Nitrogen removal in renovated municipal wastewater rapid infiltration basins. [DNR-097]

Gilbert, Thomas A.; Oman, Bruce S.
Madison, Wisconsin: Wisconsin Department of Natural Resources, [s.d.]

https://digital.library.wisc.edu/1711.dl/63LKQTFZGLTZS8N

Title: NITROGEN REMOVAL IN RENOVATED MUNICIPAL WASTEWATER RAPID INFILTRATION BASINS

Investigators:

Thomas A. Gilbert, P.E. - Environmental Engineer
Bureau of Wastewater Management
Department of Natural Resources

Bruce S. Oman, P.E. - Environmental Engineer
Marinette Area Office
Lake Michigan District
Department of Natural Resources

Period of Contract: August 6, 1991 to June 30, 1993

Objectives:

To investigate the feasibility of soil modification as a method to reduce infiltration rates and enhance nitrogen removal in absorption ponds receiving municipal wastewater effluent.

Background/Need:

Approximately 125 municipalities in Wisconsin utilize the "rapid infiltration" type of wastewater land application system (also commonly referred to as "absorption pond" or "seepage cell" systems). Most existing systems were not specifically designed for compliance with Wisconsin NR 140 groundwater standards. The majority of absorption pond systems employ lagoon systems for treatment. Lagoon systems cannot consistently produce an effluent with less than 10 mg/l total nitrogen. Nevertheless, groundwater monitoring data indicates that many of these systems may comply or only marginally exceed the nitrate-nitrogen public health groundwater standard of 10 mg/l. The storage of wastewater during the winter, coupled with infiltration basins providing low infiltration rates (which may enhance nitrogen removal in the soil profile) may provide a cost-effective method for existing lagoon systems to comply with groundwater standards.

Methods:

Five test infiltration basins (each approximately 30 by 50 feet) were constructed within one infiltration basin at the Florence wastewater treatment facility. The existing native soil was left in one cell as a control. Different soil types were brought in and placed in the other four cells. Lysimeter devices were installed to collect samples of water after percolation through the upper soil profile in each cell. Effluent from the Florence aerated treatment lagoons was applied to the test cells from August to November in 1992, and from May to December in 1993.

Results:

From May to August of 1993, the applied total nitrogen ranged from 24.2 to 34.1 mg/l. No significant nitrogen removal occurred in the control test cell (number 3) during this time period. Test cell 1 contained two feet of cover soil consisting of 88.6% sand, and 11.4% fines (approximately 6.4% silt and 5.0% clay). Infiltration rates were reduced to an average of 15.3 in./day, and 46% nitrogen removal occurred in Cell 1. Test Cell 2 contained the same soil as Cell 1, but experienced a significantly higher infiltration rate (28.7 in./day), and no significant nitrogen removal occurred. The one remaining test cell (number 5) contained finer soil than in cells 1 or 2, and produced low infiltration rates comparable to cell 1, but nitrogen removal was highly variable and no removal occurred on an average basis.

Conclusions:

Covering an existing rapidly permeable sandy soil with two feet of less permeable soil, with a higher percentage of fines, was successful in producing substantially lower infiltration rates and longer retention times in the soil profile. In one test cell this improved nitrogen removal within the soil profile to 46%. The removal resulted from partial nitrification and subsequent denitrification of the applied ammonium-nitrogen. The lack of consistent nitrogen removal in two other test cells demonstrates that nitrogen removal by microbial processes is not only a function of infiltration rate, but other environmental factors which need to be recognized and managed properly.

Recommendations / Implications:

Municipalities with absorption pond systems that experience difficulty complying with groundwater standards may consider supplemental soil as a method to renovate infiltration basins and enhance nitrogen removal.

Availability of Report:

Available from Thomas Gilbert, WNNR, Bureau of Wastewater Management, 101 S. Webster Street, Box 7921, Madison, Wisconsin 53707. (608) 267-7628.

Related Publications: None

Key Words: wastewater renovation, rapid infiltration, nitrogen, nitrification, denitrification

Funding: The Wisconsin Department of Natural Resources provided funding for this project through the Groundwater Management Practice Monitoring Program which receives appropriations from the Groundwater Account. Supplemental funding was provided by the Department of Natural Resources, Bureau of Wastewater Management.

NITROGEN REMOVAL IN RENOVATED MUNICIPAL WASTEWATER RAPID INFILTRATION BASINS

Thomas A. Gilbert and Bruce S. Oman

June, 1994

INTRODUCTION

Approximately 125 municipalities in Wisconsin utilize the "rapid infiltration" type of wastewater land application system. These systems employ earthen infiltration basins designed to discharge treated wastewater to the groundwater. Infiltration basins are also commonly called absorption ponds or seepage cells. Most of these systems were designed and constructed prior to the promulgation of the Wisconsin groundwater quality standards (Chapter NR 140 of the Wisconsin Administrative Code) in 1985.

Prior to 1985, Wisconsin regulations required discharges to absorption ponds to meet a biochemical oxygen demand (BOD5) of 50 milligrams per liter (mg/l). Additionally, proposed absorption pond systems had to meet certain site criteria intended to protect groundwater quality. This criteria primarily consisted of minimum separation distances from the absorption pond bottom to groundwater, and from the infiltration area to potable water supply wells. Absorption ponds have typically been constructed on highly permeable soils which can accept high hydraulic loading rates. Past design practice in Wisconsin allowed average hydraulic loading rates up to 90,000 gallons/acre/day (100.8 feet/year).

The enactment of the Chapter NR 140 rules essentially defined a more precise performance standard for land application systems by requiring that drinking water quality standards be complied with outside a small ("design management") zone surrounding the infiltration area. Groundwater enforcement standards apply at a distance of 250 feet from the infiltration area, or at the facility property boundary, if that boundary is closer than 250 feet.

Most existing rapid infiltration systems are typically found at smaller communities which utilize conventional secondary treatment technologies (predominantly stabilization ponds or aerated lagoons) prior to discharging to seepage. These secondary treatment facilities were not designed to remove nitrogen, and are not able to *consistently* remove nitrogen (many lagoon systems do remove substantial amounts of nitrogen during warm weather). Municipal effluent treated to secondary standards typically contains 10 to 30 mg/l total nitrogen. Studies and actual groundwater monitoring data from absorption pond sites have demonstrated that the nitrate-nitrogen groundwater enforcement standard of 10 mg/l is difficult to meet and is often exceeded.

In response to the promulgation of the NR 140 groundwater quality standards, other Wisconsin regulations were revised to require any proposed *new* absorption pond system to meet a total nitrogen effluent limit (prior to infiltration) of 10 mg/l. The applicable effluent limits for *existing* systems,and the consequent need to upgrade or replace them, are based on facility specific evaluations and actual groundwater monitoring data from each facility site. Alternative effluent limits, higher than 10 mg/l total N, may be established if groundwater monitoring results demonstrate reliable compliance with NR 140 standards at the facilities' point of standards application.

All rapid infiltration systems in Wisconsin with design flows of 15,000 gallons per day, or more, are required to have groundwater monitoring systems. The minimum monitoring system includes one upgradient well and two downgradient wells. Many facilities have been monitoring since the mid-1980's and have established long-term monitoring data bases.

The monitoring results have shown significant nitrate-nitrogen exceedences in some cases, and facilities have been abandoned or significantly upgraded as a result. In many other cases, however, the monitoring results indicate compliance with the nitrate standard, or only marginal (or seasonal) exceedences. The reasons for this are not completely clear. The difficulty of accurately monitoring groundwater impacts is believed to be one factor, but it also appears that significant treatment (within the soil profile) or dilution (mixing with native groundwater) may be occurring. Many infiltration facilities are located on isolated sites, with little potential to adversely impact water supply wells. These circumstances suggest that expensive replacements or upgrading of some treatment systems may provide marginal benefit for the cost incurred. The investigation of low cost methods to enhance nitrogen removal in existing rapid infiltration systems is clearly warranted.

The only mechanism capable of removing the large amounts of nitrogen typically discharged into absorption ponds is the combined microbial processes of nitrification and denitrification. The effectiveness of these processes is dependent upon many environmental conditions, including temperature, a dominant controlling factor. Lagoon treatment systems typically have long detention times which allow substantial heat loss during cold weather. The resulting low wastewater temperatures severely inhibit microbial activity, and nitrogen removal, in both the treatment lagoons and in the soil within the absorption ponds.

Another primary factor affecting nitrogen removal (in the soil below absorption ponds) is the difficulty of retaining the nitrogen within the soil profile, in contact with the necessary microorganisms, and under the environmental conditions necessary for microbial activity. In general, nitrogen in the form of the ammonium cation can adsorb to negatively charged clay or to organic matter within the soil, whereas nitrogen in the form of negatively charged nitrate anions will be mobile and pass through the soil. Past design practices focused on locating absorption ponds on highly permeable sandy soils to ensure adequate hydraulic capacity. The resulting high infiltration rates make it impossible to accumulate standing water for long periods of time. Although a facility may have multiple absorption ponds, and multiple acres of infiltration area, the discharges are often observed to infiltrate within a small "puddle" around the discharge pipe. Under these conditions there is an extremely short retention time in the soil and little opportunity for any nitrogen removal to occur.

To address the temperature factor, many smaller lagoon systems may be able to alter their operation, to a fill and draw mode, and store wastewater during the winter. Allowing the wastewater and soil to warm up prior to land application provides a much greater opportunity for effective biological activity and treatment. Nitrogen removal during warmer conditions may still be insufficient, however, if the absorption ponds contain extremely permeable sandy soil and thus little retention time in the soil profile.

This study was conducted to investigate the feasibility of reducing infiltration rates and enhancing nitrogen removal within an absorption pond by placing two feet of less permeable soil (containing a measured percentage of fine soil particles) over an existing "excessively" permeable soil. Previous studies (Gilbert R.G., et.al.- 1979, and Lance J.C., et.al.- 1973) have shown that most treatment within the soil profile occurs within the top 0.5 to 1 meter of soil. The two foot cover soil depth was selected with consideration of minimizing the cost of pond modification, and still providing enough soil for effective reduction of infiltration rates and possible enhancement of nitrogen removal. The study period was restricted to the spring to late fall, in recognition of the fact that little or no nitrogen removal can be expected during extremely low winter temperature conditions.

Nitrogen Removal Mechanisms

Nitrogen in the natural environment may be cycled through a complex series of biological and chemical processes. In rapid infiltration systems, nitrogen may be immobilized in the soil by adsorption of NH_4-N ions onto soil cation-exchange sites, fixation by clay minerals, adsorption by organic matter, and incorporation into microbial tissue. Nitrogen may be transferred from the soil to the atmosphere in gaseous form by biological denitrification or volatilization of ammonia (Lance, J.C. - 1984). A summary of nitrogen pathways is illustrated in Figure 1.

Volatilization of ammonia (NH_3) is considered to be minimal in rapid infiltration systems. Volatilization requires considerable air-water contact which is not provided within the soil profile. Also, the pH of secondary sewage effluent is usually between 7 and 8, and less than 10 percent of the nitrogen will exist as ammonia (Lance, J.C. - 1984). Significant nitrogen removal by vegetative uptake and harvesting is also not possible due to the high hydraulic loading rates and large nitrogen loadings used in rapid infiltration. As a result, to promote

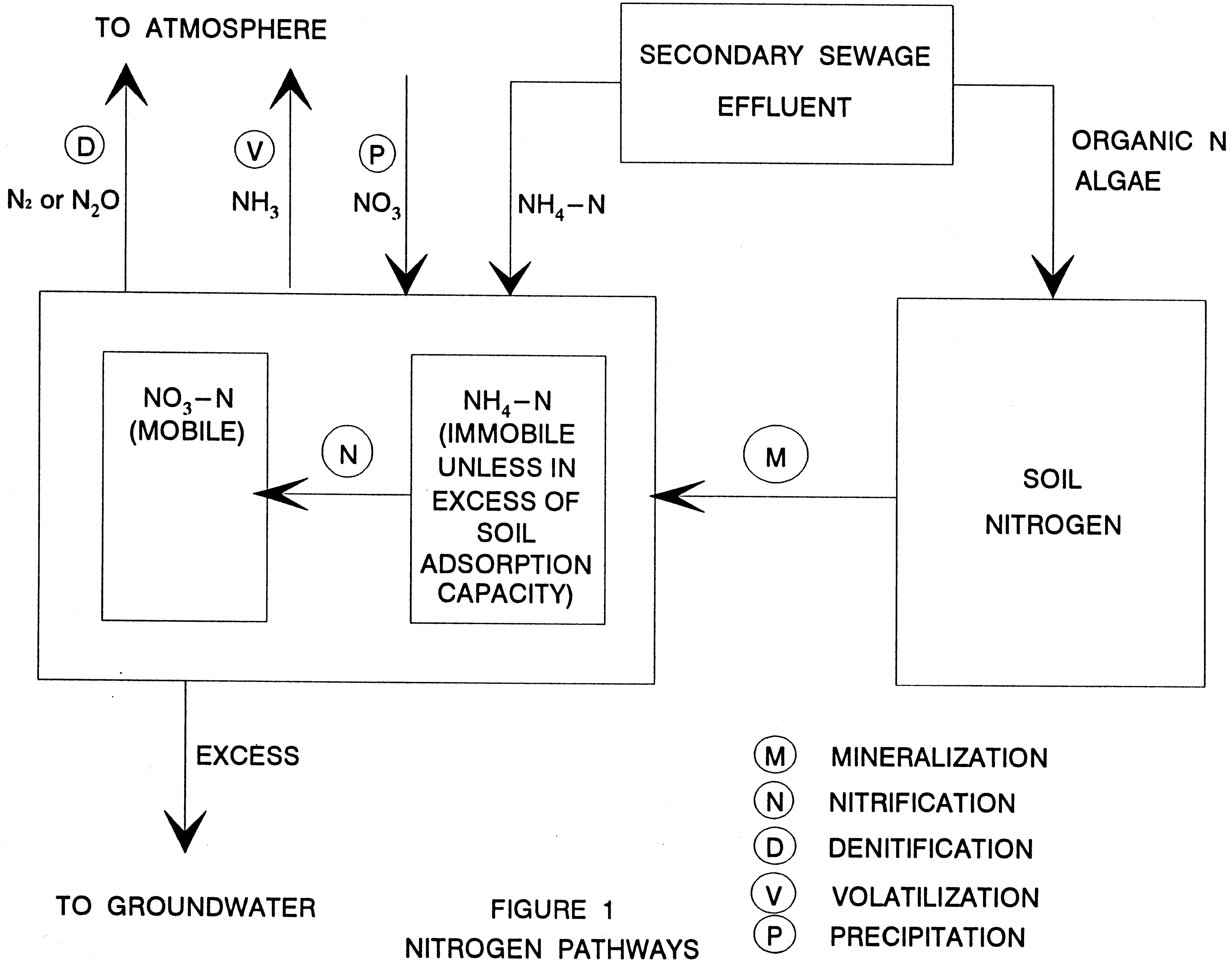


FIGURE 1
NITROGEN PATHWAYS

nitrogen removal, and minimize the leaching of excess nitrogen into the groundwater, it is necessary to promote the biological process of denitrification.

Municipal secondary effluent usually contains nitrogen as ammonium ions (NH_4-N) and as organic nitrogen. Therefore the first requirement for denitrification is that the NH_4-N must be oxidized to nitrate. Nitrification is a two step process in which aerobic autotrophs oxidize NH_4-N to NO_3. Ammonia is first converted to nitrite (NO_2) by *Nitrosomonas*. Nitrite is then converted to nitrate by *Nitrobacter*. The optimal pH for nitrification ranges between 8 and 9. As pH decreases, the rate of nitrification deceases. Nitrification rates are also a function of temperature. The optimal temperature range is from 15°C to 35°C. The nitrification rate begins to drop at less than 15°C and is strongly inhibited at less than 10°C (Shammas, N.K.-1986).

In addition to the presence of nitrogen as nitrate, denitrification also requires organic carbon for an energy source and an environment where oxygen is absent. Denitrifying bacteria can use free oxygen, but will use nitrate as a substitute hydrogen acceptor if free oxygen is absent. Denitrification is also a function of temperature and pH. It proceeds slowly below pH 5.5 and below 10°C, and practically ceases at 2°C (Lance, J.C. - 1984).

Achieving both nitrification and denitrification in the same soil profile is difficult because one process requires aerobic conditions and the other an anoxic condition. Additionally, most of the organic carbon may be consumed in the oxidative state required for nitrification, leaving an insufficient supply for denitrification. Denitrification can occur to some extent in an otherwise aerobic soil, due to the occurrence of reduced microenvironments associated with soil aggregates or organic matter. These reduced microenvironment zones are more numerous in fine textured soils. The extent of denitrification occurring in reduced microzones is limited to less than 30% of the total nitrate, whereas all the nitrate could be denitrified in saturated soil condition (Lance, J.C. - 1984).

Previous research on secondary effluent applied to soil columns in laboratory studies (Lance, J.C. - 1976) has shown that nitrogen removals up to 80% can be achieved by careful control of loading and resting periods. The general method for accomplishing this is described by Bouwer, H. (1974): "To maximize denitrification in soil receiving secondary sewage effluent in which the nitrogen is mostly in the ammonium form and the organic carbon levels are usually fairly low, the effluent should be continuously applied for a sufficiently long period to cause oxygen depletion in the soil. The ammonium is then no longer converted to nitrate, and it can be adsorbed by the clay and organic matter in the soil. Before this cation exchange complex is saturated with ammonium, the application of wastewater should be stopped so that the soil can drain and dry. Oxygen entering the soil will then cause the adsorbed ammonium to be nitrified, after which denitrification occurs in (micro) anaerobic zones. If wastewater is then applied again, the nitrate-enriched capillary water mixes with the incoming wastewater which contains organic carbon, and denitrification can further occur when anaerobic conditions are reached."

If effluent is applied frequently and in small amounts, the upper soil profile will remain sufficiently aerobic resulting in nearly complete nitrification. For example, 1 or 2 days wet, followed by 5 days dry. Flooding periods of 2 to 3 weeks, followed by drying periods of the same length, have been shown to give approximately 30% total nitrogen removal (Lance and Whisler - 1972). Using a cycle of 9 days flooding and 5 days drying, a relationship was established between nitrogen removal and infiltration rates in a loamy sand (3% clay, 8% silt, and 89% sand). Nitrogen removal increased from about 10 to 30% as the infiltration rate decreased from 50 cm/d (19.7 in/d) to 30 cm/d (11.8 in/d), and increased from 30% to 80% as the infiltration rate decreased from 30 cm/d (11.8 in/d) to 15 cm/d (5.9 in/d), (Lance et.al. - 1976).

In this study an attempt was made to approximate the same soil and loading conditions used in the soil column laboratory studies yielding up to 80% nitrogen removal. The effluent discharges were not, however, controlled to the extent typical of laboratory experiments. This study was conducted under more variable conditions which reflects how many absorption pond systems are actually operated at small communities.

EXPERIMENTAL METHODS

The study was conducted at the existing rapid infiltration wastewater treatment facility at Florence, Wisconsin. Florence is an unincorporated community of 1,250 people, located in northeastern Wisconsin, a few miles south of the Brule River which establishes the border between Wisconsin and the Upper Pennisula of Michigan. The sewered area contains a mix of typical residential and commercial development.

The wastewater treatment facility consists of a two cell aerated lagoon system and five rapid infiltration basins. The aerated lagoon system was designed to treat a design flow of 101,000 gpd. The actual average wastewater flow rate during the study period was 73,000 gpd. At this flow, detention times of 44 and 31 days would be provided in the first and second treatment ponds, respectively. The infiltration rates in the absorption ponds are extremely rapid and the discharges typically infiltrate within a small area around the discharge pipes, without any substantial accumulation of standing water.

Five small test infiltration basins were constructed within one of the existing facility infiltration basins. The existing native soil was left in one cell as a control. Different soil types were brought in and placed in the other four cells. Lysimeter devices were installed to collect samples of water after percolation through the upper soil profile in each cell. The water collected in each lysimeter was drained off to a sump manhole outside of the test cell for sample collection. Effluent from the aerated lagoons was applied to the test cells from August to November in 1992, and from May to December in 1993.

