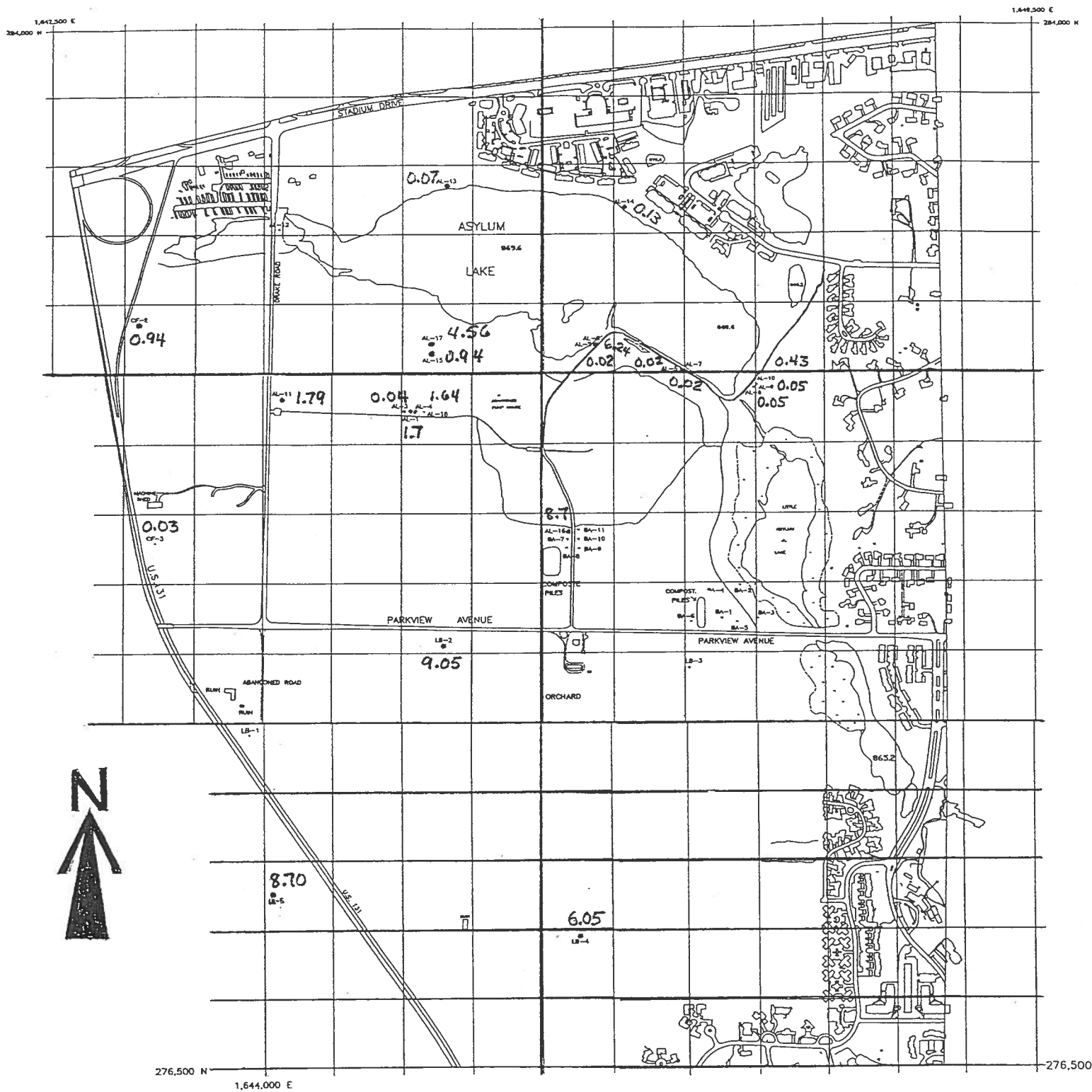


Figure 11 : Map of Nitrate ( $\text{NO}_3\text{-N}$ ) concentration in IWS/KCHE monitor wells, WMU farms property; June, 1992 sampling period. Concentrations in ppm.

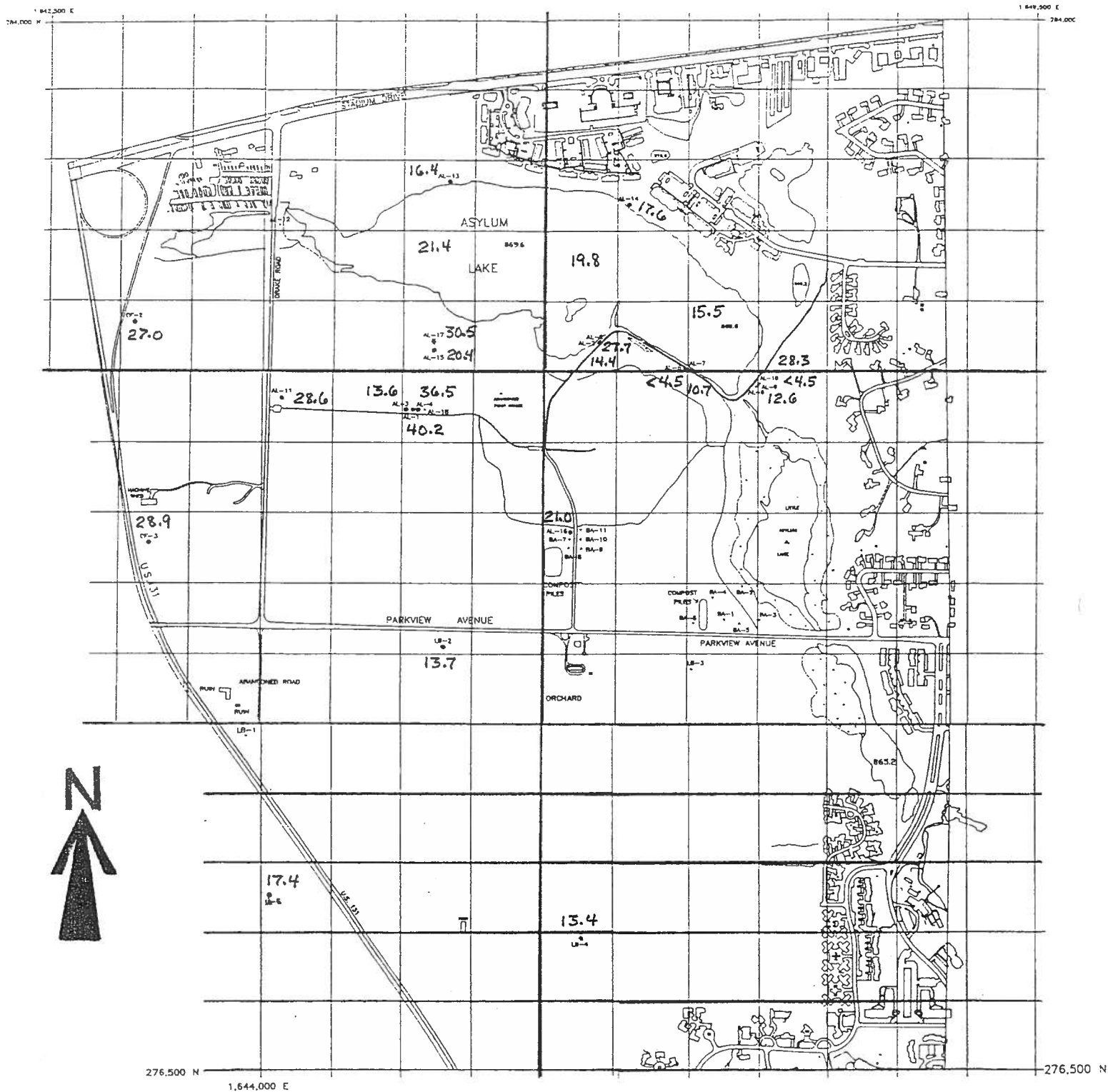


Figure 12 : Map of Sulfate ion ( $\text{SO}_4^{2-}$ ) concentration in IWS/KCHE monitor wells and surface waters of Asylum Lake, WMU farms property; June, 1992 sampling period. (In ppm).

In general, the shallow ground-water quality on the Asylum Lake and Lee Baker Farm properties is good. The shallow ground-water exhibits distinct differences from the deeper ground water (AL-3) which has been out of contact with the atmosphere for some time. Road salting effects on ground-water quality on the Colony Farms property and the western margin of the Asylum Lake property are evidenced by higher total dissolved solids contents (*ie.*, higher conductivities,  $\text{Na}^+$  and  $\text{Cl}^-$  concentrations).