Test Cells

The test cells were constructed on approximately one third of one absorption pond (see Figure 2). The existing absorption ponds consist of grass covered earthen berms with mineral soil bottoms. The bottom soil is an uncompacted sand. The initial phase of test cell construction was removal of the upper two feet of existing soil. This was done by DNR fire control personnel using a John Deere 450 caterpillar. Test cell locations were then laid out. The five test cells were each approximately 30 feet by 50 feet. Dividing walls for the test cells were constructed of treated eight foot 4 by 4's and untreated 1/2 inch plywood. The dividing walls were covered with panels of 20 mil PVC liner material. Sixteen liner panels were set in place and field seamed using MEK solvent. Liner was also installed along the berms forming the test cells, in order to prevent potential lateral water movement through the dikes. The panels along the earthen dike were tied into the upper portion of the dike by excavating a trench, laying the end of the liner in and backfilling. The toe of the liner laid in a hand dug trench and backfilled with about six inches of test soil.

Four of the five test cell lysimeters were constructed using 39 feet of 8-inch diameter **schedule 80** PVC pipe (see Figure 3). The lysimeter's open area for collection of infiltrating water was made by removing the top half of two 13 foot sections of bell and spigot pipe. The lysimeter for the control cell was 26 feet long with 13 feet of open area. A trench through the middle of each test cell was excavated using the Utility's backhoe (John Deere 310C). The lysimeters were stabilized with gravel. The open pipe area was then filled with gravel and covered with **Typar** filter fabric. A 4-inch diameter PVC riser vent was installed at the upgradient end of each lysimeter pipe except in the control cell which was not vented. This connection was a solvent weld. The lysimeter ends were sealed with concrete plugs. The pitch of the lysimeter pipe was 1/4 inch per foot verified in the field using a level. The downgradient end of the pipe terminated in a sample collection manhole. The manhole consisted of a six foot section of 30" corrugated metal pipe set on a gravel base to provide stability and drainage. The manholes were capped with a square plywood cover.

The lysimeter in cell 1 failed to produce samples so it was modified in November of 1992. The soil above the lysimeter was removed and an eight foot by 25 foot sheet of 2.75 mil plastic was worked underneath the lysimeter and extended up on each side to increase the collection area and not allow water to move around the lysimeter. After the modification the lysimeter produced a significant volume of water.

Two feet of soil was placed in each of the test cells. Existing soil was retained in the center cell (number 3) for use as the control cell. Three different soil types were placed in the remaining four cells. The same soil type was used in both cells 1 and 2. Test soil was purchased from local borrow pits. The soil was placed by dumping it on the earthen berm then pushing it into the cells and bringing it to grade with a John Deere 450 bulldozer. The soil was brought to grade along the walls by hand. The soil, especially along the walls, was

TEST CELL LAYOUT AND DISTRIBUTION PIPING

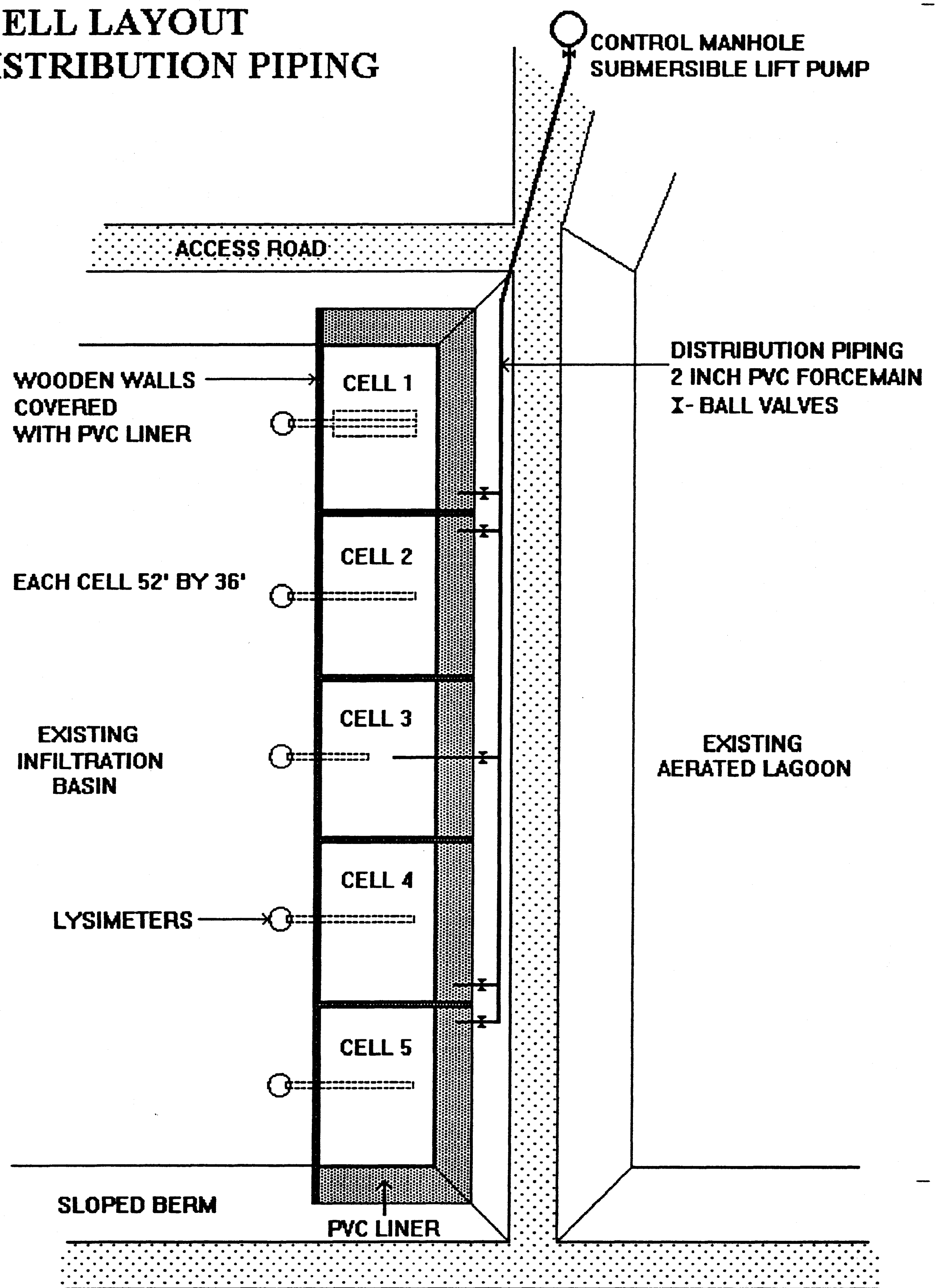


FIGURE 2

LYSIMETER CROSS SECTION

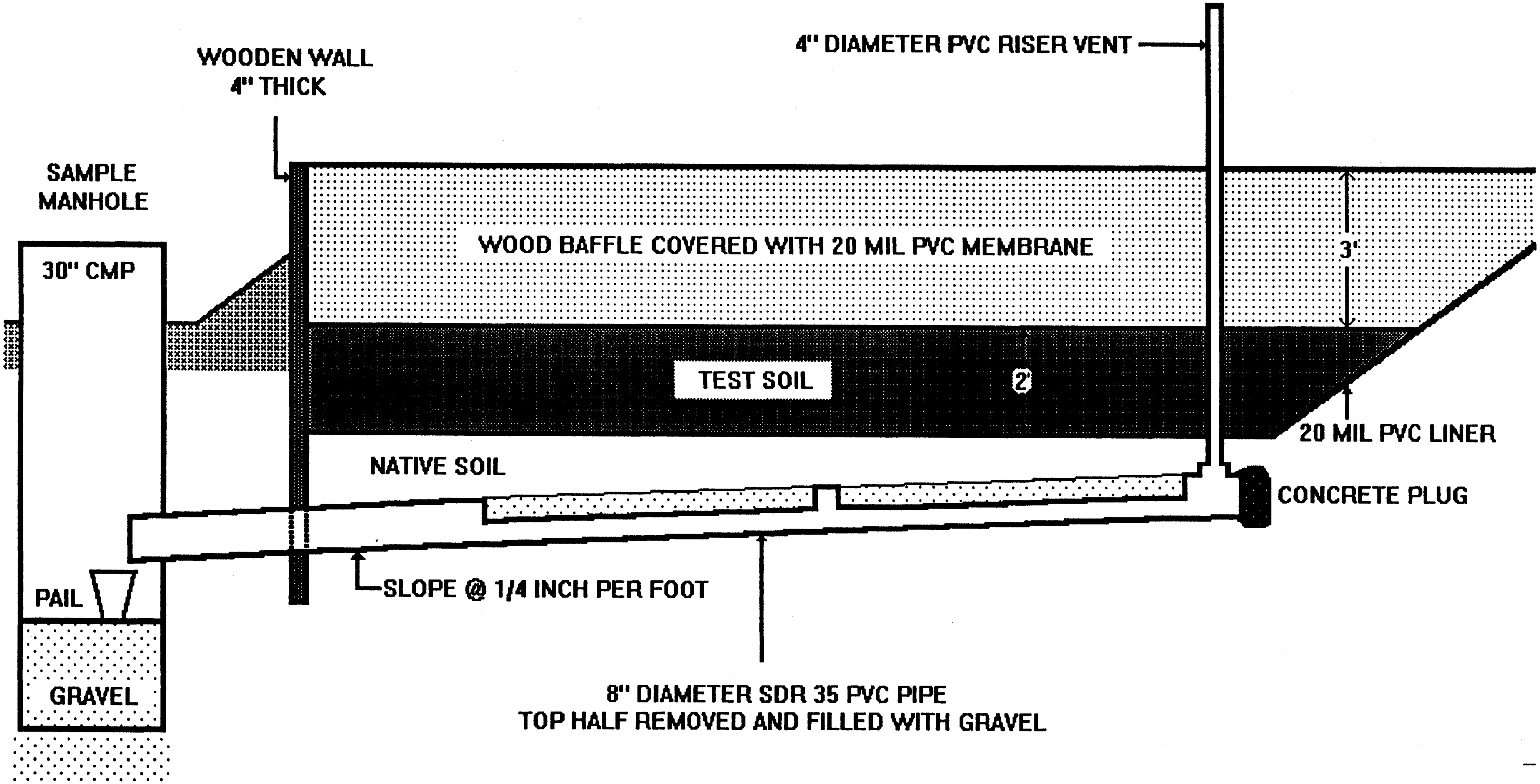


FIGURE 3

compacted using a Case model 1300 compactor. Native soil was placed along the outside of the long wall connecting the ends of the test cells to provide lateral support.

Soils

Previous laboratory research with soil columns demonstrated that significant nitrogen removal can be obtained using a soil consisting of 89% sand, 8% silt and 3% clay. The existing absorption pond soil is a fine to medium grained sand with 5.6% fines and virtually no clay content. Prospective test soils were evaluated with the intent of providing sufficient fines for reducing infiltration rates and sufficient clay for cation exchange capacity. Specific test soil evaluation criteria included maintaining fines (percent passing #200 sieve) at less than 20% and clay at less than 10%. Several soils in the Florence area were considered as test soils. Grain size analyses were performed on approximately ten soils. Three soils were chosen for the project.

The soil testing was done at the laboratory of McDonald - Maas Associates. The testing consisted of sieve analysis and moisture content for all prospective soils. After the test soils were selected and placed in the cells, each of the soils were tested again for grain size distribution as well as field compaction. Results of soil analyses and grain size distribution curves for all of the test soils are found in Appendix 1. Following are descriptions of the three test soils as well as the control:

Cells 1 & 2:

This soil was obtained from the Hardy pit. It was apparently not native to the pit and had been brought in from another location. Based on the grain size distribution it is classified as sand w/silt, fine to medium grained, with a little gravel. The percent fines was 11.4% and the percent clay about 5%.

Cell 4:

This soil was obtained from the Gollakner - Site 2. It is a native soil from a pit located in the NW1/4 of NW1/4, Sec 36, T40N-R18E, Florence Township, Florence County. Available soils mapping indicates this soil is Vilas series. Based on the grain size distribution it is classified as a fine-grained sand w/silt. The percent fines was 11.9% and the clay content about 3%.

Cell 5:

This soil was obtained from Gollakner - Site 1. It is a native soil from a pit located in the SW1/4 of SE1/4, Sec 22, T40N-R18E, Town of Florence, Florence County. No soils mapping information was available for this soil. The top soil had been removed from this borrow area prior to obtaining the soil for the project. Based on the grain size distribution it is classified as a fine grained silty sand, with a little gravel. The percent fines was 26.8% and the percent clay about 4%.

Cell 3 (Control):

The soil for the control cell was the existing native soil at the Florence treatment plant site. Available soils mapping indicates this soil is Pence series. Pence series soils exist in loamy deposits with underlying stratified sand and gravel. During the original construction of the seepage cells, the upper 1 to 2 feet of surface soil was removed and used to construct the dikes. This exposed the underlying sandy soil. Based on grain size distribution testing it is classified as fine to medium grained sand with silt, and a little gravel. The percent fines is 5.6% with virtually no clay content.

Basin Loading and Maintenance

The test cells were dosed using a Tsurumi model LB-400 submersible pump (rated at 50 gpm @ 15 feet of head) and 2 inch schedule 40 PVC distribution piping. Ball valves were provided to control flow to each test cell and one was used to throttle the flow when necessary. Test cell valves were housed in valve boxes made of sections of 12 inch PVC piping with an insulated cover. The distribution piping was pitched at 1/8 inch per foot to the control cell (Test Cell 3). This allowed the distribution system to be completely drained by gravity to prevent freezing. An air relief valve was installed after the pump and before the throttling valve to break the vacuum and allow drainage. All joints in the distribution system were joined using MEK solvent welds. The distribution piping is shown in Figure 2.

The discharge pipe in Test Cell 3 was extended out into the cell and the discharge occurred on an existing concrete pad, approximately 5 feet from the lysimeter. In the other cells, the discharge pipe terminated upon the synthetic liner on the inner berms. The lysimeters were approximately 3 feet from the edges of the lined berms receiving the discharge.

The pump used to dose the test cells was calibrated every two to four weeks by using a stopwatch and an eight gallon pail. For about the first year the pump was calibrated at each test cell when the control valve was wide open and also when the control valve was throttled to approximately half the maximum pump discharge. After the first year the pump was only calibrated through the control cell valve. Pump rates through the other test cell valves were determined using correlations obtained from the previous years measurements. This was done to reduce the time needed to perform the calibration and because it was difficult to calibrate at the other test cells. Pump times were recorded using daily log sheets.

The typical discharge schedule involved alternating the discharge to 2 or 3 cells on a daily basis, for a 1 to 2 week period. Longer discharge/flooding periods of approximately 3 weeks were used in the fall of 1993. The Florence utility operator would normally start or redirect the pump discharges at 6 AM and 3 PM each day. For example, pumping to Cell 1 from 6 AM to 6 AM of the next day, then switching the discharge to Cell 2 from 6 AM to 3 PM, and finally to Cell 3 from 3 PM to 6 AM of the third day. When only 2 cells were in operation, the discharge would normally be alternated to the other cell at 6 AM each day.

The discharge rates were also modified by either completely opening the valves for the maximum rate, or closing the valve to the preestablished setting providing a rate approximately 1/2 the maximum rate. In 1993, the maximum discharge rates for all cells averaged 58.7 gallons per minute (gpm), and the throttled setting rates averaged 33.8 gpm. Complete pump discharge data is provided in Appendix 2.

Standing water levels in the cells were normally measured at the start and end of each pump discharge period. Additional water level readings were made to record the water level drop over time, after the pump discharge ceased. The measurements were made by reading aluminum staff gages located on a wall in each of the cells.

Several leaks along the test cell walls were observed, especially during the first year. The water was apparently channeling through the cover soil, along the soil/wall interface. The leaks were repaired by excavating at the leak locations, backfilling with a test soil/bentonite mixture and recompacting the area. Cell 5 had the most severe leakage problems which persisted throughout the entire study period. Standing water and lysimeter samples were routinely obtained from cell 5, but the persistent leakage suggests that the measured infiltration rates for this cell may be over-estimated.

The cells were first dosed in August of 1992. The initial infiltration rates in cells 1, 2 and 5 were relatively the same and sufficient to induce flooding. The infiltration rate in cell 4 was still excessively high. It was therefore decided to eliminate cell 4 from further study.

Some soil compaction was done and the bottoms of the cells were not routinely tilled to improve infiltration. Accumulations of algae were observed but it was removed on only one occasion. Several small patches to the synthetic liner were required, but in general, it held up well. Holes in the liner were due to whitetail deer walking on the exposed area and equipment damage during installation of test soil. Rocks beneath the liner may have been responsible for some of the damage.

Sampling

Water samples from the lysimeters were collected in PVC pails placed at the discharge end of the lysimeter drains. The pails were typically placed 24 hours prior to sample collection, but longer collection times of 2 or 3 days were also used. Sample temperature, pH and volume was noted at the time of sample collection. The samples collected for nutrients were transferred to 250 ml polypropylene bottles and immediately preserved with sulfuric acid and stored in a Florence Utility refrigerator. Samples collected for other parameters were collected in appropriate bottles preserved and refrigerated. Approximately once per week a shipment of samples were iced and sent, by either the US Postal Service or United Parcel Service, to the Wisconsin State Laboratory of Hygiene in Madison for analysis. Effluent samples were also taken to supplement the data obtained from Florence's required routine effluent sampling.

The effluent applied to the test cells and the lysimeter samples were routinely analyzed for total nitrogen (TN), nitrate plus nitrite-nitrogen (NO_3+NO_2-N), ammonium-nitrogen (NH_4-N), and total kjeldahl nitrogen (TKN). The effluent was additionally analyzed for biochemical oxygen demand (BOD_5), total suspended solids (TSS), temperature, pH, alkalinity, hardness, calcium, magnesium, chloride, and conductivity.

RESULTS AND DISCUSSION

Effluent Characteristics

A plot of effluent total nitrogen (TN) and temperature during the study period is shown in Figure 4. In early April of 1993, effluent temperature was less than 5°C. It warmed up to 10°C at the beginning of May, and reached approximately 15°C by the end of May. The maximum temperature of 20°C was reached by the end of June and persisted until the end of August, when it began to decrease steadily until reaching 10°C again at mid-October, and 5°C in early November. A similar pattern occurred in the fall of 1992.

The effluent nitrogen occurred primarily as NH_4-N. Effluent NO_3-N was usually less than 1 mg/l and never exceeded 2.86 mg/l. Organic N normally averaged about 3.5 mg/l, but high values (ranging from 12.0 to 33.7 mg/l) did occur on May 4 and 6, June 30 and July 13. These high values are believed to be associated with algae blooms. Apart from two high values on May 4 and 6, TN ranged from 34.1 to 24.2 from April to mid-August. A steady decrease in TN occurred from August to a low value of 4.04 mg/l in mid-October. Levels then started increasing again, reaching 16.8 mg/l on December 8, 1993. The 1992 data also showed very low TN concentrations from late August to November (an average of 8.3 mg/l)

The improved nitrogen removal in the aerated lagoons in late summer and fall is the probable result of the establishment of a nitrifying population during the warmer temperatures (greater than 15°C) from June to August. The process of denitrification is quite effective and the efficiency of nitrogen removal is therefore normally limited by the nitrification phase (Shammas, N.K. - 1986). The nitrogen removals achieved in the fall of each year were more efficient than originally anticipated. The low effluent nitrogen concentrations were detrimental to the study's purpose of attempting to characterize an absorption pond's performance when subjected to nitrogen loadings in excess 10 mg/l.