Ground-water and surface runoff inputs to Asylum Lake are evidenced by higher alkalinity, lower pH and higher  $\text{Ca}^{++}$  concentrations which may differ substantially over the course of a year. This snapshot of water quality conditions reflects conditions during the latter part of the project period only. In-lake water quality indicators were good as well during the spring of 1992. However, the lake shows strong thermal and chemical stratification which would be expected to change substantially through summer and fall seasons.

#### SAMPLING OF SURFACE WATERS:

The principal body of water on the property is Asylum Lake. As mentioned in the first report, a bathymetric survey was done prior to beginning any other studies. The Sonar map is shown in a simplified digital rendition as Figure 13, with contour lines at 10 ft. intervals and the locations of transects 1 - 9 shown. (Later, a report including a Sonar map was provided by Dr. J.G. Engemann of the WMU Biological Sciences Dept. which is almost identical to this map.) Sampling for physico-chemical characterization was done in June, 1992 in the middle of transects 2, 6, and 8. Sampling for microbiological purposes was done at approximately 1-week intervals from May through Aug., 1992 at 3 sites on Asylum Lake and one at the outfall of Little Asylum Lake at the Parkview Ave. culvert.

#### **Physico-chemical Results-**

Measurements made at 3 depths below the midpoints of the three transects were plotted to produce a series of longitudinal sections, from WNW to ESE, through the Lake. Figure 14 shows the temperature distribution in mid-June, 1992. It shows a well-established thermocline at 7 - 8 ft. depth. The next section, Figure 15, shows the specific conductance at these sampling points. A marked density stratification with apparently 33% higher concentration of dissolved solids near the bottom, relative to the near-surface water, is shown. In addition, a sample at the far west end of the Lake has a value similar to that of the bottom water, and is due to the influx of high dissolved solids water from the marsh below the mobile home park west of Drake Road. Examples of the conductivity and temperature data plotted as vertical profiles are shown in Figure 16 for Transects 5 and 6. Figure 17 shows the two-dimensional distribution of pH along this section. It clearly shows a decrease in pH with depth (increase

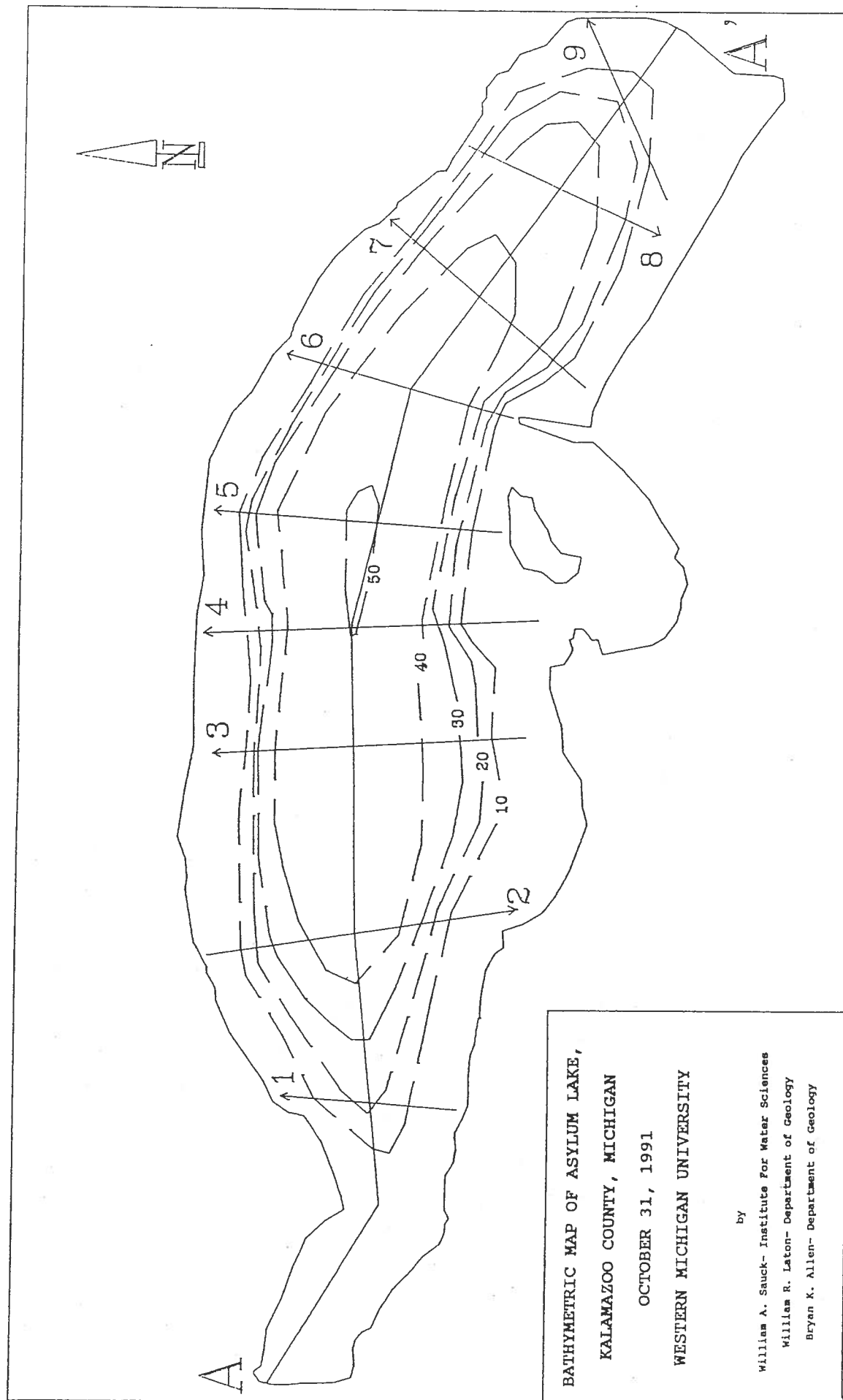


Figure 13 : Bathymetric contour map of Asylum Lake, Kalamazoo Co., MI, showing locations of data transects. (Depth contours in feet).

# ASYLUM LAKE

## CROSS SECTION

West

Date Sampled - June 18-19, 1992

East

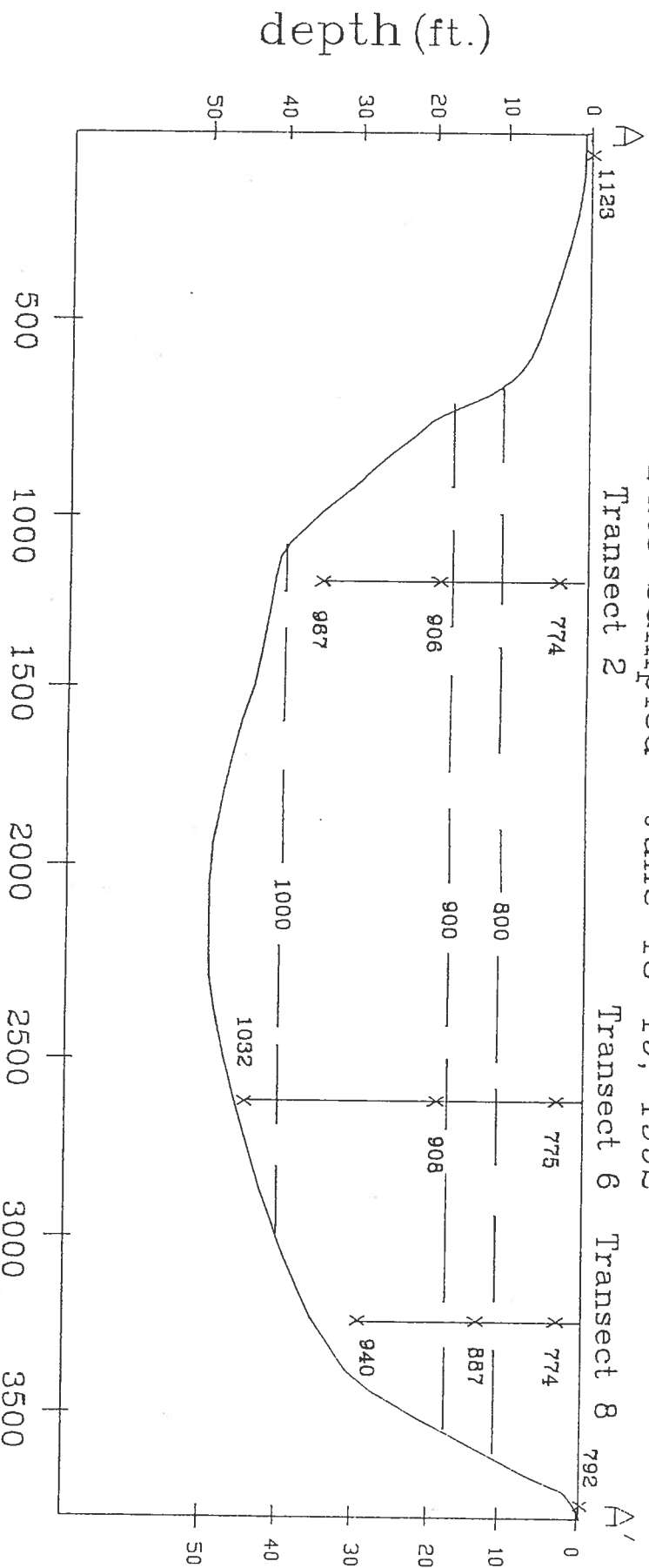


Figure 15 : Longitudinal section of Asylum Lake, with water conductivities in micro-Siemens/cm.