Effluent samples were taken twice per month for BOD_5 and TSS. A plot of the resulting data is shown in Figure 5. From April to the end of June, BOD_5 averaged 21.2 mg/l with a range from 17.0 to 25.0 mg/l. Three of the four samples for July and August had very low BOD_5 levels of 6 or 7 mg/l. From September to November, BOD_5 averaged 12.5 mg/l with a range from 10 to 16 mg/l. A similar pattern occurred in the fall of 1992. The TSS levels averaged

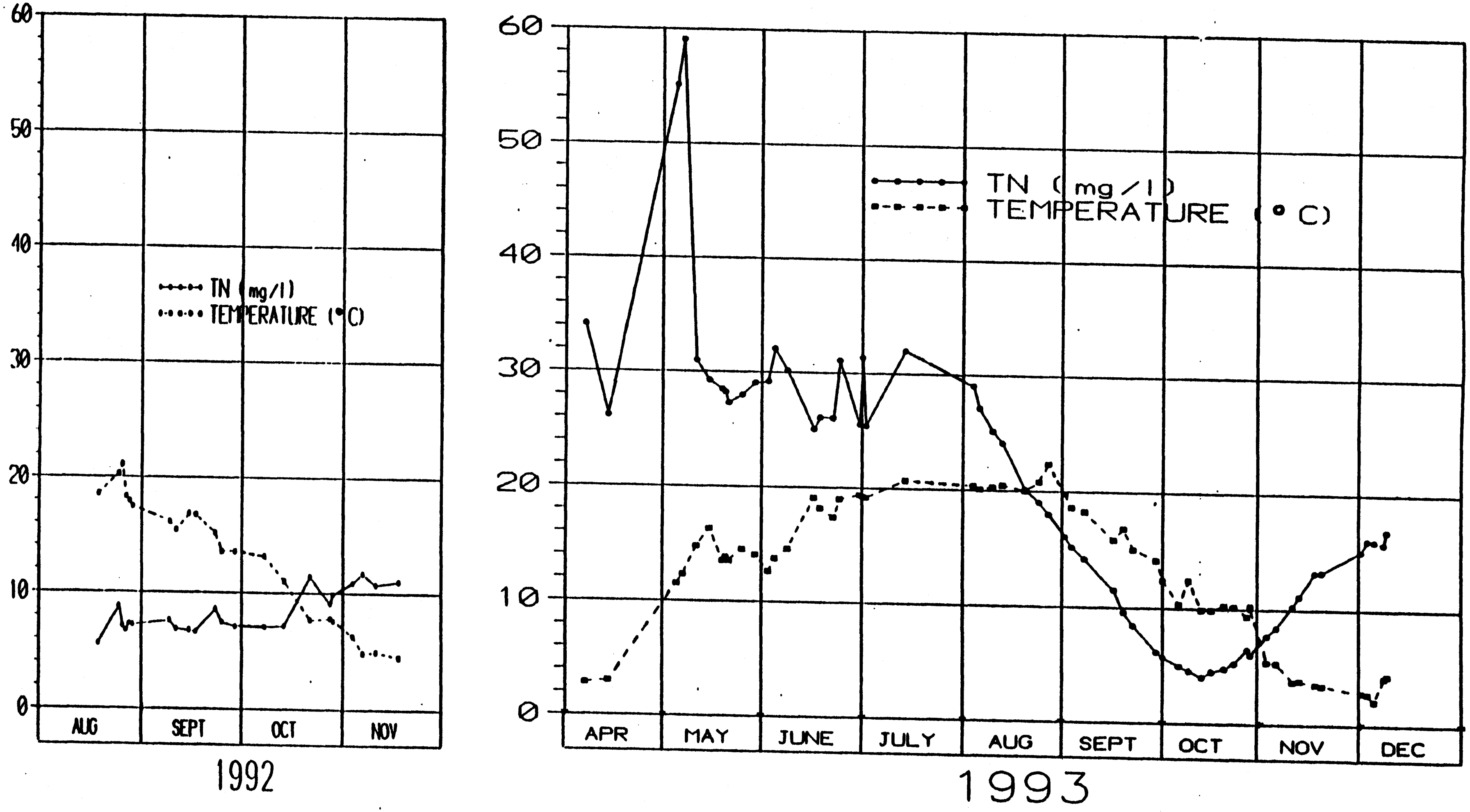

60
50
40
30
20
10
0
TN (mg/l)
TEMPERATURE (°C)
AUG
SEPT
OCT
NOV
1992
60
50
40
30
20
10
0
TN (mg/l)
TEMPERATURE (°C)
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
1993

FIGURE 4

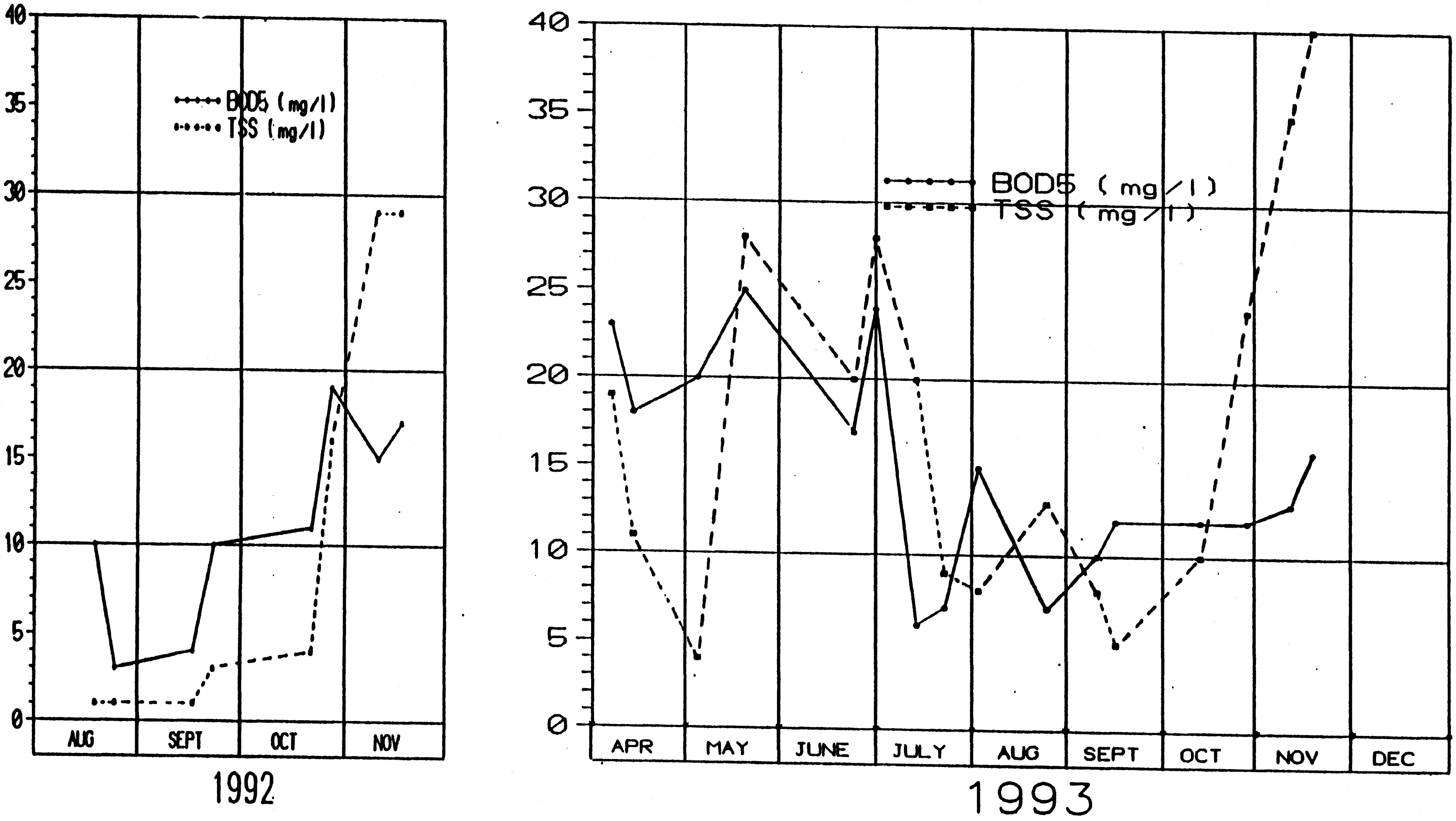

40
35
30
25
20
15
10
5
0
BOD5 (mg/l)
TSS (mg/l)
AUG
SEPT
OCT
NOV
1992
40
35
30
25
20
15
10
5
0
BOD5 (mg/l)
TSS (mg/l)
APR
MAY
JUNE
JULY
AUG
SEPT
OCT
NOV
DEC
1993

FIGURE 5

TABLE 1

EFFLUENT	UNITS	AVERAGE	RANGE	NUMBER OF SAMPLES
ALKALINITY	MG/L	225	168 – 266	9
HARDNESS	MG/L	209	180 – 340	9
CALCIUM	MG/L	47	41 – 74	9
MAGNESIUM	MG/L	22	19 – 37	9
CHLORIDE	MG/L	71	56 – 79	9
CONDUCTIVITY	UMHOS/CM	753	622 – 881	9

LYSIMETER 1	UNITS	AVERAGE	RANGE	NUMBER OF SAMPLES
ALKALINITY	MG/L	166	126 – 202	5
HARDNESS	MG/L	180	160 – 190	5
CALCIUM	MG/L	40	35 – 42	5
MAGNESIUM	MG/L	20	18 – 21	5
CHLORIDE	MG/L	69	65 – 73	5
CONDUCTIVITY	UMHOS/CM	624	574 – 701	5

LYSIMETER 2	UNITS	AVERAGE	RANGE	NUMBER OF SAMPLES
ALKALINITY	MG/L	202	152 – 259	3
HARDNESS	MG/L	230	190 – 270	3
CALCIUM	MG/L	50	43 – 55	3
MAGNESIUM	MG/L	26	21 – 32	3
CHLORIDE	MG/L	72	69 – 74	3
CONDUCTIVITY	UMHOS/CM	709	589 – 785	3

LYSIMETER 3	UNITS	AVERAGE	RANGE	NUMBER OF SAMPLES
ALKALINITY	MG/L	188	160 – 228	3
HARDNESS	MG/L	340	190 – 750	4
CALCIUM	MG/L	74	41 – 160	4
MAGNESIUM	MG/L	37	19 – 85	4
CHLORIDE	MG/L	71	70 – 74	3
CONDUCTIVITY	UMHOS/CM	692	614 – 761	3

LYSIMETER 5	UNITS	AVERAGE	RANGE	NUMBER OF SAMPLES
ALKALINITY	MG/L	269	192 – 346	2
HARDNESS	MG/L	320	–	1
CALCIUM	MG/L	73	–	1
MAGNESIUM	MG/L	33	–	1
CHLORIDE	MG/L	74	63 – 84	2
CONDUCTIVITY	UMHOS/CM	1040	890 – 1190	2

17.6 mg/l in 1993, with a range from 4 to 40 mg/l. Very low TSS values, from 1 to 4 mg/l,occurred from August 18 to October 21 in 1992.

As a general rule, a 1:1 ratio of organic carbon to NO_3-N is needed for 80-90% denitrification (Lance, J.C. - 1984). Effluent total organic carbon was not analyzed in this study but BOD_5 also provides a indication of the availability of a carbon source.

The results of additional effluent sampling and analysis are provided in Table 1. The average alkalinity of 225 mg/l (range: 168 to 266 mg/l) was sufficient for not inhibiting nitrification. The nitrification process requires 7.14 mg/l alkalinity for every mg/l of NH_4 converted to NO_3. The denitrification process produces 3.57 mg/l of bicarbonate alkalinity. Therefore, when both processes occur together a net loss of 3.57 mg/l alkalinity can be expected. Effluent pH averaged 7.6 in both 1992 and 1993 with only minor variability.

Infiltration Rates

Information detailing the effluent loading cycles for each cell are provided in Appendices 3, 4, 5, and 6; for cells 3, 1, 2, and 5, respectively. These charts have days plotted as the horizontal axis. In the center of each chart are two rows entitled "Collect/Sample" and "Dose/Flood". The "Collect/Sample" row contains lines indicating the time period during which the sample collection container was inserted and collecting drainage from the lysimeter. The downward pointing arrow at the end of each line indicates when the sample was taken. The "Dose/Flood" row contains thick solid bars to indicate when effluent was being applied by pumpage. These rows also contain thinner lines indicating the estimated periods of standing water above the soil (flooding). The applied nitrogen and discharged nitrogen (from the lysimeters) is also graphed on these charts.

An average infiltration rate was estimated for each loading cycle. These rates were calculated by multiplying the calibrated pump discharge rate times the time of discharge, and dividing by the cell's total area and the total flooding time. The results indicate the average infiltration rate only during the time of flooding (the averages do not include drying periods). The time of completion of infiltration was not routinely recorded, but was estimated by referring back to the most previous water level reading, and calculating the time for it to infiltrate, using the infiltration rate derived from the time period previous to the water level reading. Assuming infiltration rates would decrease towards the end of the flooding period, this method of estimation may be under-estimating the length of flooding, and thus over-estimating the infiltration rate. Since this methodology was used for each cell, however, a comparison of rates between cells should still be valid.

Other factors may have also contributed to the estimating error for the infiltration rate. Based on 7 separate calibrations in 1993, the complete range of maximum discharge rates (valves fully open) varied by no more than 3.8 gpm (6.5% of average rate). With a valve in the throttled setting, however, the calibrated rates varied by 10.7 gpm (31.7% of average rate).

Minor variations in manually setting the valve for the reduced flow rate may have caused the greater variability. In calculating discharged volumes at the unthrottled setting, the most recent calibrated value was used. In calculations for discharged volumes at the throttled setting, the average rate for the entire year was used due to the greater uncertainty in the data.

Algae mats, approximately 1/8 inch thick, were observed on the cell soil surfaces on at least two occasions. These mats appeared to restrict infiltration, but upon drying, would crack and allow previous infiltration rates to be restored.

The number of water level readings for each loading cycle varied throughout the study, and for some cycles minimal data was available, or conflicting data was reported. For these combined reasons, it was not possible to reliably determine how the infiltration rate varied over time during all dosing periods. Certain loading cycles were well monitored, however, and one of these is illustrated in Figure 6. The associated Table 2 shows the time and water level readings. The figure illustrates how the infiltration rates were typically significantly higher during the pumping periods, and subsequently decreased upon termination of pumping, even though the cell continued to contain standing water in the intervals between pumping. Apparently, the higher water pressure caused by increased water depth was significant in increasing the infiltration rate. This would result in a cyclic infiltration rate pattern during loading cycles receiving multiple pumped doses.

The average infiltration rates for Cells 1, 2 and 5 are plotted in Figure 7. Despite the data limitations, it was possible to reasonably determine total flooding time per loading cycle in most cases. Consequently, these average values, and especially the relative differences between cells 1 and 2, are believed to be reasonably accurate. As previously discussed, leakage problems were persistent in cell 5. No significant trend is apparent from Figure 7. There does appear to be a significant difference between Cell 2 (average of 24.7 in./d.) and Cell 1 (average of 15.9 in./d.). Cell 3 (control) infiltration rates are not shown since no ponding occurred and calculated infiltration rates were well in excess of 76 in./day. Estimating that no more than 25% of Cell 3 was employed for infiltration, the infiltration rate would exceed 304 in./d.

In previous studies (Lance, J.C., et.al. - 1976) with a 9 days flooding, 5 days drying cycle, nitrogen removal from sewage effluent increased exponentially as the infiltration rate decreased, according to the equation $\log Y = 3.40 - 1.27 \log X$. Where X equals the infiltration rate in cm./day and Y is the % nitrogen removal. Using this equation yields 23% potential removal for Cell 1 at 15.9 in./d. (40.4 cm./d.), 13.2% removal for Cell 2 at 24.7 in./d (62.7 cm./d.), and 19.5% removal for Cell 5 at 18 in./d. (45.7 cm./d.).

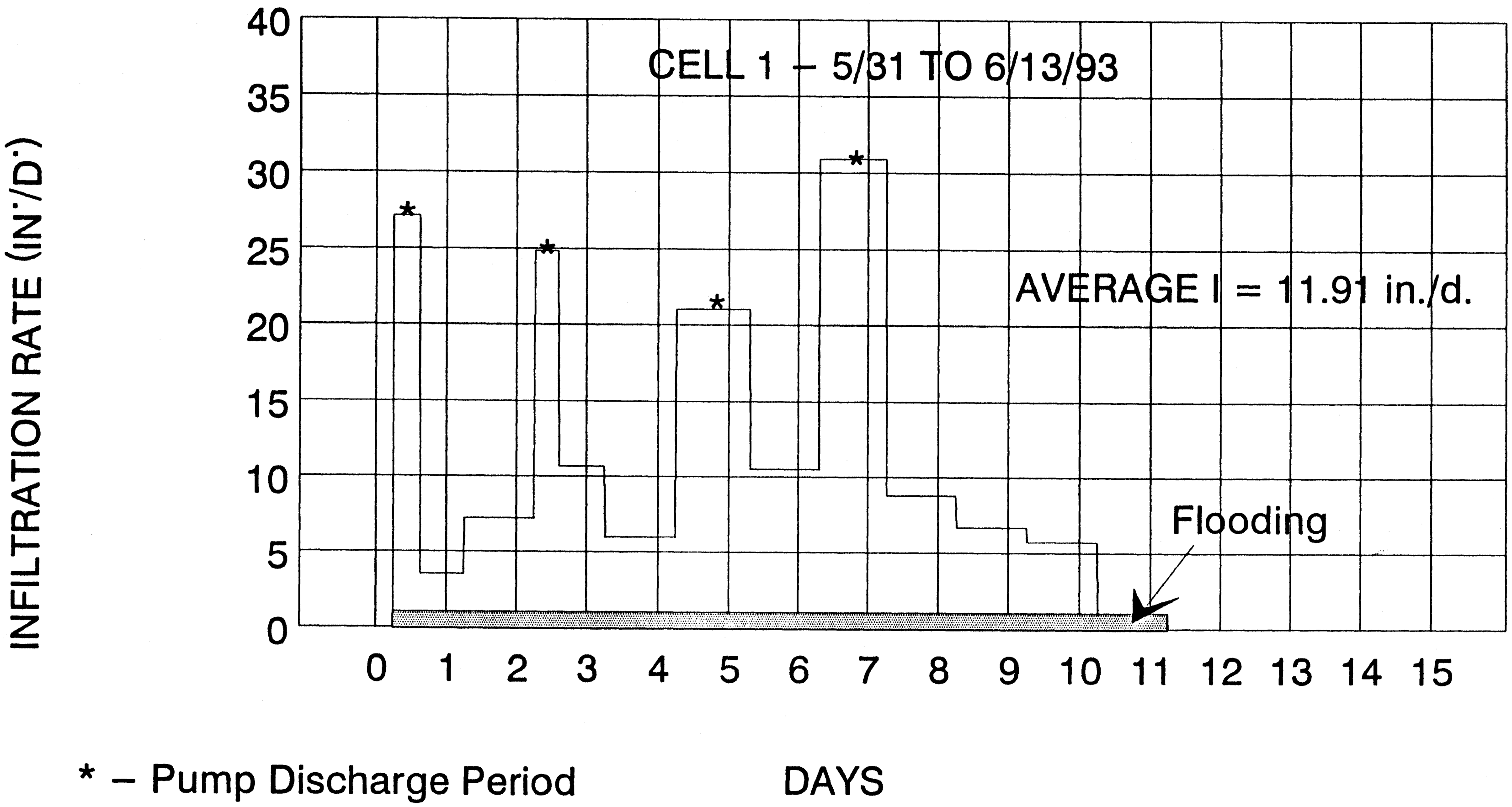

CELL 1 – 5/31 TO 6/13/93
AVERAGE I = 11.91 in./d.
Flooding
INFILTRATION RATE (IN'/D')
DAYS
* – Pump Discharge Period

FIGURE 6

FLORENCE ABSORPTION POND RESEARCH RESULTS

Dates: 31–May to 13–Jun

Cell No.: 1

Cell Area: 1944 ft.²

Dose Rate:
57.8 (gpm) All Valves Open
33.7 (gpm) Throttled Valve

Date of Calibration:
4/26/93
1993 AVG

Dates	Day
31–May	1
01–Jun	2
02–Jun	3
03–Jun	4
04–Jun	5
05–Jun	6
06–Jun	7
07–Jun	8
08–Jun	9
09–Jun	10
10–Jun	11
11–Jun	12
12–Jun	13
13–Jun	14

Dose				Dosing Period	Day	Time	Time of WL Reading Day	Time	WL (inch)		Infil. Rate (in./day)
Dose 1				Start	1	06:00 AM	1	06:00 AM	0.00	*	27.115
	Rate:	57.6	(gpm)	End	1	03:00 PM	1	03:00 PM	15.50		3.5409
	Volume:	31,104	gal.				2	06:15 AM	13.25		7.25
		2.14	ft.								7.25
											7.25
Dose 2				Start	3	06:15 AM	3	06:15 AM	6.00	*	24.812
	Rate:	57.6	(gpm)	End	3	02:30 PM	3	02:30 PM	21.00		10.666
	Volume:	28,512	gal.				4	06:15 AM	14.00		6
		1.96	ft.								6
											6
Dose 3				Start	5	06:15 AM	5	06:15 AM	8.00	*	21.037
	Rate:	33.7	(gpm)	End	6	07:30 AM	6	07:30 AM	28.00		10.5
	Volume:	51,056	gal.								10.5
		3.51	ft.								10.5
											10.5
Dose 4				Start	7	07:30 AM	7	07:30 AM	17.50	*	30.883
	Rate:	33.7	(gpm)	End	8	06:25 AM	8	06:25 AM	26.25		8.8111
	Volume:	46,338	gal.				9	06:15 AM	17.50		6.7266
		3.19	ft.				10	06:20 AM	10.75		5.75
							11	06:20 AM	5	>	5.0174
Dose 5				Start			12	06:15 AM	0.00	*	ERR
	Rate:		(gpm)	End							0
	Volume:	0	gal.								0
		0.00	ft.								0
							14		0.00		0

* Calculated with Dose Rate

Load/Rest Cycle (14 days) Totals

Total Volume Applied:
157,009 gal.
10.80 ft.