# ASYLUM LAKE

## CROSS SECTION

West Date Sampled - June 18-19, 1992 East

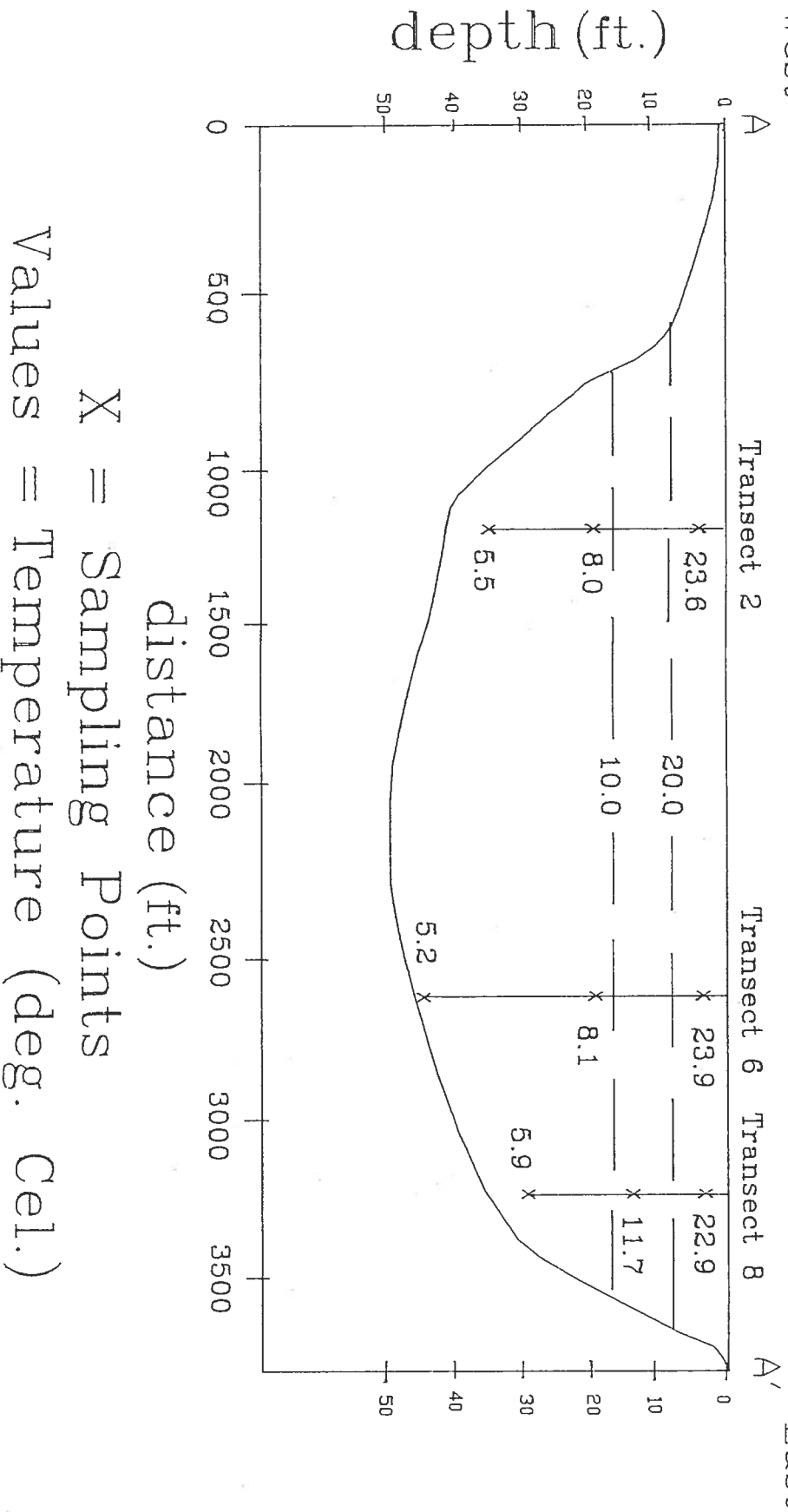
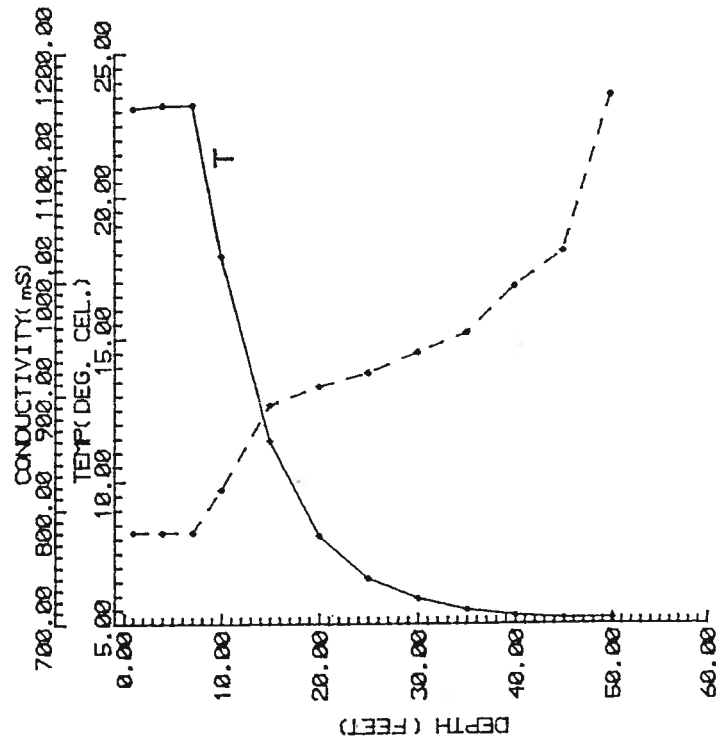


Figure 14 : Longitudinal section of Asylum Lake showing water temperatures.



..... PROFILE OF TEMPERATURE  
 AND CONDUCTIVITY VS. DEPTH  
 CENTER OF TRANSECT #5  
 ASYLUM LAKE  
 JUNE 18, 1992  
 B. ALLEN



..... PROFILE OF TEMPERATURE  
 AND CONDUCTIVITY VS. DEPTH  
 CENTER OF TRANSECT #6  
 ASYLUM LAKE  
 JUNE 18, 1992  
 B. ALLEN

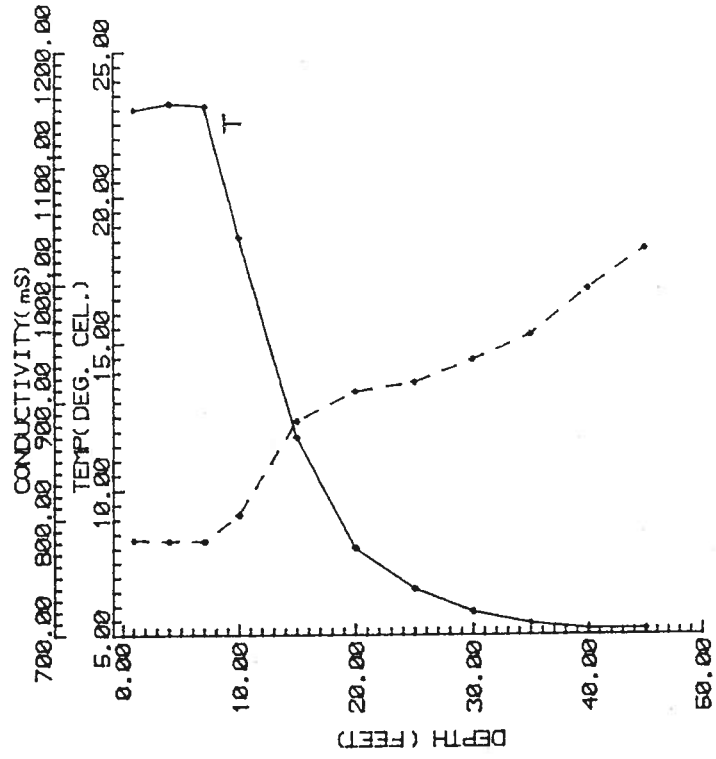


Figure 16 : Depth profiles in Asylum Lake showing both conductivity and temperature  
 at transects 5 and 6.