Avg. Infil. Rate:
11.91 in./d

Avg. Hydralic Loading
251,297 gpad

Total Flooding Time:
10.88 day

Total Dry Time
3.12 day

Wet/Dry Ratio:
3.49

TABLE 2

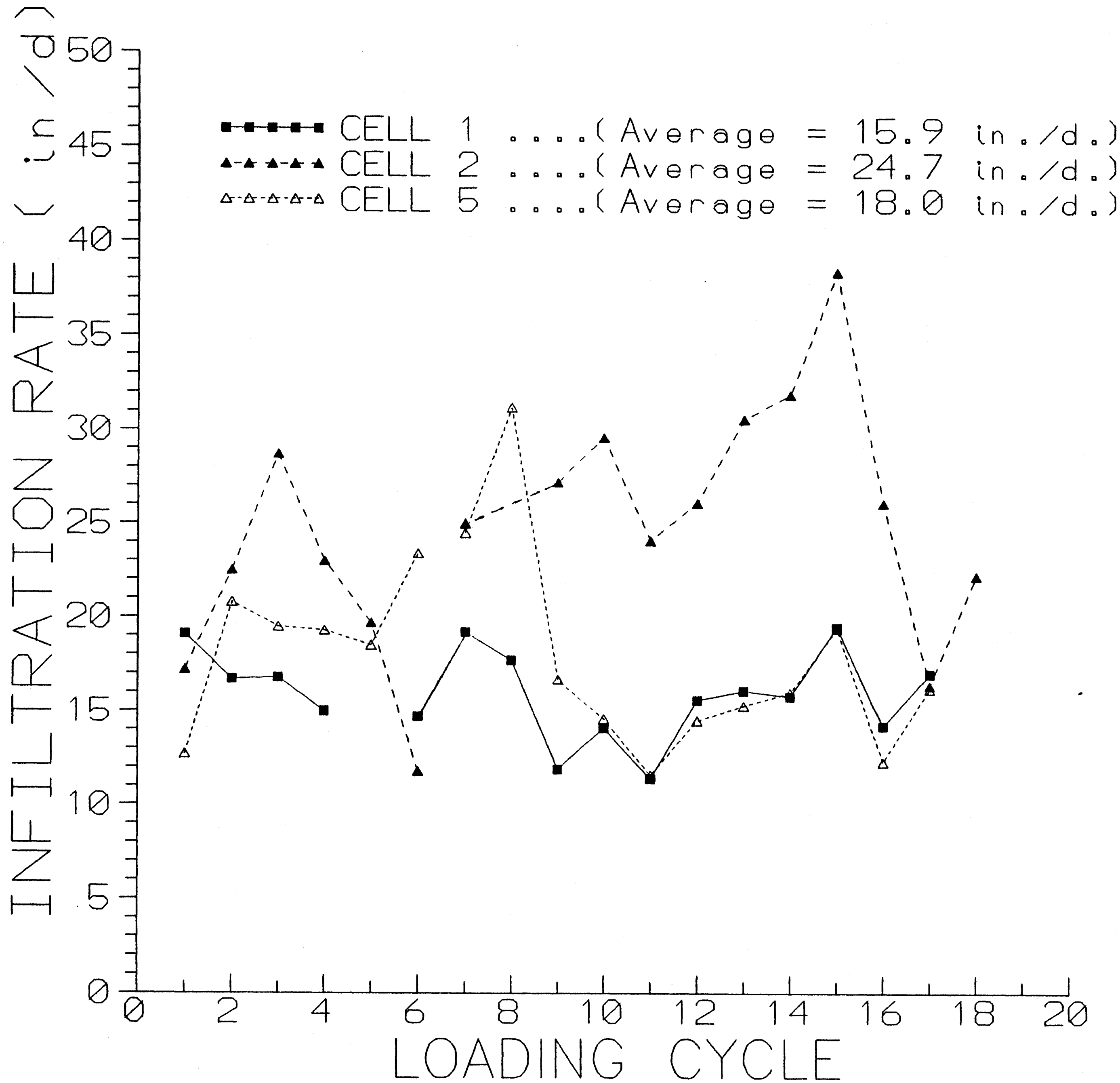

CELL 1 ....(Average = 15.9 in./d.)
CELL 2 ....(Average = 24.7 in./d.)
CELL 5 ....(Average = 18.0 in./d.)
INFILTRATION RATE (in/d)
LOADING CYCLE
0
5
10
15
20
25
30
35
40
45
50
0
2
4
6
8
10
12
14
16
18
20

FIGURE 7

Lysimeter Hydraulic Performance

An estimate of the average retention time in the soil profile, above the lysimeters, is provided in Table 3. These estimates are based on an assumed 48% porosity and account for the soil volume taken up by hydroscopic water which does not freely drain. For the average infiltration rates occurring in 1993, the resulting average retention times are 15.5, 9.9 and 12.4 hours for cells 1, 2, and 5, respectively. For Cell 3, an average retention of less than 3.9 hours results assuming infiltration across the entire cell area. Since infiltration typically occurred on less than 1/4 of this area, the soil retention time would actually be less than 1 hour.

Using the open area of each lysimeter, an estimate was also made for the expected discharge rate from the lysimeter, assuming 100% capture of the infiltrating water, at the average infiltration rate for each cell. In May of 1994, more intensive field monitoring of the lysimeter flow rates was conducted for Cells 1, 2 and 3. The results are graphed in Figures 8, 9, and 10.

As shown in Figure 8, a typical dose of 29.8 gpm was applied to Cell 1 for 25 hours. Complete infiltration occurred over a time period of 33.3 hours for an average infiltration rate of 28.2 in./d.. Although higher than the 1993 average infiltration rate of 15.9 in./d., this rate is typical of the higher rates experienced during the pumping periods. At 28.2 in./d., the theoretical average soil retention time is 8.76 hours. The observed lysimeter flow rate increased significantly from 4 to 6 hours after the start of flooding. From 9.5 hours after the start of flooding, to the end of flooding, the lysimeter flow rate averaged 1.4 gpm. The lysimeter flow rate dropped sharply after the completion of infiltration.

Cell 2 was dosed at 20.1 gpm for 25 hours. Complete infiltration occurred over a time period of 26.33 hours for an average infiltration rate of 24.8 in./d. (based on uniform infiltration across the entire cell). It was noted that only 70% of the cell was actually flooded during the infiltration period. Correcting for this yields an infiltration rate of 35.4 in./d.. The theoretical average soil retention times for these two rates are 9.3 and 6.9 hours. A measurable lysimeter flow rate of 0.0014 gpm was first observed 7 hours after the start of flooding. The lysimeter flow rate increased to a peak of 0.0047 gpm at the end of the dosing period. The lysimeter flow rate then decreased more gradually (than in Cell 1) to 0.0004 gpm, 6.08 hours after pumping was terminated.

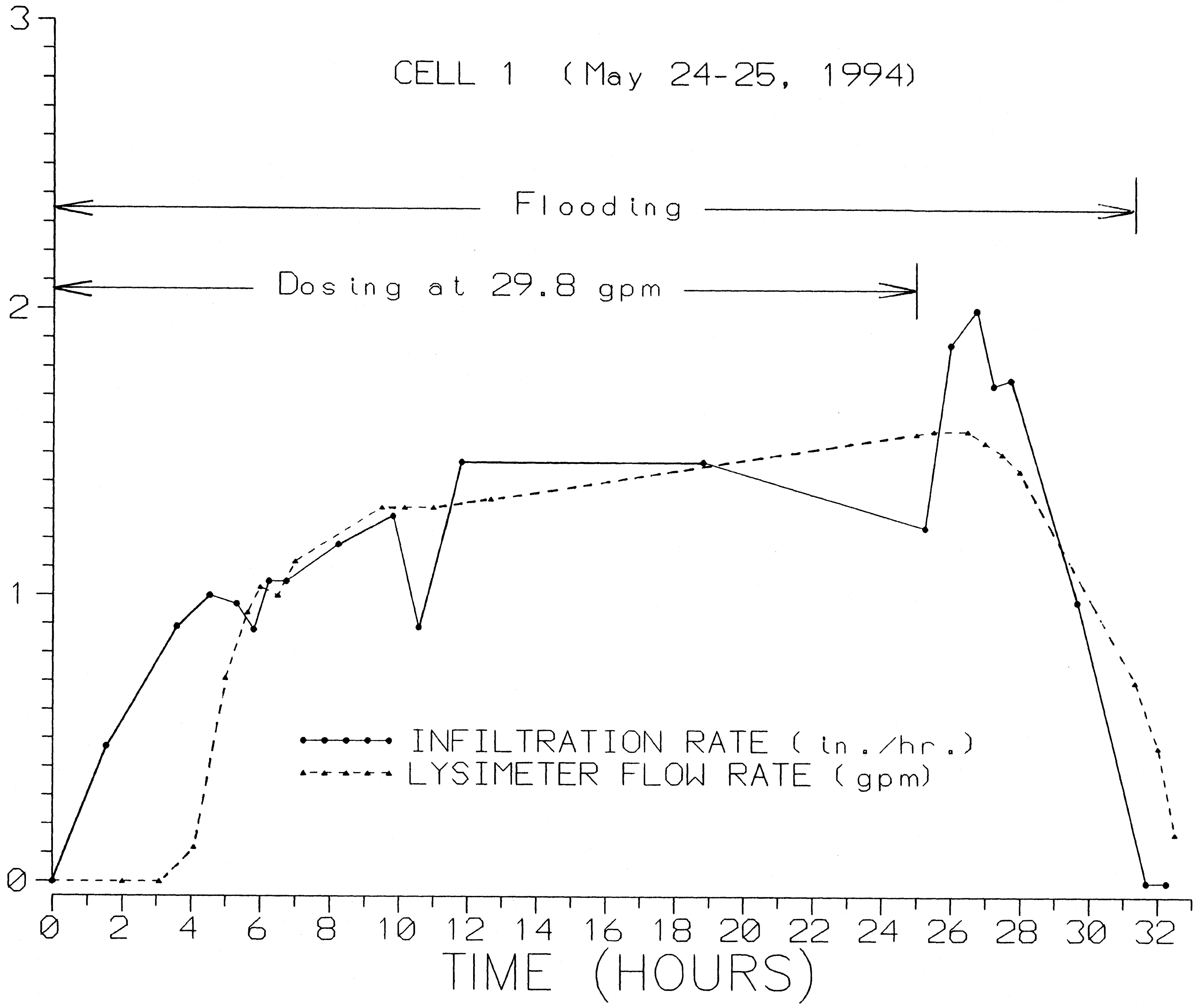
Cell 3 was dosed at 63.1 gpm for 5.42 hours. Standing water did not accumulate. A lysimeter flow rate was first detected 37 minutes after the start of flooding. Approximately 7 minutes later, the flow rate was 0.67 gpm even though less than 33% of the lysimeter was covered by water. The lysimeter flow rate increased to a maximum of 1.76 gpm at the end of the dosing period. The flow rate ended sharply, immediately after the pump dosing was terminated. Accounting for the fact that only 10% of the cell was utilized for infiltration, the average infiltration rate calculates out to 734 in./d., with a corresponding average soil retention time of 24 minutes.

CELL	AVAILABLE CAPACITY IN SOIL PROFILE * (Inches)	AVERAGE INFILTRATION RATE (I) (Inches/day)	RETENTION TIME IN SOIL PROFILE (hours)	LYSIMETER COLLECTION SURFACE AREA (sq. feet)	DISCHARGE RATE AT AVERAGE I ** (gpm)
1	10.3	15.9	15.5	200	1.38
2	10.2	24.7	9.9	13.3	0.14
3	12.3	>76.0	<3.9	6.7	0.22
5	9.3	18.0	12.4	13.3	0.10

* – Based on moisture content measurements from October 22, 1992 and assumed soil porosity of 48%

** – Assuming 100% capture of infiltrating water above lysimeter collection area

TABLE 3



CELL 1 (May 24-25, 1994)
Flooding
Dosing at 29.8 gpm
INFILTRATION RATE (in./hr.)
LYSIMETER FLOW RATE (gpm)
0
1
2
3
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
TIME (HOURS)

FIGURE 8

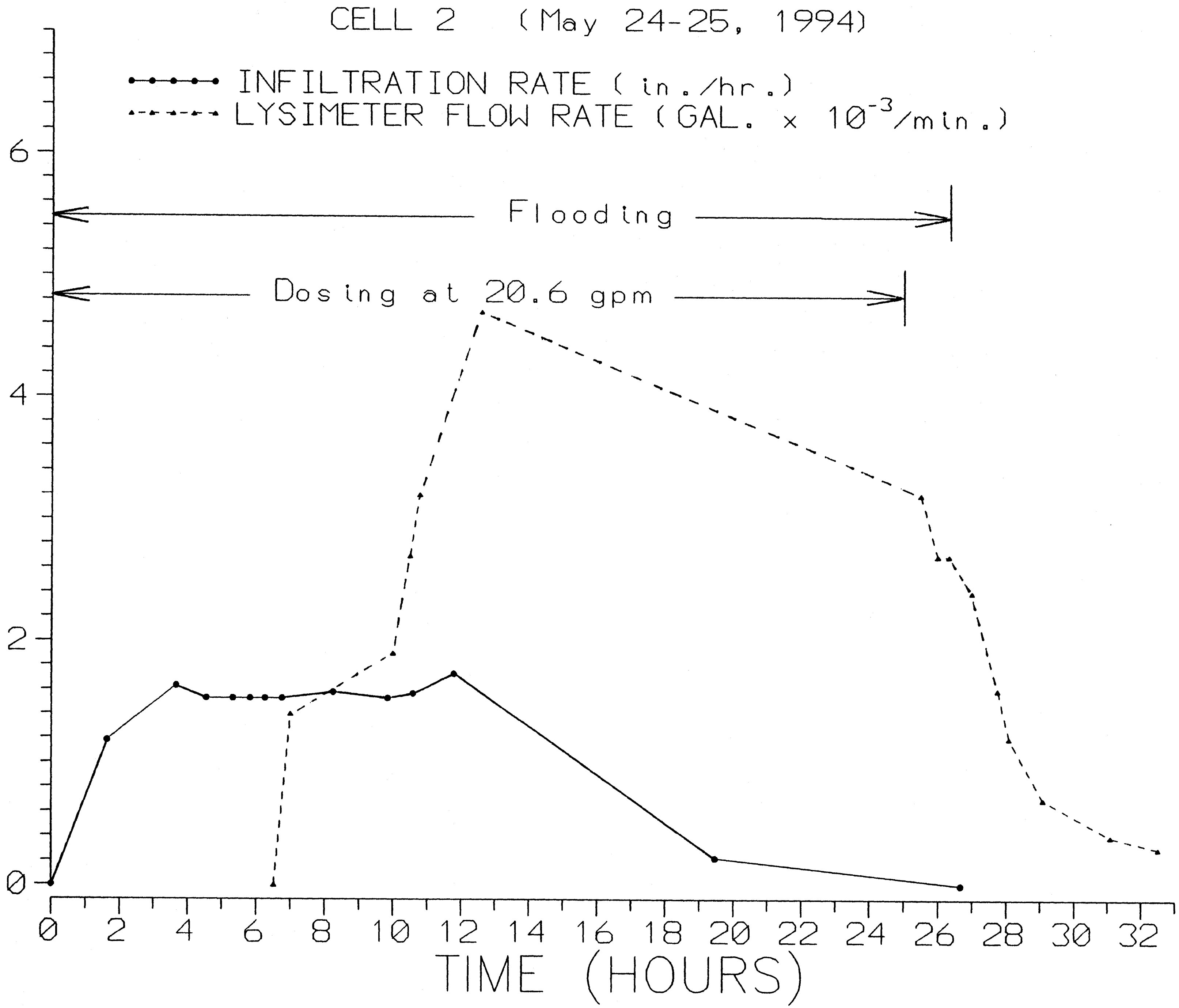

CELL 2 (May 24-25, 1994)
INFILTRATION RATE (in./hr.)
LYSIMETER FLOW RATE (GAL. x 10^-3/min.)
Flooding
Dosing at 20.6 gpm
0
2
4
6
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
TIME (HOURS)

FIGURE 9

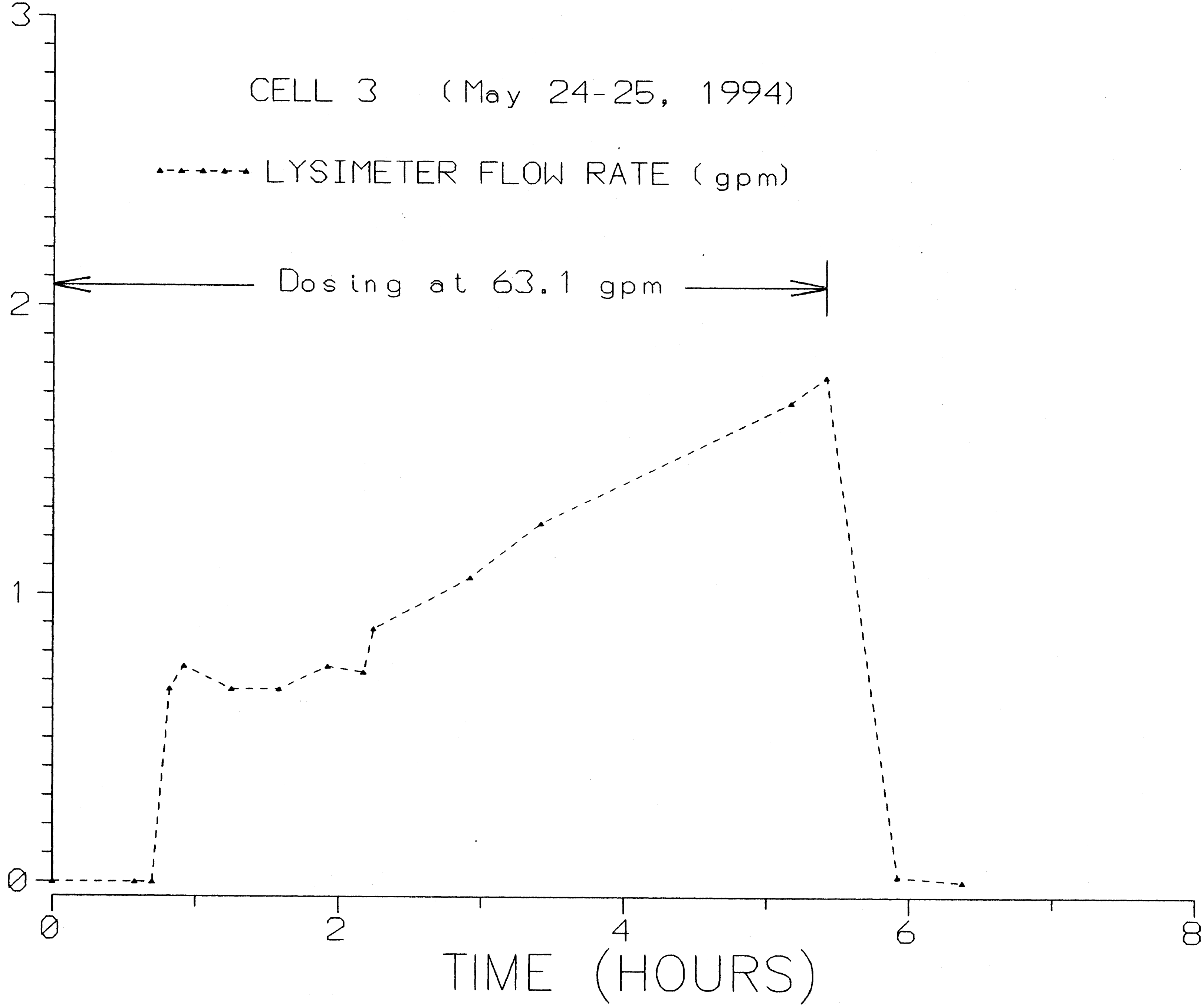

CELL 3 (May 24-25, 1994)
LYSIMETER FLOW RATE (gpm)
Dosing at 63.1 gpm
3
2
1
0
0
2
4
6
8
TIME (HOURS)

FIGURE 10

These special infiltration and lysimeter flow rate investigations confirmed the general observations made throughout the entire 1993 study period. In general, significantly higher lysimeter flow rates occurred in Cells 1 and 3, as compared to Cells 2 and 5. In Cell 3, high rates were due to the concentration of the discharge into a small area, and the soil essentially served as a direct conduit into the lysimeter. In Cell 1, the higher rates were due to the lysimeter modification which expanded its collection area to 200 square feet, compared to 13.3 square feet in Cells 2 and 5.

Sample volumes obtained during the sample collection periods were routinely recorded. This data, plus additional sample information, is tabulated for each cell in Appendices 3, 4, 5, and 6. A 12 quart container was used to collect lysimeter flows. In Cells 1 and 3, this container was normally full at the end of a 24 hour collection period. With typical lysimeter flow rates on the order of 1.5 gpm, it is apparent that the containers were routinely overflowing during the collection period, and the samples essentially represent a grab sample at the end of the collection period. In a few cases, less than 12 quarts were collected from Cells 1 and 3. In Cell 3 this was probably due to the infiltration not occurring directly above the lysimeter. In Cell 1, standing water occasionally accumulated in the sample collection manhole, causing the sample container to tip over. When this occurred, the container was emptied and the operator manually held the container in place to collect a sample. Volumes less than 12 quarts were sometimes collected in this manner. The sample volumes taken from Cells 2 and 5 were normally less than 12 quarts. In 1993, the average sample volumes from Cells 2 and 5 were 3.4 and 2.0 quarts, respectively. Since no overflowing occurred, these samples provided a complete composite for the collection period.

Water quality analyses were not conducted in conjunction with the special investigation of flow rates in May, 1994. It is noteworthy, however, that the effluent was colored green with algae at this time. The lysimeter flow in Cell 3 was consistently colored light green or green. The lysimeter flow in Cell 1 was clear until the pump dose was terminated, it then became green colored. The lysimeter flow in Cell 2 was clear throughout the entire collection period. A green colored lysimeter sample was also noted in Cell 3 in June of 1993. This occurred in conjunction with the formation of an algae mat on the soil surface.

Nitrogen Removal

Nitrogen removal was calculated for each loading cycle. The applied N was determined by averaging, or interpolating from the applied effluent N data nearest in time to the pumped application periods. The discharged N was based on a sample average for the entire loading cycle, unless indicated otherwise. Very low effluent TN loadings (less than 10 mg/l) occurred in the fall of 1992. No removal occurred during this time. In general, the low 1992 loadings precluded the generation of useful information. Discussion will therefore focus on the 1993 data, and in particular, on the higher TN loading period from May to August.

Cell 3 (Control):

Graphs of applied and discharged nitrogen for Cell 3 are provided in Figures 11, 12, and 13. Complete nitrogen data is in Appendices 3 and 7.

Loading Cycle 7 in early May shows a substantial TN removal of 28.1 mg/l (see Figure 11). Closer examination reveals that the effluent TN contained a high organic N concentration of 31.6 mg/l, which corresponds closely to the TN removal. Organic N will be associated with organic matter which will normally be filtered out and retained within the soil profile. For this reason, N removal graphs were also generated based only on NO_3 + NH_4, which are the predominate forms of nitrogen in the effluent and lysimeter samples. See Figure 12. This graph clearly indicates that no significant nitrogen removal occurred in the control cell. In some cases, the discharged nitrogen is greater than the applied nitrogen. This may be partially due to estimating errors, but may also reflect the mineralization of accumulated soil organic nitrogen, occurring during dry periods, which is then flushed out as NO_3 or NH_4 during subsequent effluent application periods.

The form of the discharged N is shown in Figure 13. This graph indicates that the discharged N occurred primarily as NH_4-N until mid-August, when, starting with loading cycle 13, nitrate became the dominant form. This time period corresponds to the beginning of lower effluent N due to the probable establishment of a nitrifying microbial population in mid-summer. Nitrification within the soil profile appeared to have continued from this point in time to the end of the study in early December. The effluent temperatures during the two final loading cycles 19 and 20 were less than 5°C.

For two loading cycles, some of the discharged N data was considered abnormal and was not used. Only one sample was obtained from loading cycle 10, and its reported NO_3-N concentration was 183.9 mg/l. For loading cycle 12, two samples were taken. The first sample had a "normal" TN value (approximately equal to applied N), but the second sample had a reported NO_3-N concentration of 162.2 mg/l. Previous studies with laboratory soil columns (Lance, J.C. and Whisler, F.D. - 1972; and Lance, J.C. et.al. - 1976) have demonstrated that concentrated nitrate peaks can occur as the result of adsorbed NH_4-N being nitrified during dry periods and then being flushed out with subsequent dosing. Nitrate peaks from these studies, however, were in the range of 50 to 80 mg/l. The 183.9 and 162.2 mg/l peaks seem unusually high, especially considering that there is no clay in the control cell soil to provide cation exchange capacity for NH_4-N adsorption. During loading cycles 14 and 16, two samples were taken from each cycle. In both cases, the first sample showed significantly higher NO_3-N compared to the second sample, however, these values were 21.7 and 19.3 mg/l.

During loading cycle 19, in mid-November, two separate lysimeter samples had organic N levels of 10.8 and 10.4 mg/l. These were the highest organic N values recorded for any lysimeter sample (from any cell) during the study. The effluent TSS concentration at this time was 40 mg/l. Different forms and types of algae will occur in lagoons and these high values may have been the result of an algae which was not removed by the soil. Algae breakthrough was also indicated by green colored lysimeter samples during the special infiltration study in May 1994.

In summary, The soil in cell 3 was effective in temporarily removing organic nitrogen, except for one loading cycle. No significant nitrogen removal occurred but nitrification was enhanced after mid-August. There was fairly significant variability in the form of nitrogen (either NO_3 or NH_4) and two extremely high nitrate values occurred. It is uncertain if these high values are real or the result of some unknown source of contamination or sampling/laboratory error.

Cell 1:

The nitrogen removal in Cell 1 is graphed in Figures 14, 15 and 16. Nitrogen data is contained in Appendices 4 and 7.

In 1992, Cell 1 only produced minimal lysimeter flow and data was obtained for only one loading cycle. The lysimeter was modified in November of 1992 and subsequently produced substantial flows throughout 1993. The dosing schedule to Cell 1 generally resulted in sustained flooding periods of approximately 7 to 10 days. In a few cycles, short drying periods occurred between the pumped doses. The schedule was modified in August to produce longer sustained flooding periods of approximately 18 to 21 days. This was done to create anoxic saturated soil conditions to further promote denitrification in anticipation that nitrification might start occurring within the aerated treatment lagoons during this warm weather time period.

Figures 14 and 15 indicate consistent and significant nitrogen removal from May to the end of August (loading cycles 7 through 13). A 53.3% TN removal, and a 46.3% $NO_3 + NH_4$ removal was achieved in this time period. The predominant from of discharged nitrogen was NH_4. This suggests partial nitrification and subsequent denitrification of the produced NO_3. The discharged NH_4 indicates a loading in excess of the soil's adsorptive capacity.

The longer flooding schedule was started with loading cycle 14 (flooding occurred for 20 days from August 30 to September 18). This is the first cycle in which nitrate became the predominant form of discharged N. The 7 lysimeter samples taken during this cycle show an increasing trend in TN and NO_3. Samples taken 2 and 4 days from the start contained approximately 6 mg/l TN and less than 1 mg/l NO_3. The last 4 samples taken 13, 17, 20, and 23 days from the start, averaged 16.6 mg/l TN and 15.7 mg/l NO_3. Also during this cycle the applied TN decreased steadily from 16.0 to 11.5 mg/l and the BOD_5 was low (average of 2 samples: 11 mg/l). Similar to the control cell, nitrification was enhanced at this time, but it also appears that denitrification was inhibited, possibly due to a low carbon to nitrogen ratio.

In loading cycle 15, lysimeter samples were taken every day in an attempt to characterize data variability within one flooding period. The applied TN was low at this time (5 mg/l) and BOD_5 was approximately 12 mg/l. The first sample taken 1 day after start, contained 42.0 mg/l TN and 41.2 mg/l NO_3. All subsequent results were consistently low (less than 6 mg/l TN). This nitrate peak may be the result of stored NH_4 being nitrified during the previous dry period and subsequently being flushed out during the following initial flooding period. The mineralization of organic matter may also have contributed. Nitrate peaks of this magnitude were not observed to occur in other samples taken from the end of the first day of a new cycle. For example, the first sample taken from loading cycle 14 only contained 0.37 mg/l NO_3. The first sample from loading cycle 7 contained 13.8 mg/l NO3 (compared to the subsequent sample of 2.44 NO_3). First day samples were not taken for the remaining cycles.

Cell 2:

The nitrogen removal in Cell 2 is graphed in Figures 17, 18, and 19. Nitrogen data is provided in Appendices 5 and 7.

Cells 2 and 1 had the same soil and similar loading schedules, but behaved differently. As illustrated in Figure 7, the infiltration rates in cell 2 were significantly higher than the rates in Cell 1. For the May to August time period, Cell 2 averaged 28.7 in./d. compared to 15.3 in./d. in Cell 1. At this higher rate, flooding occurred during the pumped discharge period, but infiltrated relatively rapidly thereafter and dry periods typically occurred between pump discharges. It should also be noted that the Cell 2 lysimeter was not modified as was done for Cell 1, and collected sample volumes were therefore significantly less.

Figures 17 and 18 do not demonstrate any nitrogen removal, and in fact, the average percent removal values are negative, suggesting the discharged N exceeded the applied N. Significant N removal occurred in only one case (loading cycle 9, starting on May 25). Figure 19 indicates the occurrence of nearly complete nitrification for all but the last two loading cycles. This would be expected due to the improved aeration resulting from more frequent resting (dry) periods.

Loading cycle 16 is noteworthy because nearly the entire lysimeter flow was collected and used for sample analysis. The discharged nitrogen was nearly all in the nitrate form and averaged 15.2 mg/l with a range from 9.09 to 23.0 mg/l. An initial nitrate peak was not detected.

Cell 5:

The nitrogen removal in Cell 5 is graphed in Figures 20, 21, and 22. Nitrogen data is provided in Appendices 6 and 7.

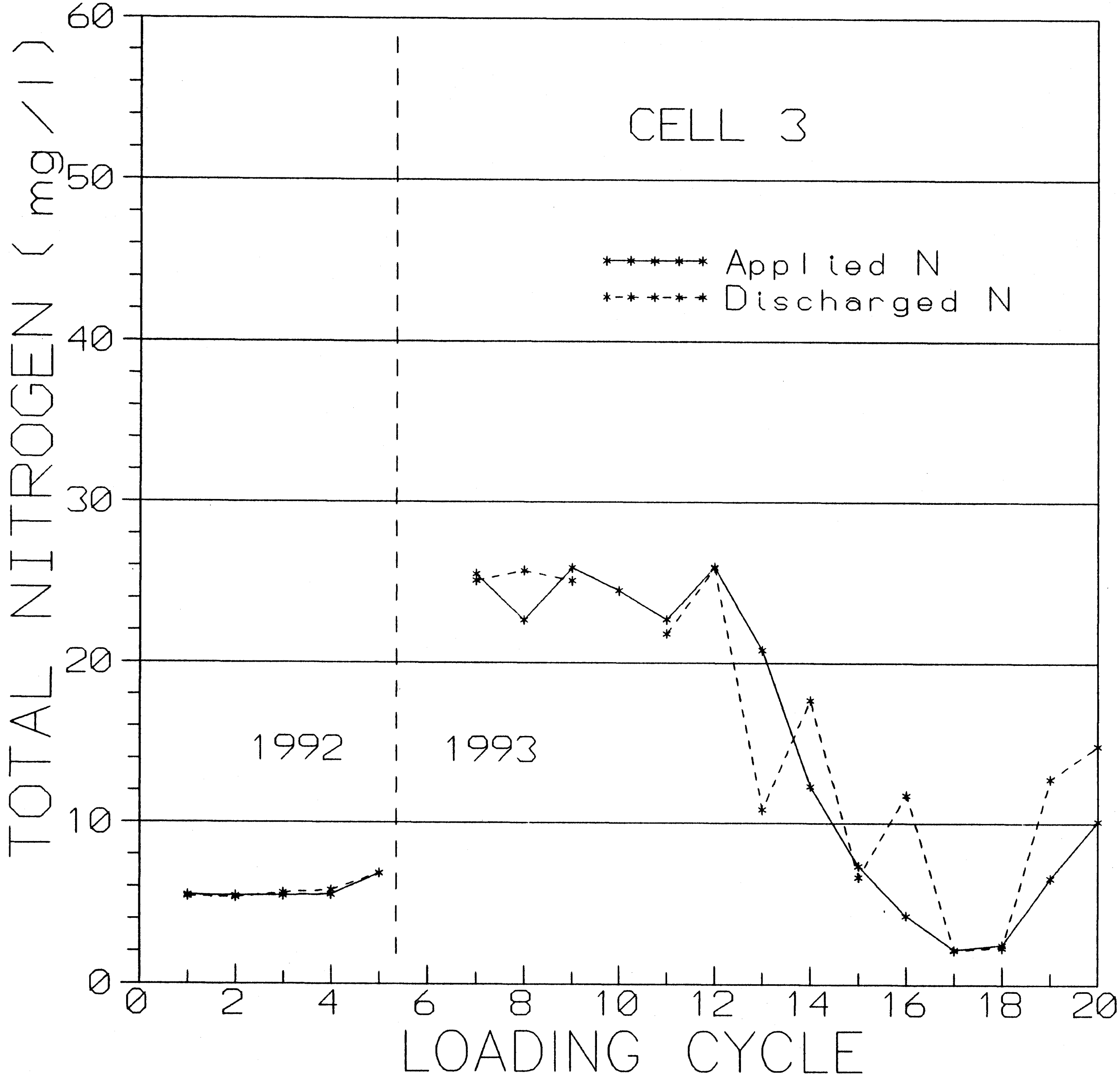

CELL 3
Applied N
Discharged N
1992
1993
TOTAL NITROGEN (mg/l)
LOADING CYCLE
0
10
20
30
40
50
60
0
2
4
6
8
10
12
14
16
18
20

FIGURE 11

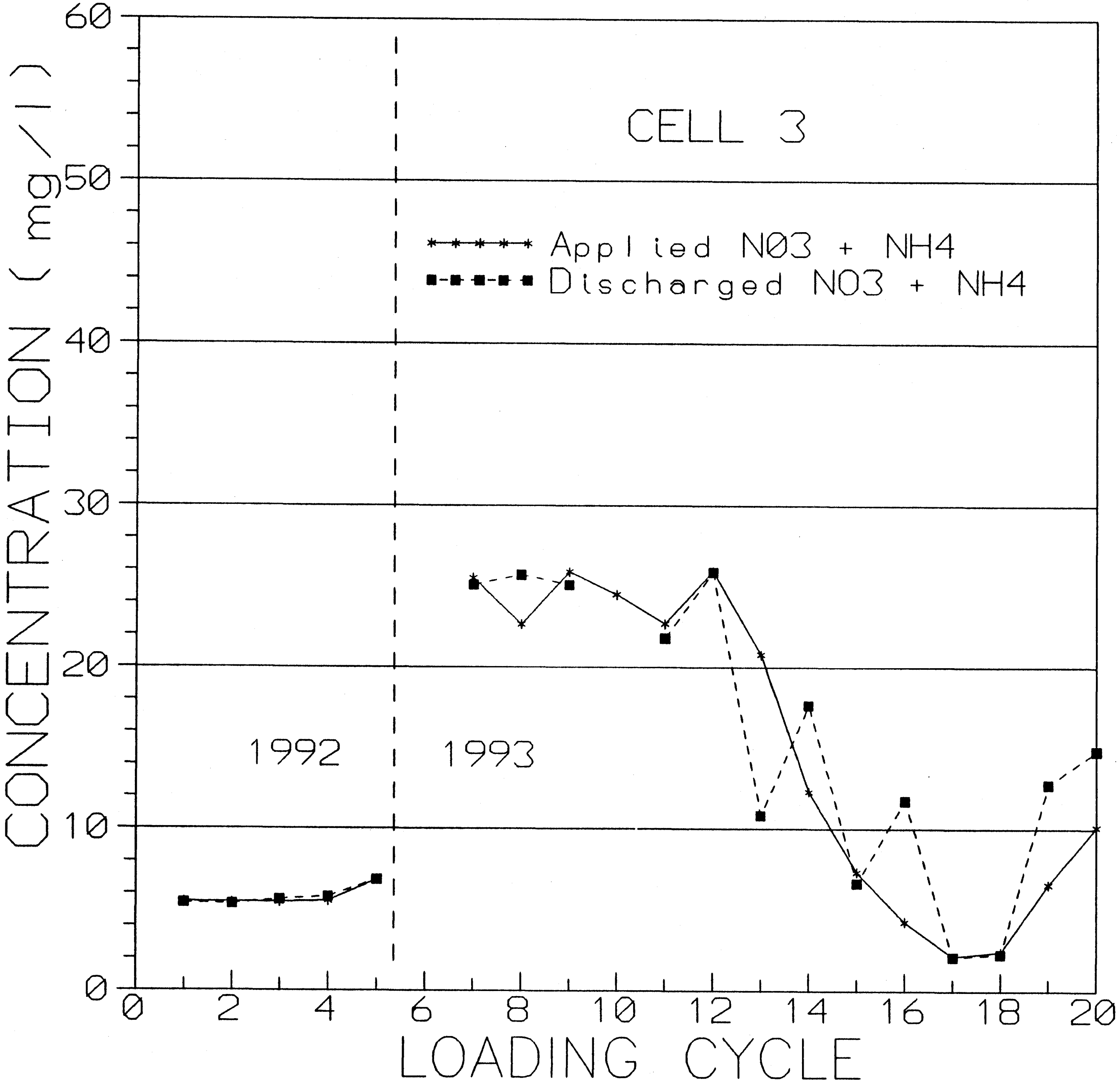

CELL 3
Applied NO3 + NH4
Discharged NO3 + NH4
1992
1993
CONCENTRATION (mg/l)
LOADING CYCLE
0
10
20
30
40
50
60
2
4
6
8
12
14
16
18