# ASYLUM LAKE

## CROSS SECTION

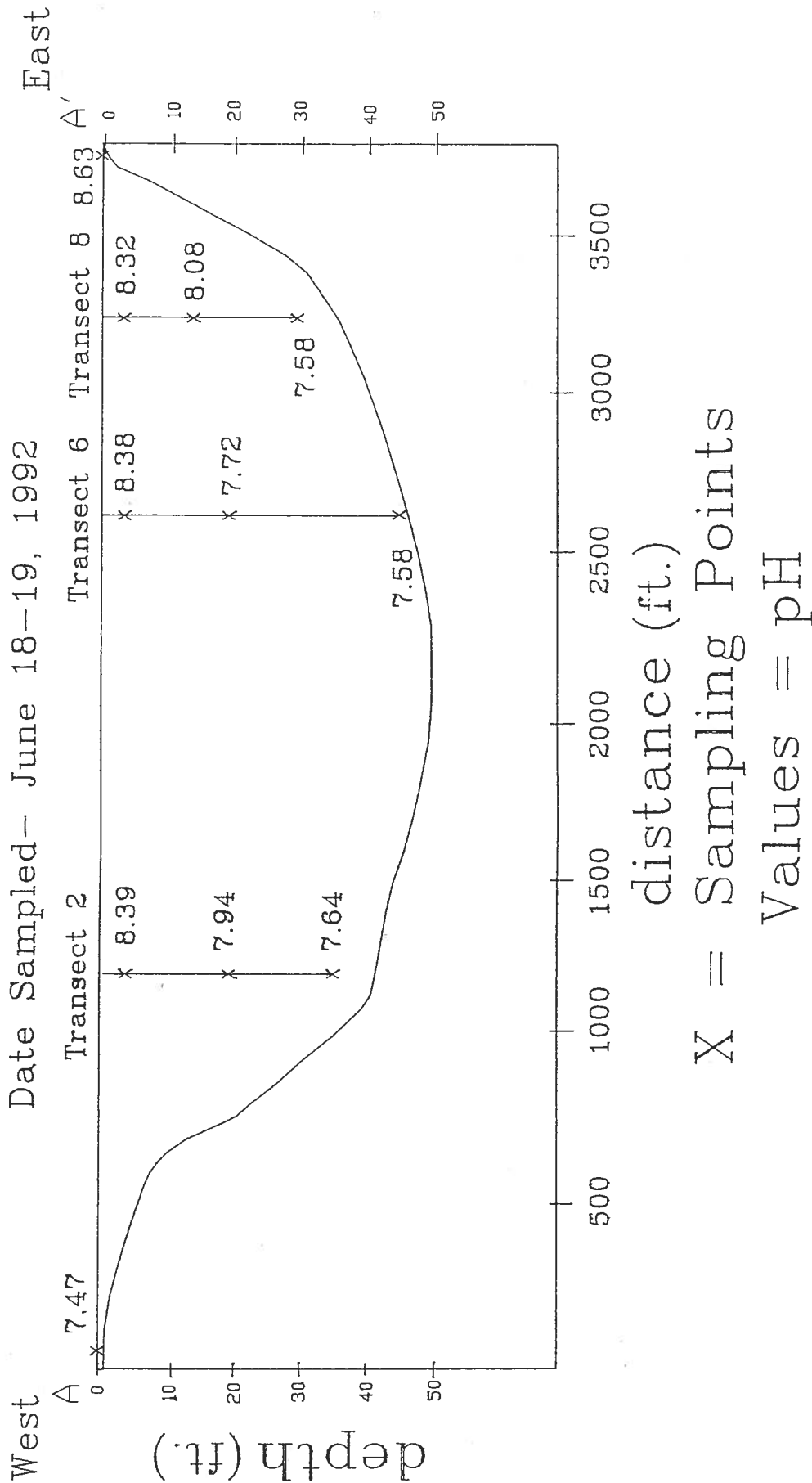


Figure 17 : Longitudinal section through Asylum Lake showing pH as a function of depth.

in acidity), as well as one anomalous point, again at the west end of the Lake. The surface values are near the equilibrium value for a calcite solution in contact with the atmosphere. The trend of decreasing pH was also observed by Engemann (1978) for samples taken in July, Sept., and Oct., 1976. The total alkalinity section in Figure 18 shows a general increase with depth, and again an anomalous value at the west end. This is probably due to the influx of high alkalinity water from the wetland south of the trailer park, and generalized ground-water input. The historical data of Engemann (1978) show the same increase with depth during the four months sampled, although their values are systematically an average of 40-50 ppm less than those measured in 1992. The section (Figure 19) showing silica content ( $\text{SiO}_2$ ) indicates a deficiency in the surface waters and low to moderate values below the thermocline. Once again there is an anomalous value at the west end of the Lake. The silica depletion in the surficial waters is probably due to the uptake by radiolarians in the sunlit interval, while the high value to the west is another indication of contamination from surface runoff.

#### **Methodology; Microbiological-**

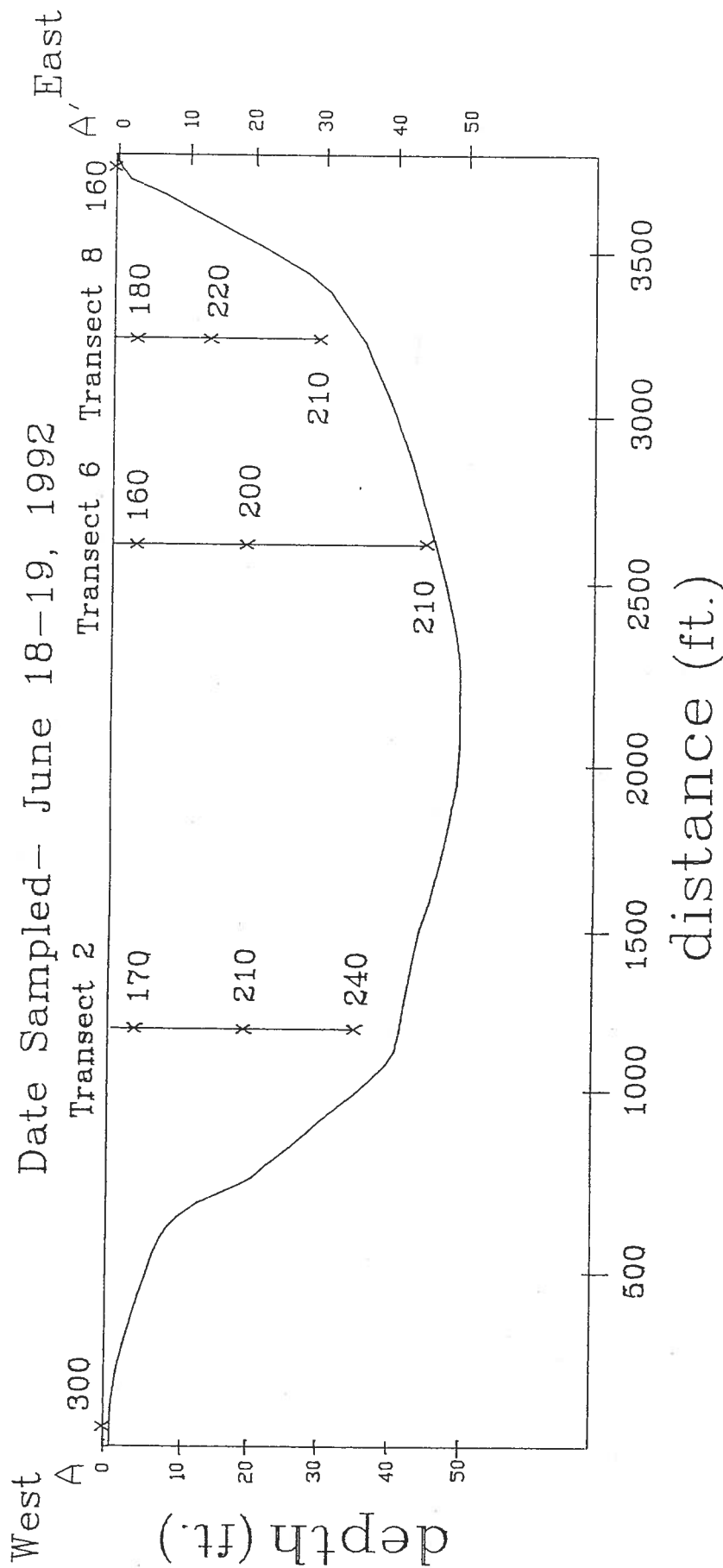
The testing of surface waters from Asylum Lake and vicinity for the presence of Fecal Coliform bacteria (*E. coli*) began in April, 1992. Regular weekly sampling began May 19 and extended to Sept. 3, 1992. All tests were run by membrane filter procedures as described in Section 900 of "Standard Methods For the Examination of Water and Waste Water", 16th Edition. The 100 ml samples were run through a 47 mm diameter Millipore filter having a pore size of 0.45 microns. Each filter was then placed in a petri dish that contained Difco™ Fecal Coliform Broth (M-FC Broth), and incubated for 24 hours in a 44.5°C water bath. The resulting blue colonies were then counted. Samples known to be highly contaminated were diluted by 1:10 before filtering and incubation, and the resulting counts were then multiplied by 10.