FIGURE 12

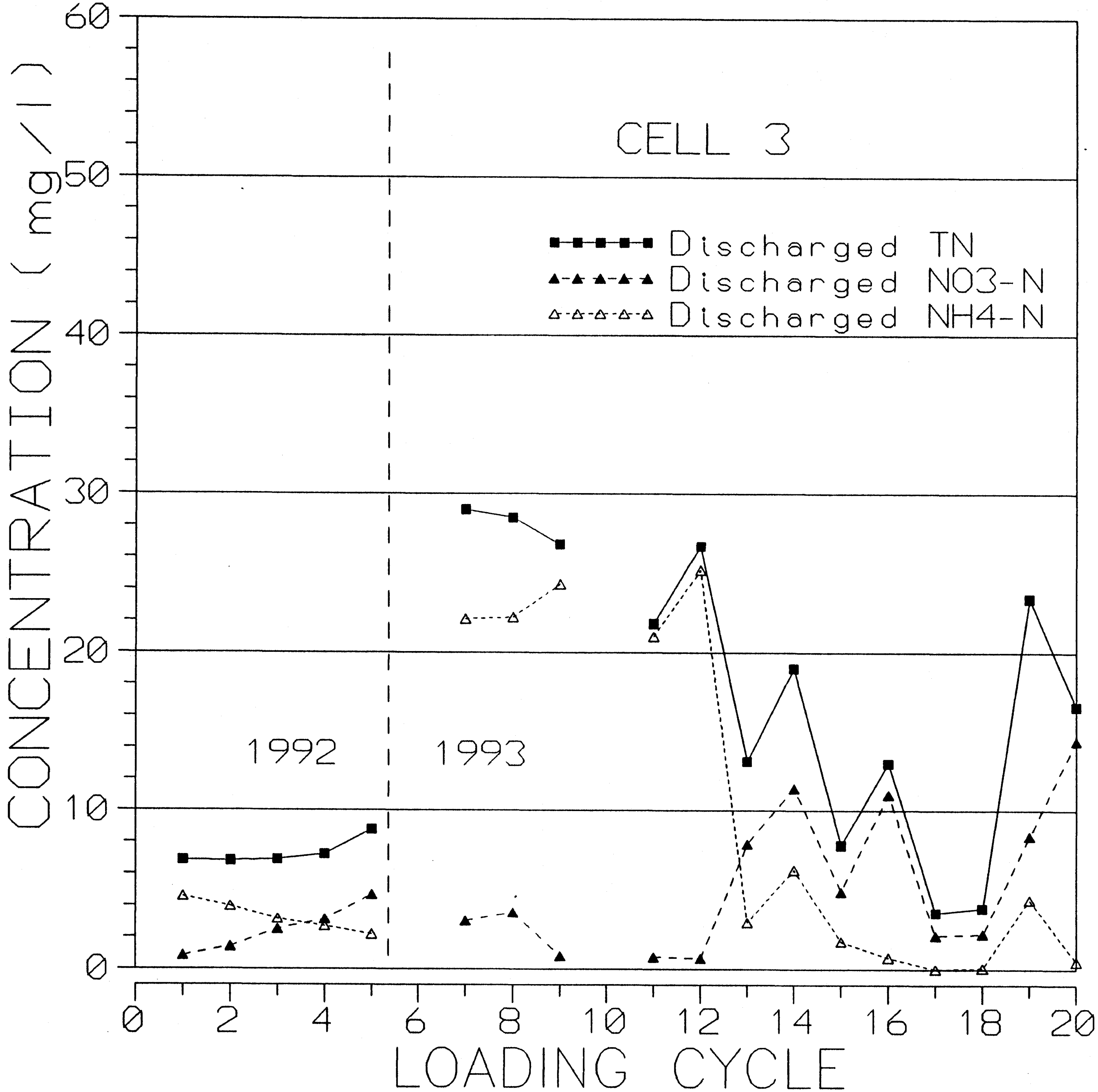

CELL 3
Discharged TN
Discharged NO3-N
Discharged NH4-N
1992
1993
CONCENTRATION (mg/l)
LOADING CYCLE
0
10
20
30
40
50
60
0
2
4
6
8
10
12
14
16
18
20

FIGURE 13

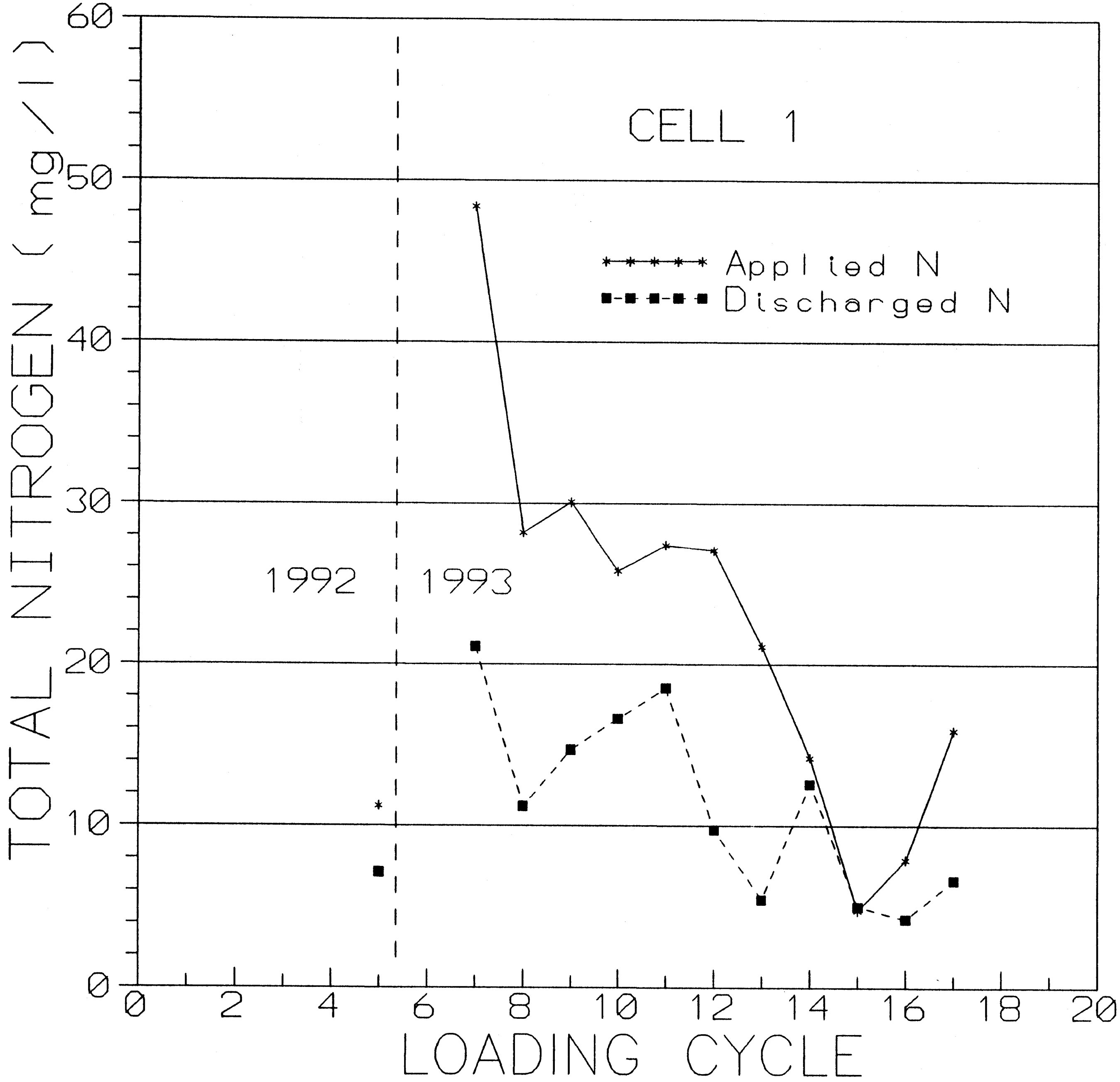

CELL 1
Applied N
Discharged N
1992
1993
TOTAL NITROGEN (mg / l)
LOADING CYCLE
0
10
20
30
40
50
60
0
2
4
6
8
10
12
14
16
18
20

FIGURE 14

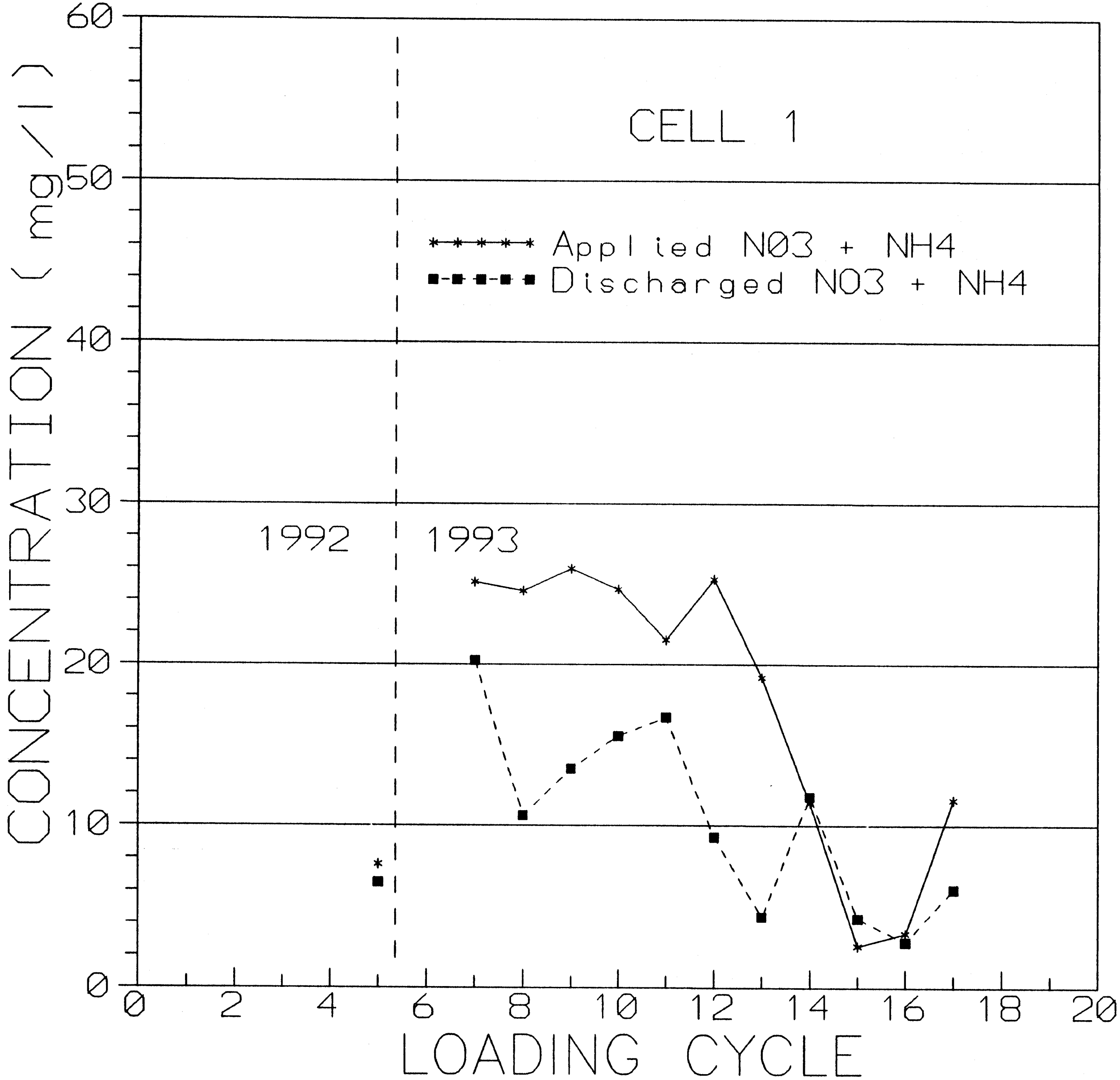

CELL 1
Applied NO3 + NH4
Discharged NO3 + NH4
1992
1993
CONCENTRATION (mg/l)
LOADING CYCLE
0
10
20
30
40
50
60
0
2
4
6
8
10
12
14
16
18
20

FIGURE 15

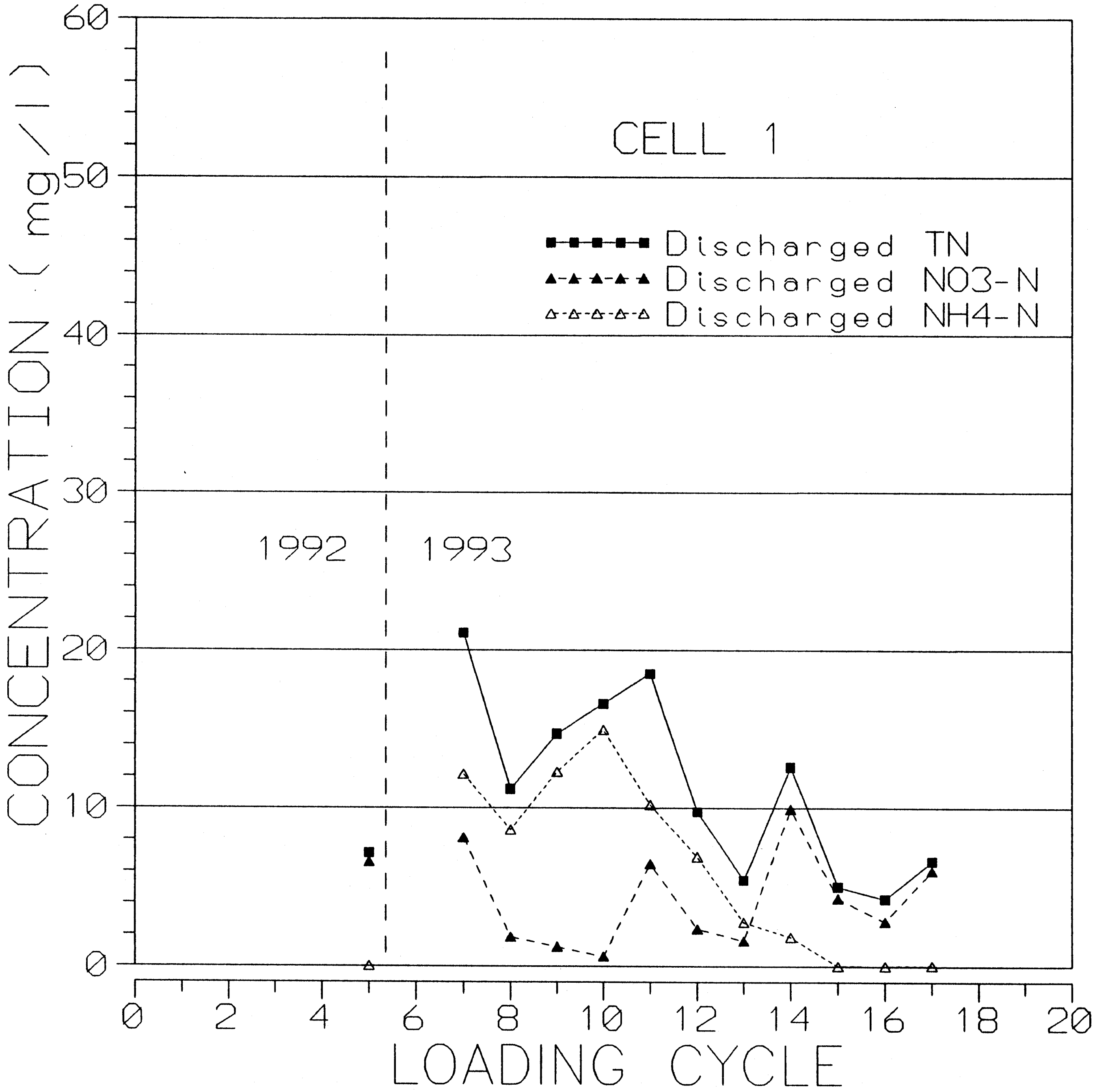

CELL 1
Discharged TN
Discharged NO3-N
Discharged NH4-N
1992
1993
CONCENTRATION (mg/l)
LOADING CYCLE
0
10
20
30
40
50
60
0
2
4
6
8
10
12
14
16
18
20

FIGURE 16

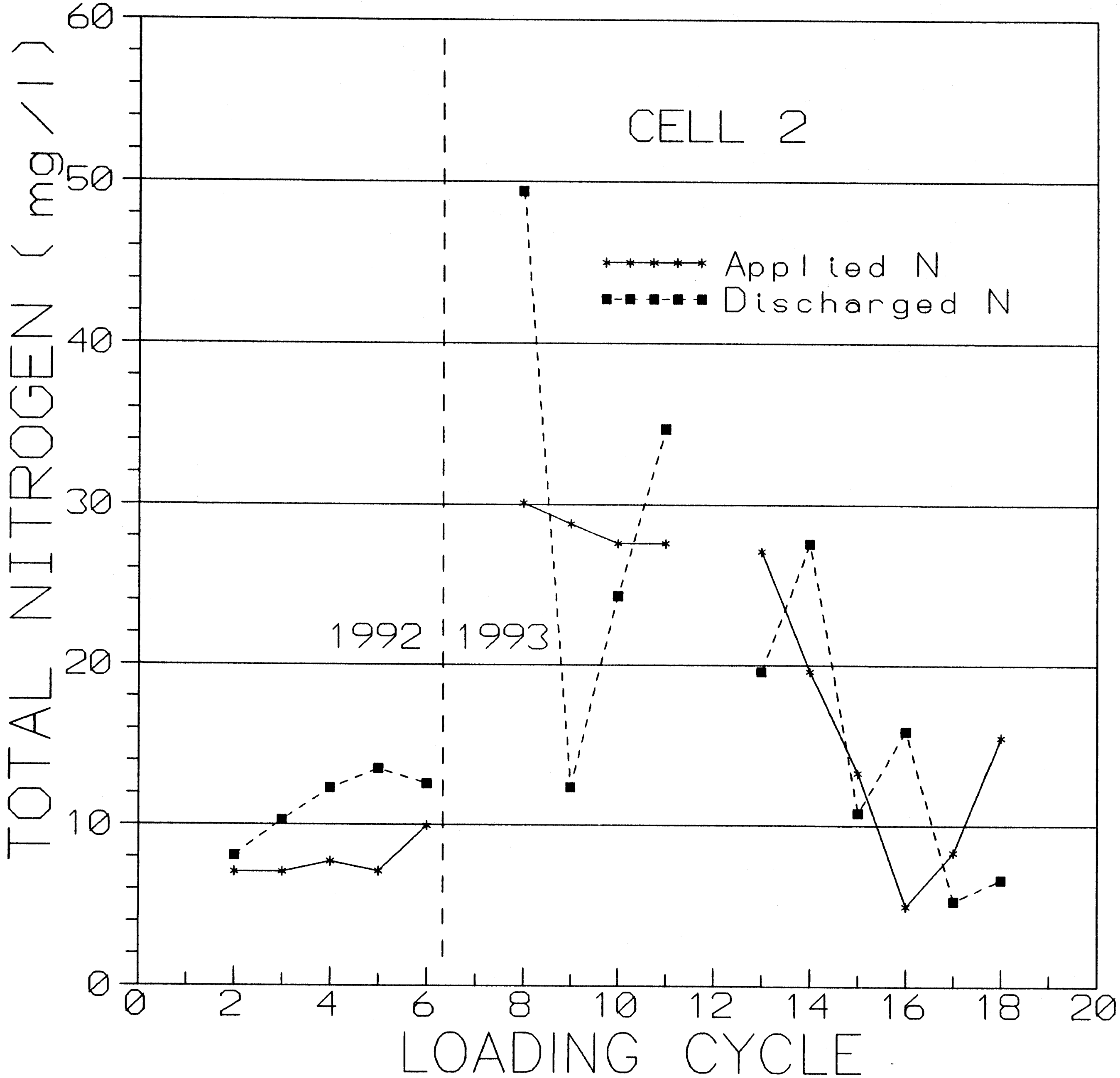

CELL 2
Applied N
Discharged N
1992
1993
TOTAL NITROGEN (mg/l)
LOADING CYCLE
0
10
20
30
40
50
60
0
2
4
6
8
10
12
14
16
18
20