#### **Results; Microbiological-**

Appreciable numbers of coliform bacteria were found at all collection sites for the entire sampling period. The south inlet culvert under Drake Rd. was especially contaminated. Bacterial levels in these samples increased substantially in mid-June and remained above 350 colonies/100 ml for the rest of the summer. (The Board of Health limit for body contact is 200 colonies/100 ml.) These data are shown as Table 1, and are also plotted in Figure 20. Data at times when sampling conditions included rainfall or turbidity were not shown on this graph, because apparently higher numbers of the bacteria reside in the bottom muds than in the water column. Water temperatures were also recorded at the times of collection, but the coliform abundances did not appear to have any correlation with this factor. The most important result is that Asylum Lake is, and apparently has been for some time, receiving a heavy

# ASYLUM LAKE

## CROSS SECTION

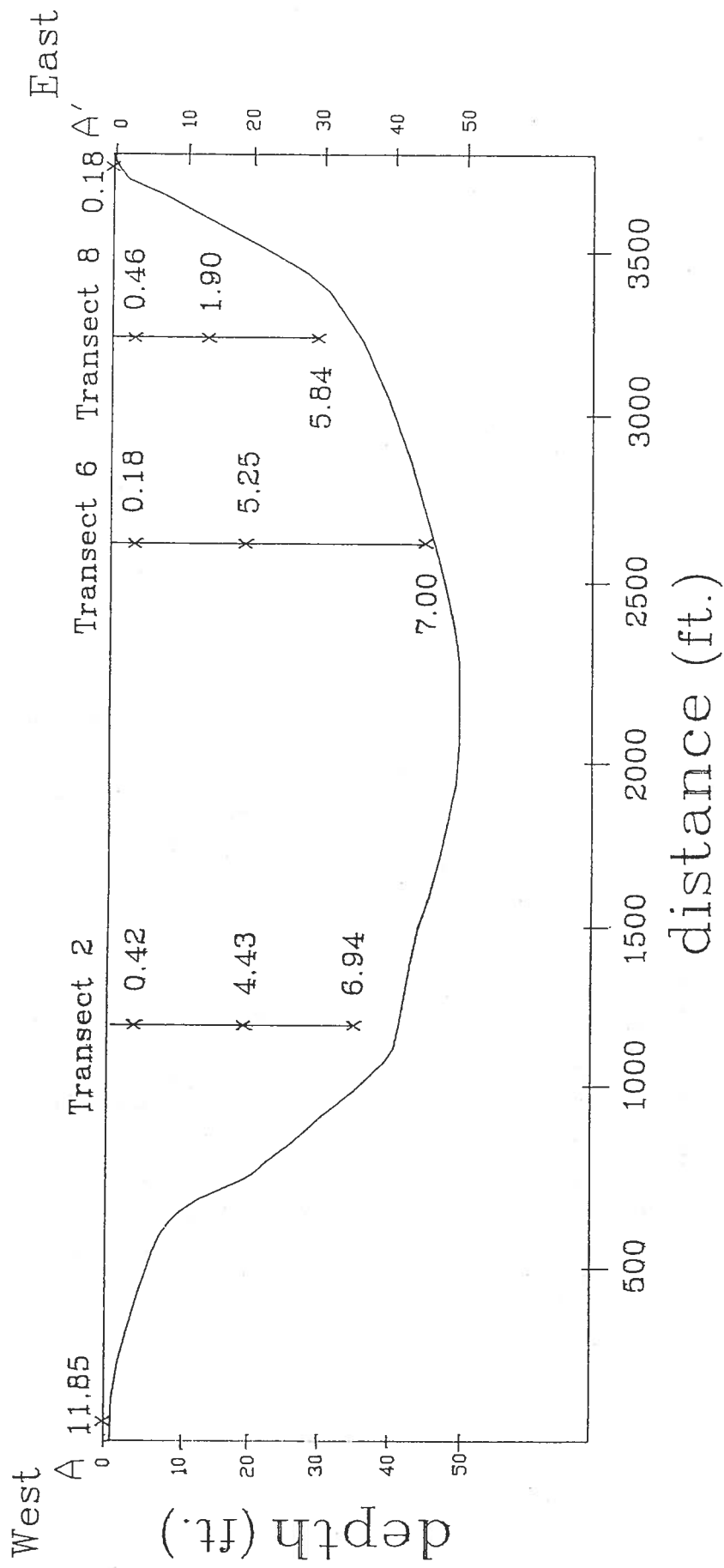


X = Sampling Points  
 Values = Alkalinity (ppm CaCO<sub>3</sub>)

Figure 18 : Longitudinal section through Asylum Lake showing total alkalinity of the water.