FIGURE 17

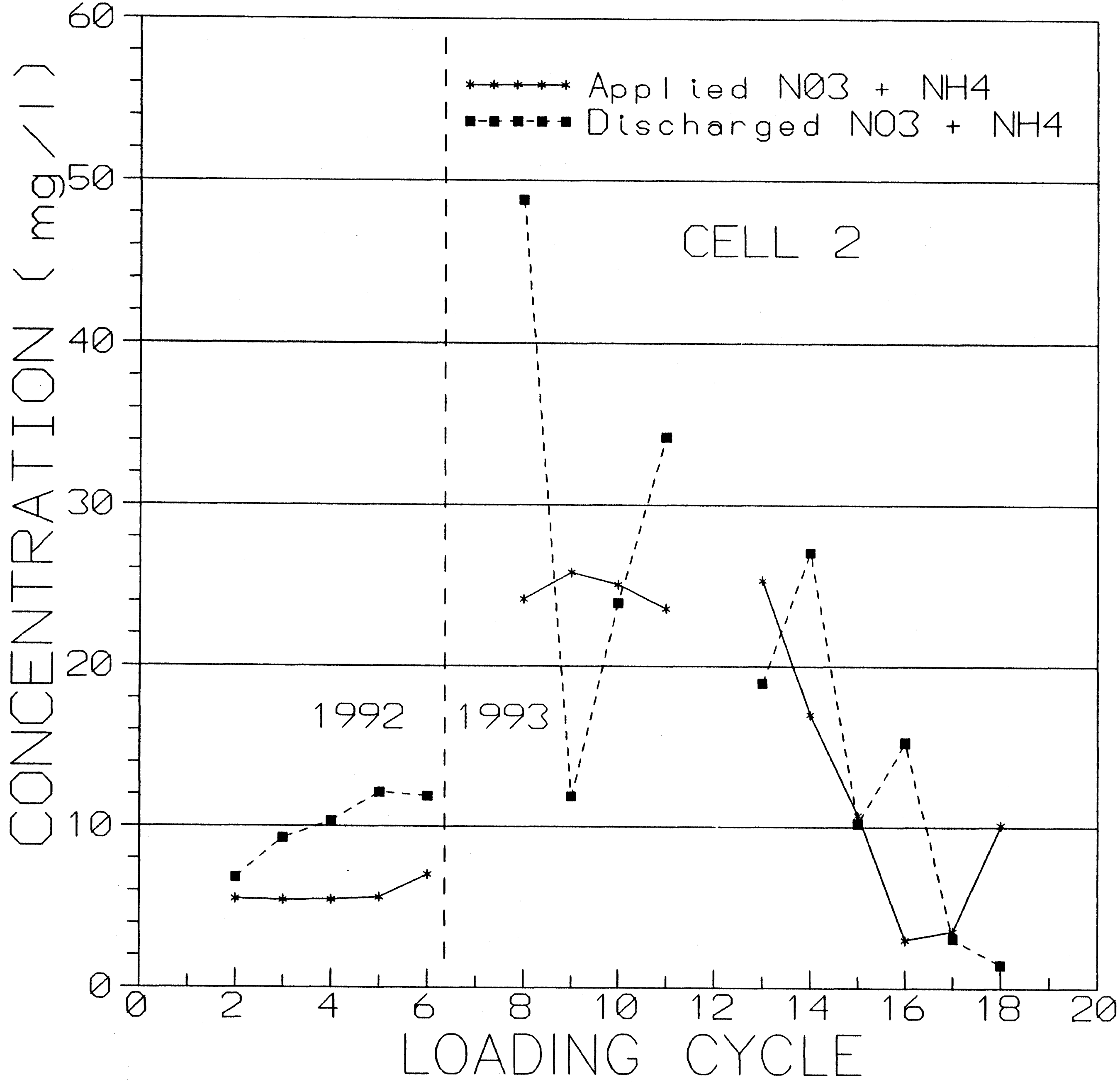

60
50
40
30
20
10
0
CONCENTRATION (mg/l)
Applied N03 + NH4
Discharged N03 + NH4
CELL 2
1992
1993
0
2
4
6
8
10
12
14
16
18
20
LOADING CYCLE

FIGURE 18

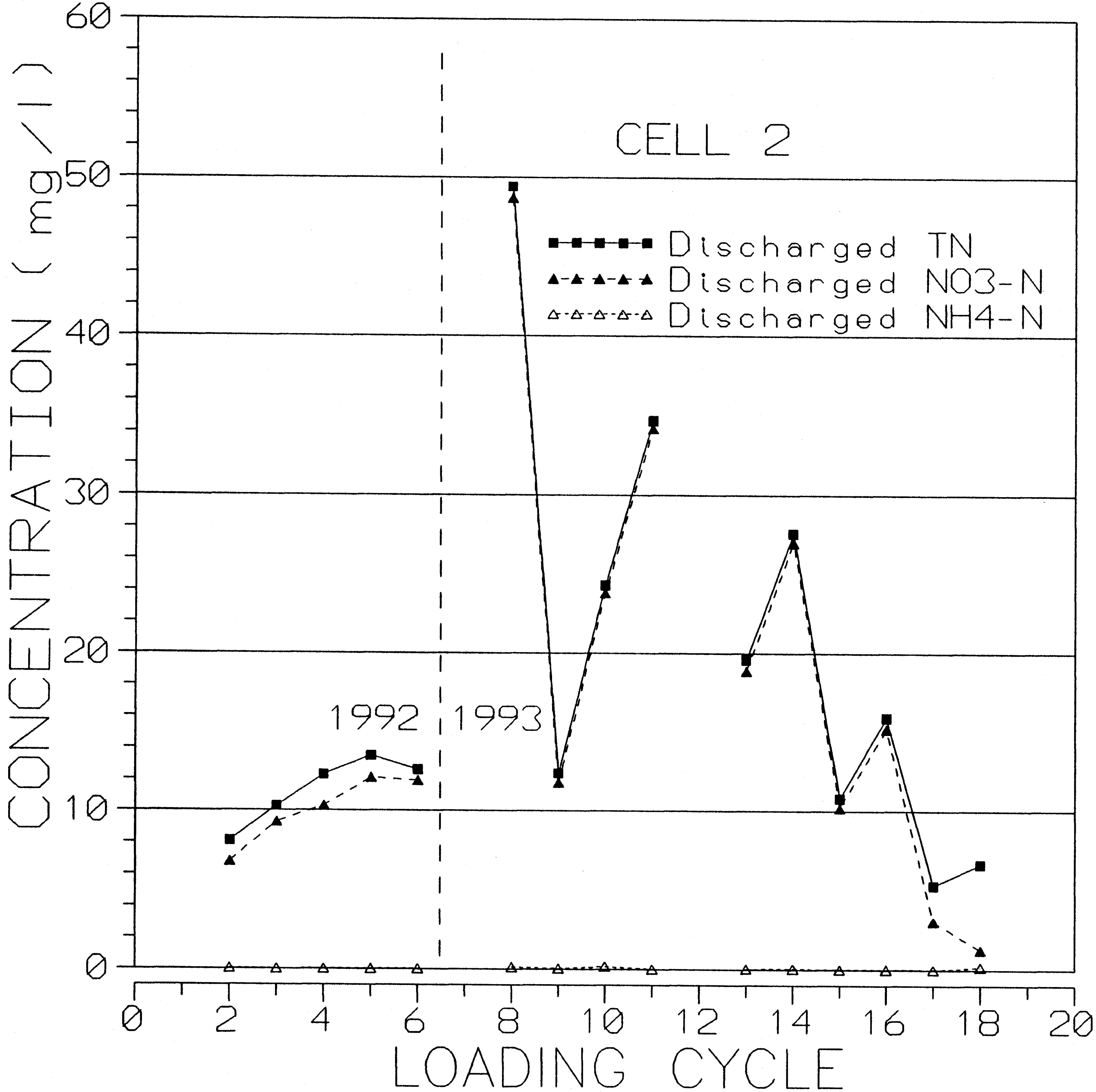
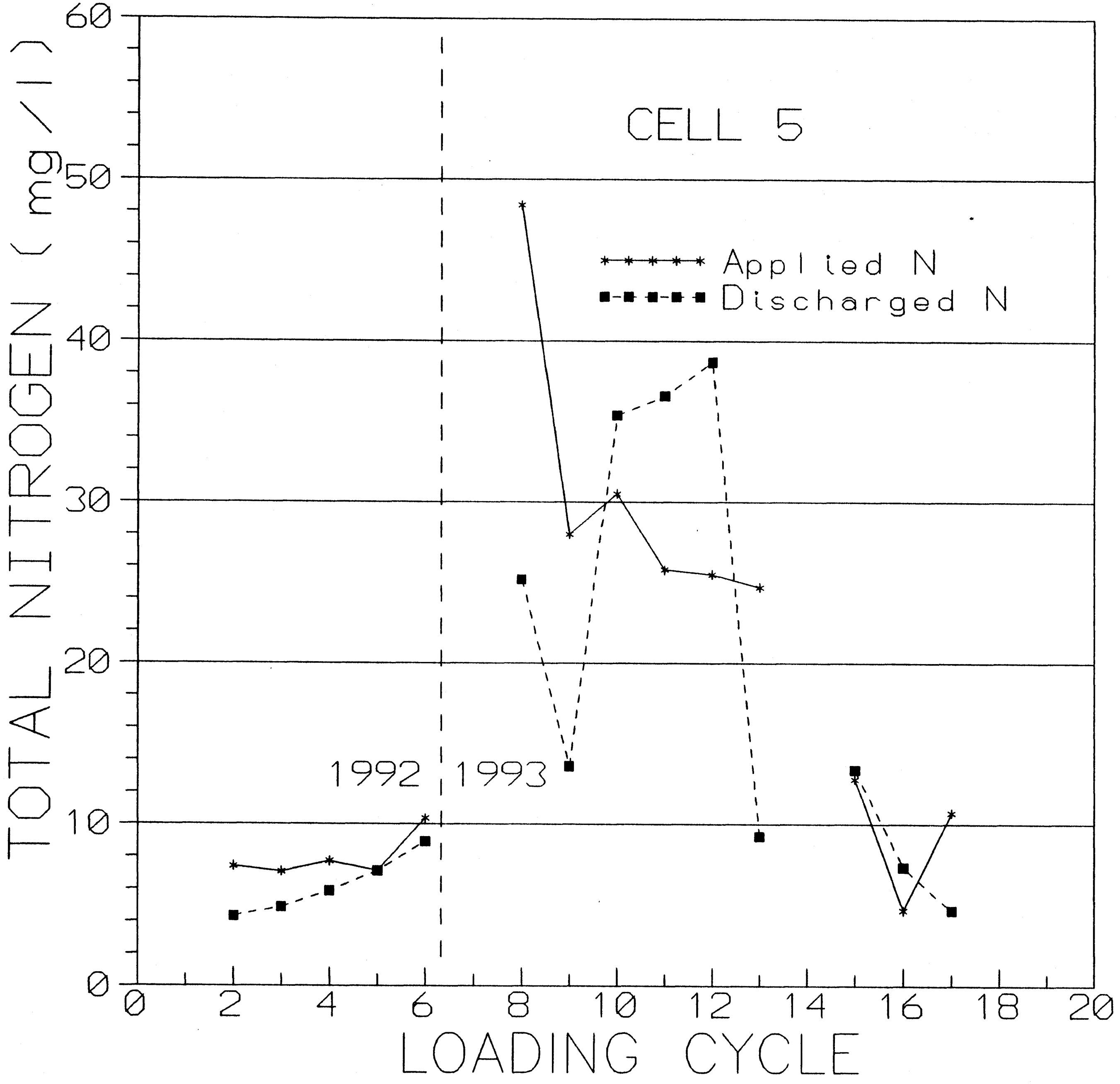
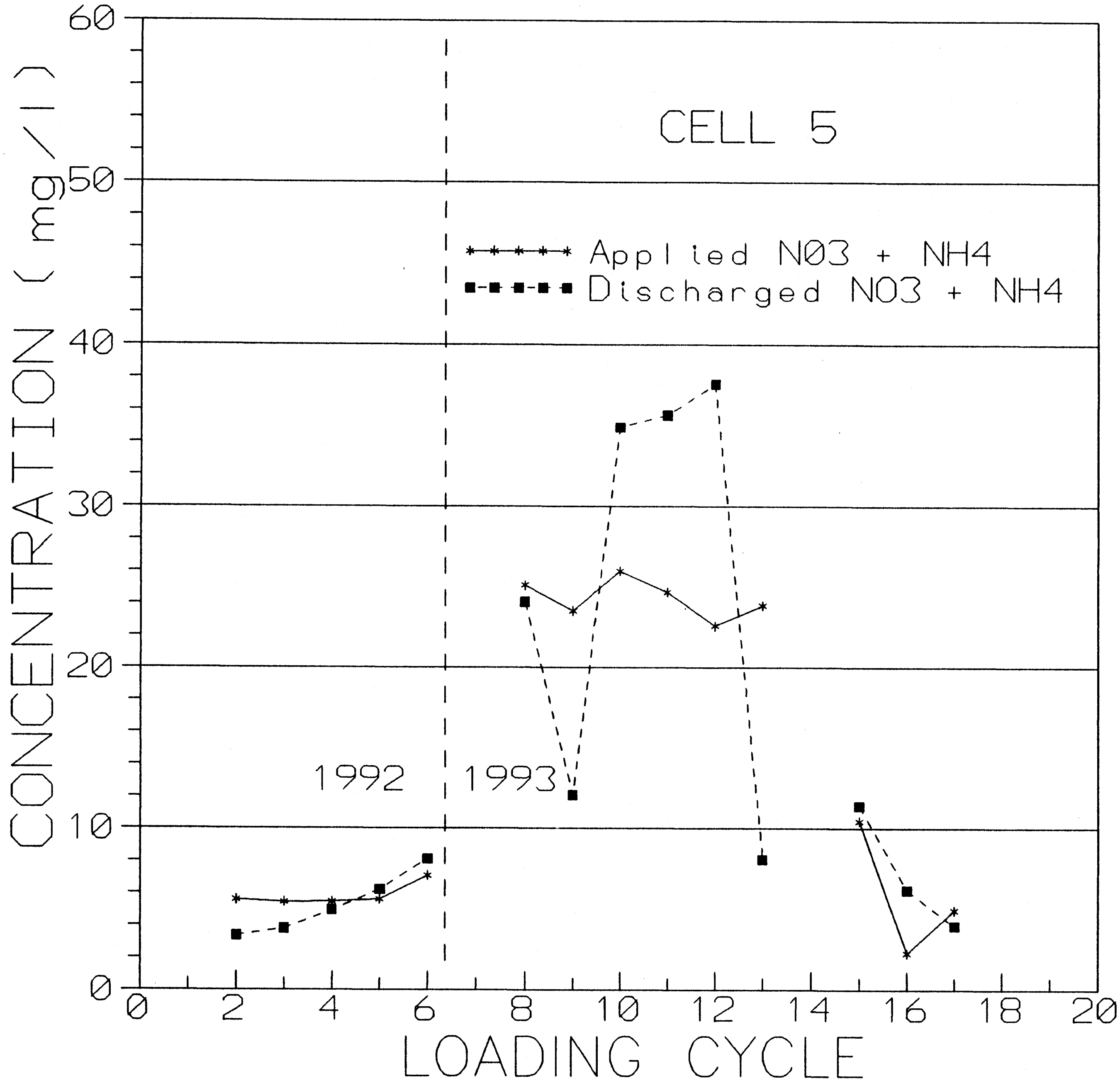

CELL 2
Discharged TN
Discharged NO3-N
Discharged NH4-N
1992
1993
CONCENTRATION (mg/l)
LOADING CYCLE
0
10
20
30
40
50
60
0
2
4
6
8
10
12
14
16
18
20

FIGURE 19



60
50
40
30
20
10
0
TOTAL NITROGEN (mg / l)
CELL 5
Applied N
Discharged N
1992
1993
0
2
4
6
8
10
12
14
16
18
20
LOADING CYCLE

FIGURE 20



CELL 5
Applied NO3 + NH4
Discharged NO3 + NH4
1992
1993
CONCENTRATION (mg/l)
LOADING CYCLE
0
10
20
30
40
50
60
0
2
4
6
8
10
12
14
16
18
20

FIGURE 21

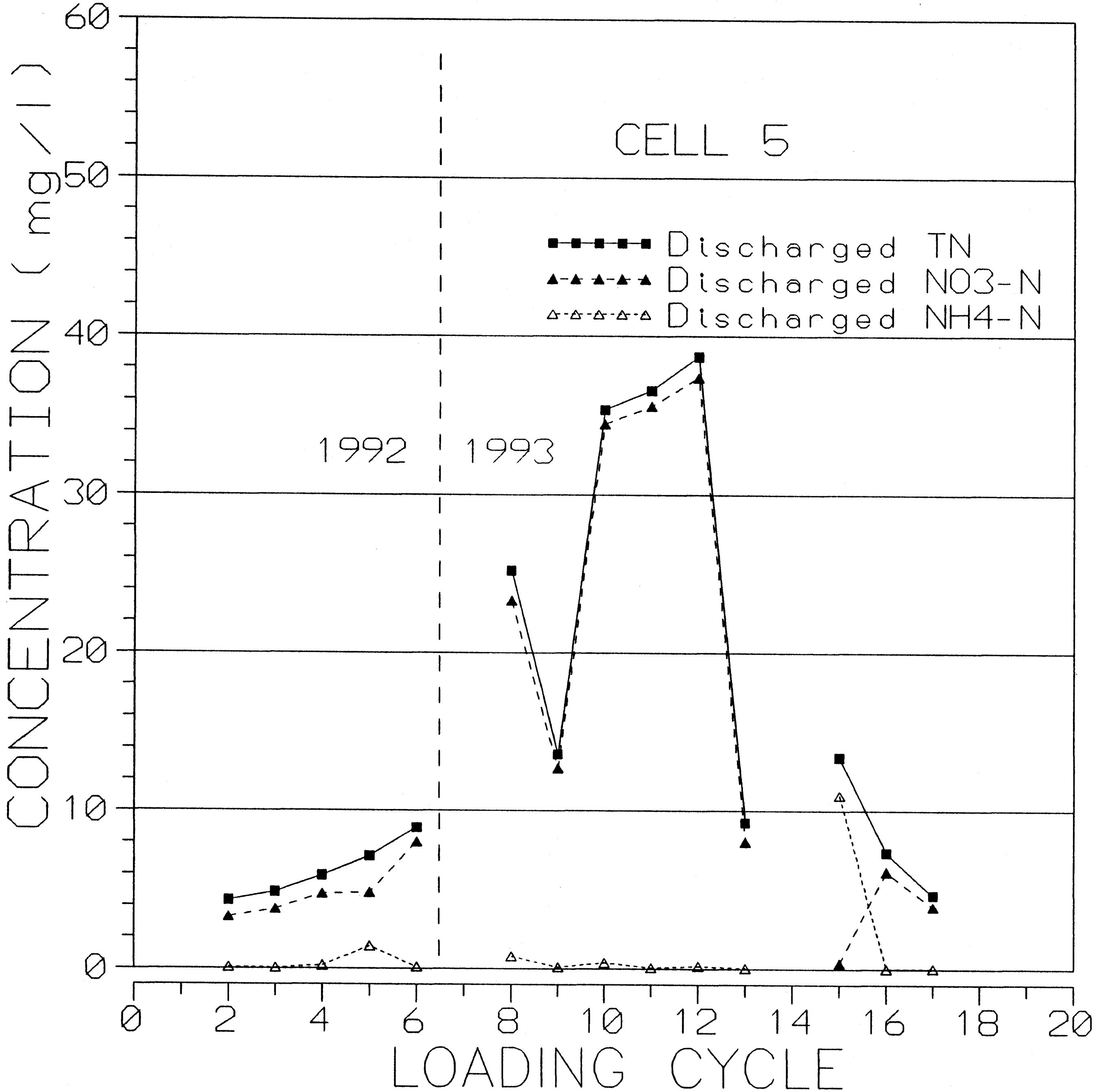

CELL 5
Discharged TN
Discharged NO3-N
Discharged NH4-N
1992
1993
CONCENTRATION (mg/l)
LOADING CYCLE
0
10
20
30
40
50
60
2
4
6
8
12
14
16
18

FIGURE 22

The soil placed in Cell 5 has a higher percentage of fines (26%) than the Cell 1 and 2 soils. The average infiltration rate for the May to August period is 17.3 in./d. which is comparable to Cell 1. Persistent leakage problems occurred in Cell 5, however, suggesting the 17.3 value may be an overestimate. After loading cycle 7, sustained flooding periods were obtained in Cell 5.