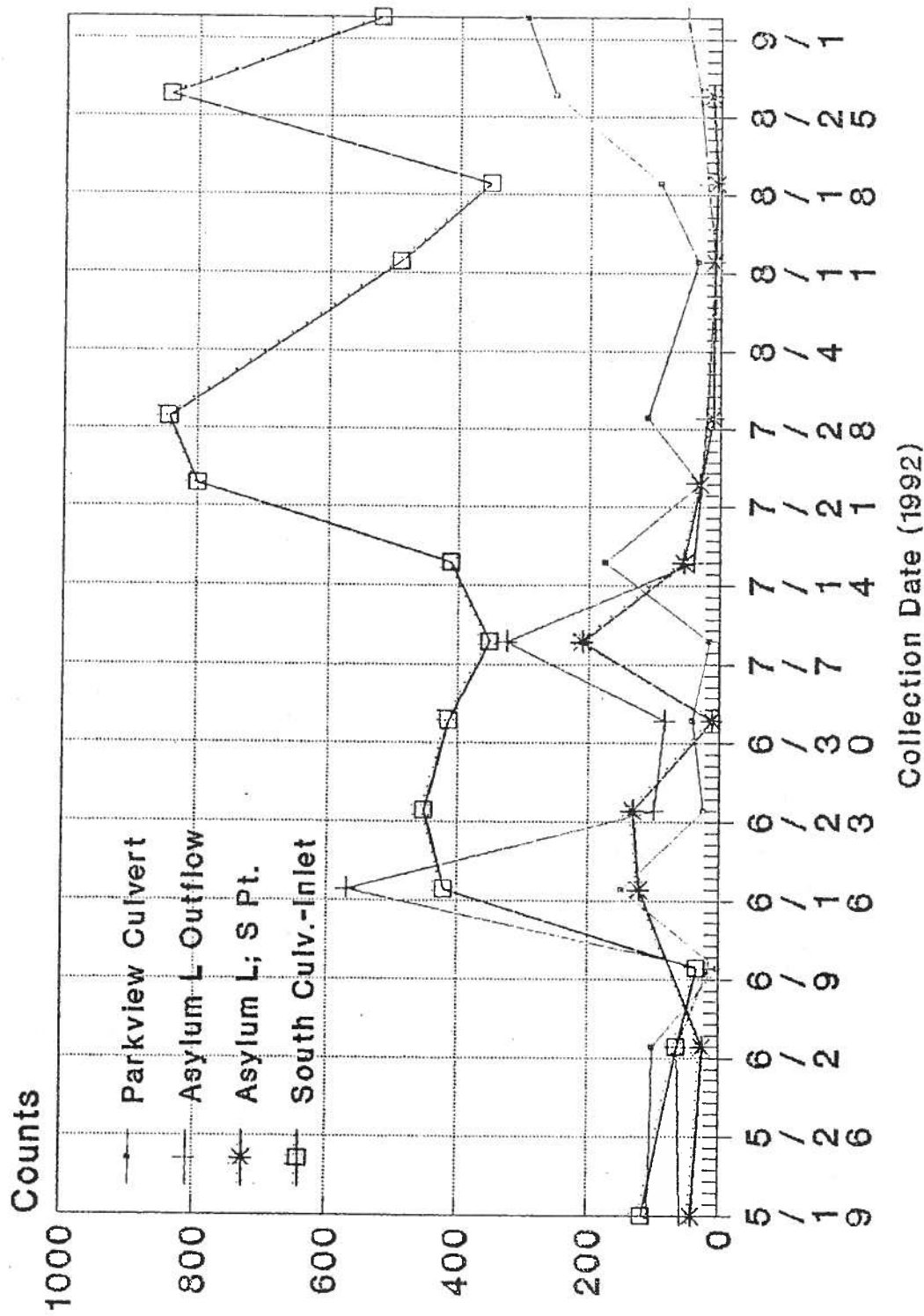
# ASYLUM LAKE

## CROSS SECTION



X = Sampling Points  
 Values = Silica Conc.(ppm)

Figure 19 : Longitudinal section through Asylum Lake showing silica concentrations at different depths.



**Jerry Johnson, (Microbiologist - KVCC)**

Figure 20 : Results of fecal coliform bacteria tests during the summer of 1992 at four sampling sites.

load of fecal coliform bacteria from the standing water pooled just west of Drake Road and south of the mobile home park. There is obviously a septic leak or spillage resulting from inadequate sewage management. A spot check at another site showed very high coliform bacteria counts (1126) in water leaking from a city "storm" sewer at the NW corner of Parkview and Tamsin.

Table 1: Results of microbiological analyses for coliform bacteria (colonies/100 ml) at four sampling sites in the Asylum Lake drainage. Sample temperature is given at time of collection.

Date	Drake Culvert Colonies (°C)		South Point Colonies (°C)		Outlet Culvert Colonies (°C)		Parkview Culvert Colonies (°C)	
5/19/92	117	22	41	25	59	24	107	27
5/27/92	*	12	*	18	*	17	*	15
6/03/92	64	23	25	26	64	25	102	27
6/10/92	34	23	*	26	16	25	2	26
6/17/92	418	21	122**	25	568**	26	150**	27
6/24/92	450	18	132	25	101	23	25	25
7/02/92	412	21	11	28	84	27	43	31
7/09/92	350	18	210	24	324	23	15	23
7/16/92	410-d	17	55	23	41	23	176	22
7/23/92	798-d	16	31	22	29	21	33	21
7/29/92	840-d	16	11	22	22	21	112	21
8/12/92	490-d	16	9	24	8	23	35	22
8/19/92	350-d	17	5	24	20	23	93	22
8/27/92	840-d	18	12	24	33	23	253	23
9/03/92	520-d	17	239***	24	52	23	296	22

\* equipment failure; no growth.

\*\* collection during rainfall.

\*\*\* water was turbid.

## GEOPHYSICAL INVESTIGATIONS - Surface:

A number of geophysical methods were tested on the site during the project year. Electrical resistivity soundings were done in the vicinity of wells CF-1, CF-3 to attempt to verify the perched aquifer reported there by the driller. The aquifer itself or the clay-rich aquitard below it should show clearly as a conductive layer at the depth interval 20 - 25 ft. The Schlumberger array Vertical Electrical Sounding (VES) done near this well is shown in Figure 21. The inversion or solution which best fits the field data (crosses) indicates a high-resistivity layer extending to 19 m (62 ft.), which is the depth to the main aquifer in the area. The high resistivity layer has a resistivity typical of a sand-gravel unsaturated zone, and shows no indication of an intermediate perched aquifer at 6 - 8 m depth. Two other VES measurements were made east of Drake Road, one about 300 ft. north of the Cherry Lane driveway (Figure 22) and the other 300 ft. south of that driveway (Figure 23) in the open fields. The interpretations of both these soundings show a stratigraphy almost identical to that of Figure 21, thus reinforcing the conclusion that there is no perched aquifer. Another VES was done south of the woods, about 300 ft. east of well AL-16, where water table is known to be at about 35 ft. below the surface. The unconstrained inversion solution to the field data (Figure 24) gave a depth to the base of the unsaturated zone of 9.77 m or 32 ft.

Ground Penetrating Radar (GPR) has been tried several times on both the Colony Farm Orchard and the Asylum Lake properties. Because the topsoil resistivities are so low, in the range of 40 to 90 Ohm-m, the penetration is severely restricted and results are marginal. The antennae are impedance matched to a higher resistivity earth, so in this area a great deal of ringing is caused by the mis-match. No GPR records are included in this report.

An electromagnetic induction device having two coils separated by about 12 ft. was tested during two days in July, 1992. This was a GEONICS EM-31 instrument on loan from GEONICS Ltd. (Canada). This instrument has a fixed coil separation of 3.7 meters, and a maximum exploration depth of about 6 meters. The coils were positioned in the co-planar orientation with their axes vertical. The conductivity setting (quadrature) resulted in strong negative readings over a pipeline, flanked by positive "shoulders". When operated in a search mode it detected numerous conductors buried in the Colony Farms Orchard, from Drake Rd. west to the steel shed, along both sides of the driveway. On the Asylum Lake fields, N-S profiles were run at E-W intervals of 100 ft. to search for buried water lines suspected to have once joined the two habitated areas. (Wooded area near Asylum Lake, where the water supply well was located, and the Orchard area west of Drake Rd. where the water tower was located.) Twelve survey lines, each extending about 700 ft. south from the Cherry Lane driveway, were traversed. Locations interpreted to be buried metallic conductors are shown as dark crosses on the map (Figure 25).



VES ID.= OrchFarm02

RESIST.=	40*	THICK.=	.33
RESIST.=	2900	THICK.=	18.7 *
RESIST.=	90*		19.03

RMS ERROR = 4.495  
FOR ITERATION No. 3

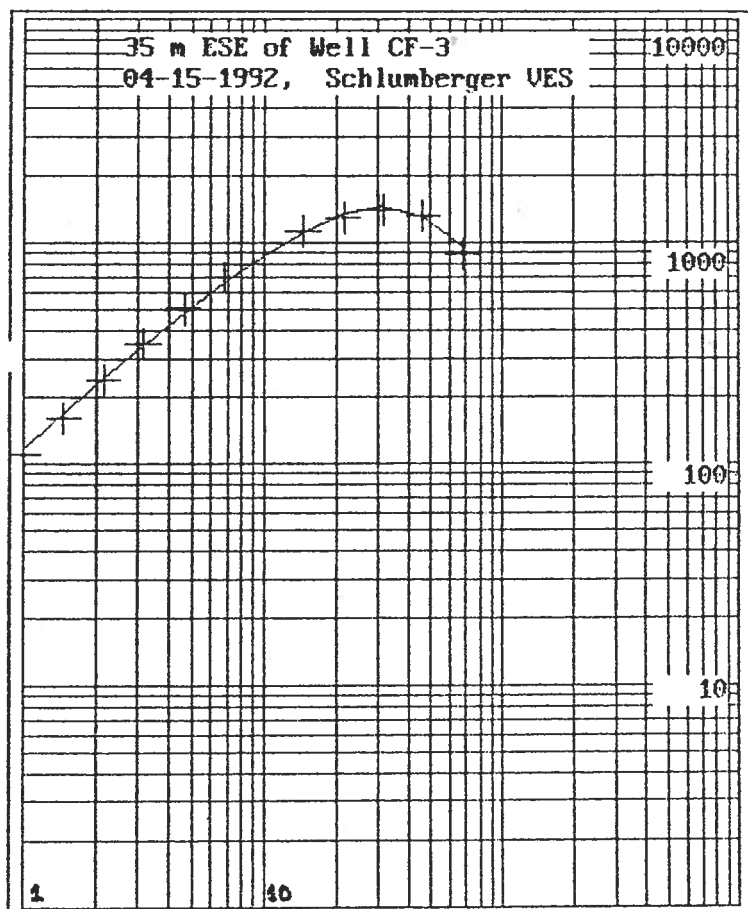


Figure 21 : Log-log graph of expanding Schlumberger array VES earth resistivity data (crosses), showing how electrical resistivity changes with depth. The Y-axis is apparent resistivity in Ohm-m, and the X-axis is the half-separation of the current electrodes ( $AB/2$ ) in meters. The smooth curve is the result of the inversion process whose final layer parameters are shown to the left, with thicknesses in meters.

VES ID.= ASYLUM\_L; E-W

RESIST.= 52	THICK.= .84	0
RESIST.= 2225	THICK.= 18 *	.84
RESIST.= 50		18.84

%RMS ERROR = 3.667  
FOR ITERATION No. 10

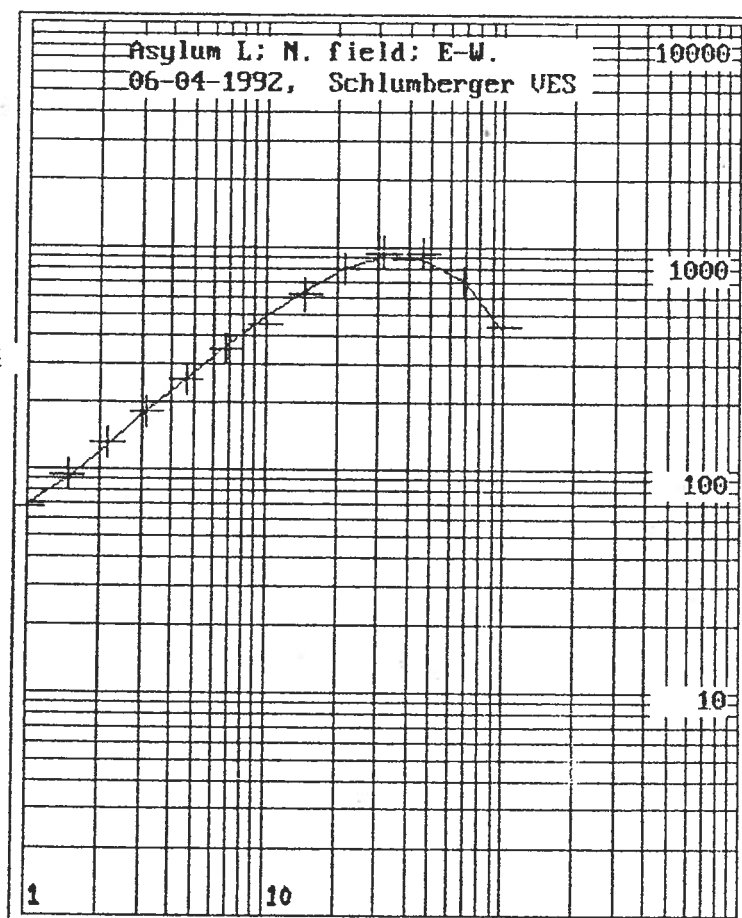


Figure 22 : Vertical Electrical Sounding data and inversion results for a location 350 feet east of Drake Road and 300 feet north of Cherry Lane. (E-W expansion of electrode array.) The thick unsaturated zone causes the high apparent resistivity, and the sudden decrease is due to the aquifer.

VES ID.= ASYLUM\_L; S FLD

RESIST.	THICK.
83	.95
2698	19.2 *
75*	20.15

%RMS ERROR = 5.128  
FOR ITERATION No. 10

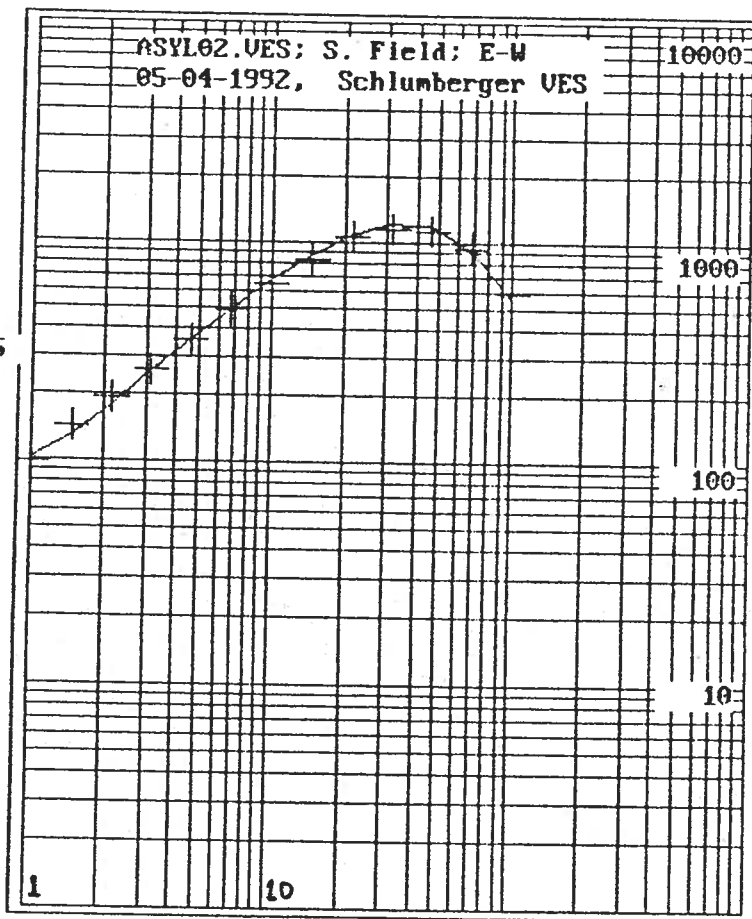


Figure 23 : VES data and inversion results for a location 350 feet east of Drake Road and 300 feet south of Cherry Lane (E-W expansion). Dimensions are in meters and the resistivities in Ohm-m.

VES ID.= AL-10; FC'92  
 -----  
 RESIST.= 138 THICK.= .65  
 -----  
 RESIST.= 2735 THICK.= 2.15  
 -----  
 RESIST.= 267 THICK.= 1  
 -----  
 RESIST.= 2266 THICK.= 5.97  
 -----  
 RESIST.= 111  
 -----  
 %RMS ERROR = 2.040  
 FOR ITERATION No. 10

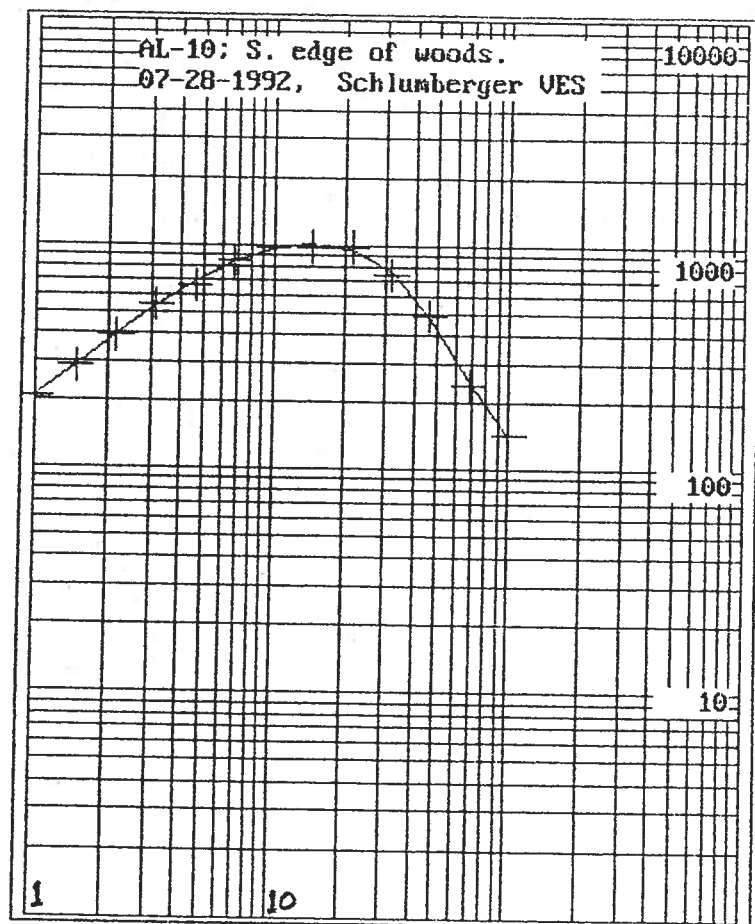


Figure 24 : VES data and inversion results for a location about 400 feet east of well AL-16, south of the woods. The inversion indicates a possible silty layer at 2.8-3.8 meters depth, and water table at 9.77 meters.

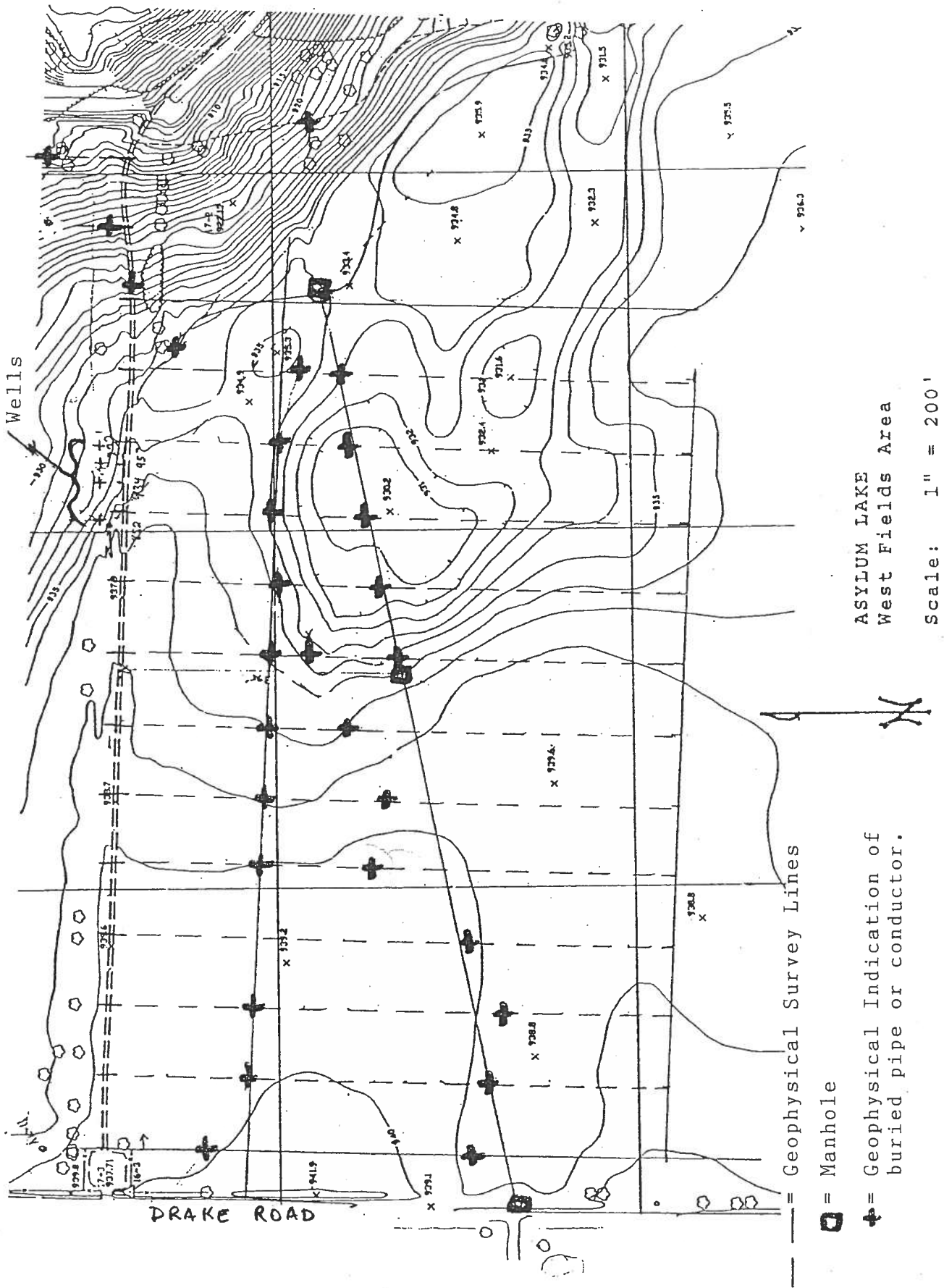


Figure 25 : Results of the GEONICS EM-31 reconnaissance survey between Drake Road and the wooded area, showing locations where the transects crossed metallic conductors.

Several short lines to the north of this driveway also revealed a conductor trending NE into the woods, starting just south of the first large oak tree encountered on the south side of the driveway.

#### PROBLEMS:

Two of the wells near the Lake have been vandalized. One was a lock breakage, but the other had the steel protector and its concrete base ripped out and thrown into the Lake, with the PVC riser broken off at ground level. Two other wells, AL-1 and AL-3, had their locks broken off and their covers removed sometime in Oct., 1992. Campus security was notified.

#### FUTURE WORK RECOMMENDED:

The microbiology program for monitoring coliform bacteria should be continued until the serious problem of the influx of contaminated water to Asylum Lake from the vicinity of the mobile home park is stopped.

A once-per-year sampling program should be conducted in about 20 of the monitor wells which represent a good areal coverage. Determinations should be made for major ions as well as organics and heavy metals. Lake water quality should be investigated at least quarterly for two years to provide a longer-term database. This is for the protection of WMU patrimony and is particularly crucial in light of development plans for the area.

Several more wells could be installed to improve the coverage, especially south of Parkview Ave. This could be done in cooperation with the annual Geology Department's Hydrogeology Field Course. The defective and problem wells could be replaced or reworked as part of this program.

The installation of buried geophysical targets which was contemplated for the second and third years of the original proposal should be initiated. This would make the site much more useful for field training courses in geophysics, hydrogeology, and remediation; part of the original concept of using a portion of the site as an educational and calibration facility.

#### CONCLUSIONS:

In the 12 month project life we have installed or restored to service 30 monitor wells on the WMU farms property. All were useful for characterizing lithology directly via samples or indirectly from geophysical well logs. Four of these have not proven suitable for the extraction of water samples. The upper 140 feet of section (at well AL-3) are dominated by sands, with minor silts and gravels; compatible with the hypothesis that this sequence is a glacio-fluvial outwash fan deposit. Below 140 ft

depth the clay content increases to a maximum at 150 ft., and then becomes sandy again. From about 200 ft. to 252 ft., glacial till units are intercalated with sands. Coldwater Shale bedrock was encountered at approximately 252 ft.

We have established that the ground-water flow in the upper (unconfined) aquifer comes from Oshtemo Twp., passing beneath US 131 in an easterly to ENE direction. Preliminary results from the M.S. research by Buening indicate that the western end of Asylum Lake receives ground water from the aquifer and that the eastern end of the Lake is a recharge area. Also, surface water flow at the outlet of the Lake is consistently greater than surface inlet flows, hence the difference is contributed by ground-water flow into the Lake.

The ground water quality has clearly been impacted by road salting practices along US 131 and probably to a lesser extent along Drake Road, as shown by the high conductivity, high  $\text{Na}^+$ , and high  $\text{Cl}^-$ . Nitrate reaching ground water is considerably less than expected as compared with other intensively tilled areas elsewhere in SW Michigan. No significant occurrence of heavy metals was found, and no volatile organic compounds (VOCs) were detected in the several samples of ground water which were tested for VOCs. Asylum Lake continues to receive a heavy loading of runoff salts, and weekly sampling through the summer showed that fecal coliform bacteria were consistently above the Public Health limits for body contact water in surface water entering the Lake from the west.

Surface geophysical studies have located thousands of feet of buried utilities, probably pipelines, connecting the Asylum Lake and Colony Farm Orchard areas.

The site is meeting its stated goals as an educational and research facility with three M.S. theses in various stages of completion, and an active microbiological research program being done by KVCC, another of the KCHE members. More work is underway, and several more wells have been installed since the end of July, 1992.

## REFERENCES:

- Allen, Bryan K., The Effects of Composting of Yard Wastes on the Ground Water Quality of the Western Michigan University Farms Site; M.S. Thesis (in progress); WMU Dept. of Geology, Kalamazoo, MI.
- Buening, Vince E., Investigations of Aquifer-Lake Interactions Using Geochemistry and Stable Isotopes at Asylum Lake, Michigan; M.S. Thesis (in progress); WMU Dept. of Geology, Kalamazoo, MI.
- Engemann, J.G., 1978, Observations on Asylum Lake, Kalamazoo, Michigan; Internal Report, Dept. of Biology, Western Michigan University; 11 p.
- Ring, John, The Variability of CO<sub>2</sub> and O<sub>2</sub> in the Unsaturated Zone in a Glacial Outwash Fan Deposit, WMU Farms Property; M.S. Thesis (in progress); WMU Dept. of Geology, Kalamazoo, MI.
- Sauck, W.A. and M.J. Barcelona, 1992, "Long-Term Hydrogeological Research and Educational Test Site"; Semi-annual Progress Report; WMU Institute for Water Sciences, Kalamazoo, MI.