An examination of Figures 20 and 21 for the May to August period reveals significant variability in nitrogen removal in comparison to Cells 1 and 2. Out of 6 loading cycles from May to August, 2 cycles showed significant N removal, 1 showed no removal, and 3 cycles indicated a significant negative percent removal.

Figure 22 indicates nearly complete nitrification in all but loading cycle 15. Since Cell 5 experienced infiltration rates and sustained flooding periods similar to Cell 1, it is unclear why nitrification was more complete in Cell 5. It should be noted that nitrification was extensive in both the cells with unmodified lysimeters. These lysimeters collected a relatively small percentage of the effluent water applied directly above their open collection area. It is conceivable that the longer retention times in the vented, gravel filled underdrains may have artificially enhanced nitrification.

SUMMARY AND CONCLUSIONS

Covering an existing rapidly permeable sandy soil with 2 feet of less permeable soil, with a higher content of fines, was successful in producing substantially lower infiltration rates and longer retention times in the soil profile. The test cells were partitioned by constructed wooden walls. Some channeling of water along the soil/wall interface did occur, resulting in leakage problems in Cell 5. This should not be a problem with full scale absorption ponds, however, since they are typically created by earthen berms, not vertical walls. No leakage occurred in the test cells along the soil/berm interface.

The applied effluent TN ranged from 24.2 to 34.1 mg/l from mid-April to August in 1993. Effluent TN was less than 12 mg/l in the fall of 1992, and for a portion of the fall in 1993. These low nitrogen loading periods were detrimental to the study's purpose of attempting to characterize an absorption pond's performance when subjected to nitrogen loadings significantly in excess of 10 mg/l. Effluent BOD_5 was generally sufficient to allow some denitrification, but low values in August and September could have been controlling and limited denitrification due to excessively low carbon to nitrogen ratios.

Nitrogen removal in the control cell and Test Cell 1 was characterized by taking grab samples of the infiltrated water at various times during the cell loading cycle. In Cells 2 and 5, a composite of all the water produced by the lysimeters during the sample collection period was used for water quality analysis. Not all underdrain flow was collected, however, and these samples results therefore cannot be used to conduct a complete mass balance.

The variability of the underdrain water quality during any one loading cycle was characterized by more frequent sample collection for certain loading cycles and by general inspection and comparison of data. Nitrate peaks were observed in some instances, but their frequency of occurrence and the percentage of mass contained in them, suggests that the collected water samples do provide a reasonably accurate estimation of discharged nitrogen.

A summary of nitrogen removal, from May to August of 1993, for the control cell and 3 test cells is provided in Table 4. It is concluded that a significant nitrogen reduction of approximately 46% occurred in Cell 1. No significant reduction occurred in the control cell or Cells 2 and 5. The reduction in Cell 1 resulted from the partial nitrification and subsequent dentrification of the applied NH_4-N. The discharged nitrogen was primarily in the form of NH_4-N, indicating a loading in excess of the soil's adsorptive capacity. The average infiltration of 15.3 in./d. in Cell 1 was sufficient to allow nitrogen removal. The infiltration rate during a flooding period was found to be highly dependent upon the depth of water in a cell.

Cells 2 and 5 provided nearly complete nitrification of the applied NH_4-N. In Cell 2 this may be the result of the frequent soil drying periods experienced between pumped dosing. The higher Cell 2 infiltration rate of 28.7 in./d. may have prevented denitrification. In Cell 5, with an infiltration rate and flooding schedule similar to that in Cell 1, it is unclear why complete nitrification occurred and denitrification was inconsistent (significant N removal did occur during 2 of the 6 loading cycles from May to August). It is postulated that the nitrification could have been an artifact of the method of sample collection. Instances of discharged N exceeding applied N occurred as a result of mineralization of accumulated soil organic N, or temporary adsorption of NH_4-N in the soil, and subsequent flushing out of the soil during effluent application periods. Nitrification in all cells was still observed during the end of the study in 1993 when effluent temperature was reduced to less than 5°C.

It is concluded that it is feasible to renovate an existing absorption pond with two feet of cover soil to improve nitrogen removal. For any full scale renovation project, pilot testing of a soil's infiltration rate should be conducted. In construction, care should be taken to ensure a uniform depth of soil cover to prevent channeling of water down into the more permeable soil. Pond berm material should be considered to prevent excessive lateral infiltration through the berm. An average infiltration rate of 15 in./d., or less, should be attained to enable sustained flooding periods of 1 to 2 weeks and to promote nitrogen removal by denitrification. An infiltration rate may be optimized by compaction, providing suspended solids in the effluent, and by maintaining a shallow depth of water in the cell.

SUMMARY OF NITROGEN REMOVAL

(May to August – 1993)

CELL	LOADING CYCLES	% TN REMOVAL		% NO3 + NH4 REMOVAL	
		AVERAGE	RANGE	AVERAGE	RANGE
3	7, 8, 9, 11, 12, 13	19.9	−2.5 to 49.2	7.23	−13.5 to 47.9
1	7, 8, 9, 10, 11, 12, 13	53.5	32.5 to 74.1	46.3	19.4 to 77.2
2	8, 9, 10, 11, 13, 14	−5.6	−64.1 to 57.0	−20.5	−102 to 54.0
5	8, 9, 10, 11, 12, 13	8.7	−51.8 to 62.6	3.65	−44.6 to 66.1

TABLE 4

ACKNOWLEDGEMENTS

Credits:

The authors wish to extend their sincere appreciation to Bob Friberg, the Florence Utility Director, and Bob Anderson, the Florence treatment plant operator. This study would not have been possible without their cooperation and capable assistance. In addition to his normal duties, Bob Anderson conducted the daily dosing of cells, collected water samples, took water level readings, and recorded data. We also wish to thank everyone who helped with the construction of the test cells. From the Florence Utility staff, this includes Garret Trudell, Wayne Falk, Steve Wilcox, and Brent Larsen. WDNR staff who volunteered their hard work include Milan Hedmark, Russ Heizer, Greg Sevener, Matt Hostak, Bob Behrens, Ron Rhode, Mike Smith, and Bill Phelps. Our appreciation also goes to Peggy Beaumier of LMD who helped keep the bills and financing in order. Finally, we wish to thank the capable staff at the State Lab of Hygiene, and Jim McDonald and Bob Rouse, formerly of McDonald-Maas Associates, for their expert advice and valuable assistance with the soil investigations and analyses.

Authors:

Thomas A. Gilbert, P.E. is an environmental engineer with the Wisconsin DNR, Bureau of Wastewater Management, in Madison, Wisconsin. He has authored Department guidance and administrative rules pertaining to municipal land application systems. He is currently the Acting Facility Planning Unit Leader and is responsible for the oversight and management of Department reviews on municipal wastewater treatment planning projects.

Bruce S. Oman, P.E. is an environmental engineer working in the Wisconsin DNR Lake Michigan District. His responsibilities include working with municipal and industrial wastewater dischargers to maintain compliance with their WPDES permits. Included in these facilities are several rapid infiltration land application systems.

REFERENCES

Bouwer, Herman. "Design and Operation of Land Treatment Systems for Minimum Contamination of Groundwater." Groundwater, Vol. 12, no. 33, May-June 1974.

Gilbert, R. F., J. C. Lance and J. B. Miller. "Denitrifing Bacteria Populations and Nitrogen Removal in Soil Columns Intermittently Flooded with Secondary Sewage Effluent." Journal of Environmental Quality, Volume 8, no.1, 1979.

Lance, J. C. "Land Disposal of Sewage Effluents and Residues", in Groundwater Pollution Microbiology by Gabriel Bitton and Charles P. Gerha. John Wiley & Sons, Inc. eds. New York, NY. pp.197-224. 1984.

Lance, J. C., F.D. Whisler and R. C. Rice. "Maximizing Denitrification during Soil Filtration of Sewage Water". Journal of Environmental Quality, Vol. 5, no. 1, 1976.

Lance, J. C. and F. D. Whisler. "Nitrogen Balance in Soil Columns Intermittently Flooded with Secondary Sewage Effluent." Journal of Environmental Quality, Vol. 1, no. 2, 1972.

Lance, J.C., F. D. Whisler and H. Bouwer. "Oxygen Utilization in Soils Flooded with Sewage Water". Journal of Environmental Quality, Vol. 2, no. 3, 1973.

Shammas, N. K. "Interactions of temperature, pH, and biomass on the nitrification process". Journal WPCF, Volume 58, No. 1, January, 1986.

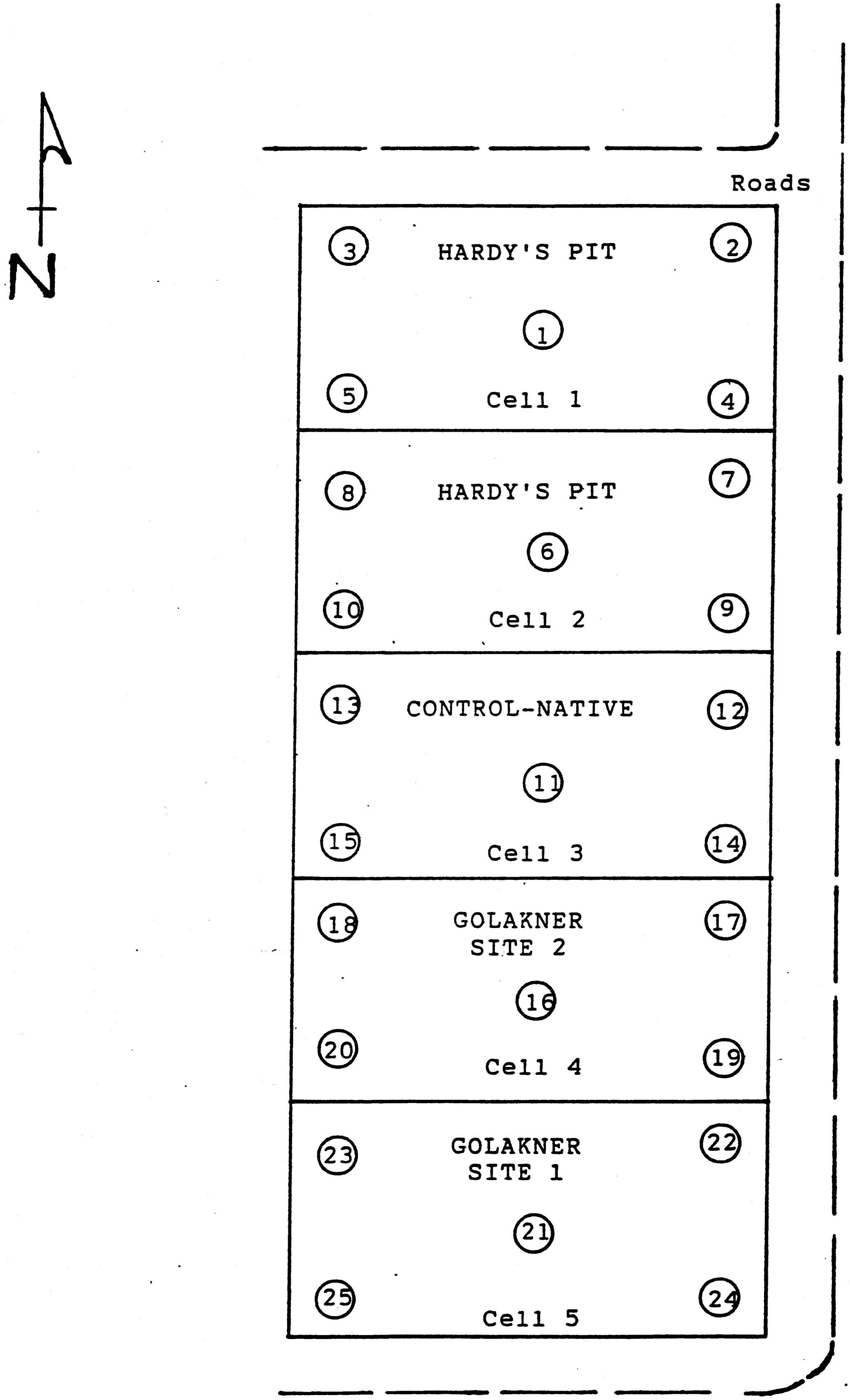
APPENDIX 1

SOILS INFO

D10 IS THE EFFECTIVE SIZE (GRAIN SIZE FOR WHICH 10% OF THE SOIL IS FINER) (mm)

Cu IS THE UNIFORMITY COEFFICIENT

	HARDY'S PIT	HARDY'S PIT	HARDY'S PIT	CONTROL	CONTROL	CONTROL	CONTROL	GOLLAKNER #1	GOLLAKNER #1	GOLLAKNER #2	GOLLAKNER #2	GOLLAKNER #2
JULY 1991				NATIVE	NATIVE	NATIVE	NATIVE					
% FINES				0.7	0.5	1.3	0.6					
% SILT				0.7	0.5	1.3	0.6					
% CLAY				0.0	0.0	0.0	0.0					
D60				0.38	0.47	0.48	0.44					
D10				0.21	0.24	0.18	0.2					
Cu				1.8	2.0	2.7	2.2					
10-31-91	1	2	3					LOW	HIGH	TOP	MIXTURE	BOTTOM
% FINES	12.9	9.2	10.2					11.7	27.6	6.3	10.3	18.9
% SILT	6.9	4.2	5.7					9.5	23.6	6.3	7.1	13.9
% CLAY	6.0	5.0	4.5					2.2	4.0	0.0	3.2	5.0
D60	0.34	0.35	0.37					0.27	0.25	0.23	0.23	0.24
D10	0.03	0.09	0.08					0.065	0.028	0.09	0.075	0.028
Cu	11.3	3.9	4.6					4.2	8.9	2.6	3.1	8.6
10-22-92	CELL #2			CELL #3				CELL #5		CELL #4		
% FINES	11.4			5.6				26.8		11.9		
% SILT	NA			5.6				NA		NA		
% CLAY	NA			0.0				NA		NA		
D60	0.38			0.42				0.29		0.23		
D10	0.07			0.17				<0.07		0.065		
Cu	5.4			2.5				>4.1		3.5		
DENSITY(DRY)	114.6			108.0				108.7		103.8		
% COMPACTION	94.2			94.0				87.9		91.3		



Florence Seepage Cells Experiment

Florence County, WI

10/22/92
Testing
Locations

DENSITY TESTS OF COMPACTED FILL

Contractor: ____________________

Compaction Equipment: ____________________

Weather: Sunny 72°

Name of Client: Wisconsin Department of Natural Resources
Project Title: Florence Seepage Cell Experiment
Date: 10/22/92
Field Book Ref: Page 1

Test No.	Test Location From Northland (Seepage)	Depth of Probe	Elevation	Proctor Used	Wet Density (pcf)	Moisture Content (%)	Dry Density (pcf)	Percent Compaction	Remarks
	Hardy Pit								
1	Cell 1 - Center	12"		121.7	126.2	7.7	117.2	96.3%	
2	Cell 1 - NE	12"		121.7	128.1	8.4	118.2	97.1%	
3	Cell 1 - NE	12"		121.7	126.2	9.7	115.0	94.5%	
4	Cell 1 - SE	12"		121.7	124.5	6.9	116.5	95.7%	
5	Cell 1 - SW	12"		121.7	122.1	8.6	112.4	92.4%	
6	Cell 2 - Center	12"		121.7	124.3	8.0	115.1	94.6%	
7	Cell 2 - NE	12"		121.7	126.9	10.0	115.4	94.8%	
8	Cell 2 - NW	12"		121.7	125.7	8.1	116.3	95.5%	
9	Cell 2 - SE	12"		121.7	123.0	8.8	113.1	92.9%	
10	Cell 2 - SW	12"		121.7	121.9	7.6	113.3	93.1%	
	Native Soil - Control Cell								
11	Cell 3 - Center	12"		114.9	113.4	4.3	108.7	94.6%	
12	Cell 3 - NE	12"		114.9	114.1	3.5	110.2	95.9%	
13	Cell 3 - NW	12"		114.9	109.2	4.0	105.0	91.4%	
14	Cell 3 - SE	12"		114.9	113.8	4.0	109.4	95.2%	
15	Cell 3 - SW	12"		114.9	111.1	4.2	106.6	92.8%	
	Golackner Site 2								
16	Cell 4 - Center	12"		113.7	115.2	8.2	106.5	93.6%	
17	Cell 4 - NE	12"		113.7	113.6	6.7	106.5	93.6%	
18	Cell 4 - NW	12"		113.7	107.0	6.5	100.5	88.4%	
19	Cell 4 - SE	12"		113.7	112.8	7.5	104.9	92.3%	
20	Cell 4 - SW	12"		113.7	108.9	8.1	100.7	88.6%	

Proctor No.	Soil Sample Number and Description	Density (pcf)	Moisture Content (%)	Compact. Spec. (%)
1	Control (Native) - SAND W/ SILT (SP-SM)	114.9	14.5	
2	Hardy Pit - SAND W/ SILT (SM-SP)	121.7	10.3	
3	Golanker Site 2 - SAND W/ SILT (SM-SP)	113.7	11.4	

General Note:

Density test results are valid only in the locations and elevations tested.

NUCLEAR DENSITY METER: Troxler MODEL NUMBER: 3440 SERIES NUMBER: 20660	DAILY CALIBRATION Std. Density Count: 3105 Std. Moisture Count:668	**MC DONALD - MAAS ASSOCIATES** Inspector: Steve Friberg

DENSITY TESTS OF COMPACTED FILL

Contractor: ____________________

Compaction Equipment: ____________________

Weather: Sunny 72°

Name of Client: Wisconsin Department of Natural Resources
Project Title: Florence Seepage Cell Experiment
Date: 10/22/92
Field Book Ref: Page 2

Test No.	Test Location From Northland (Seepage)	Depth of Probe	Elevation	Proctor Used	Wet Density (pcf)	Moisture Content (%)	Dry Density (pcf)	Percent Compaction	Remarks
	Golakner - Site 1								
21	Cell 5 - Center	12"		123.7	120.7	8.9	110.8	89.6%	
22	Cell 5 - NE	12"		123.7	123.2	10.8	111.2	89.9%	
23	Cell 5 - NW	12"		123.7	118.0	10.1	107.2	86.6%	
24	Cell 5 - SE	12"		123.7	121.4	12.6	107.8	87.2%	
25	Cell 5 - SW	12"		123.7	121.9	14.3	106.6	86.2%	

Proctor No.	Soil Sample Number and Description	Density (pcf)	Moisture Content (%)	Compact. Spec. (%)
4	Golakner Site 1 - SILTY SAND (SM)	123.7	9.5	

General Note:
Density test results are valid only in the locations and elevations tested.

NUCLEAR DENSITY METER: Troxler
MODEL NUMBER: 3440
SERIES NUMBER: 20660

DAILY CALIBRATION
Std. Density Count: 3105
Std. Moisture Count: 668

MC DONALD - MAAS ASSOCIATES

Inspector: Steve Friberg

MC DONALD - MAAS ASSOCIATES

SIEVE ANALYSIS OF COARSE TO FINE AGGREGATES (ASTM D422)

GENERAL DATA:

Client:	WDNR
Project:	Florence Seepage Cells
Location Sampled:	Cell # 2
Sample No:	FL-CE-2
Depth of Sample:	
Date Received:	10/26/92
Sample Designated For:	Seepage Cell Experiment
Source of Sample:	Hardy Pit
Munsell Color Code:	2.5 YR. 3/3

LABORATORY DATA:

Date Tested:	October 28 to November 3, 1992
Test Performed By:	DJK

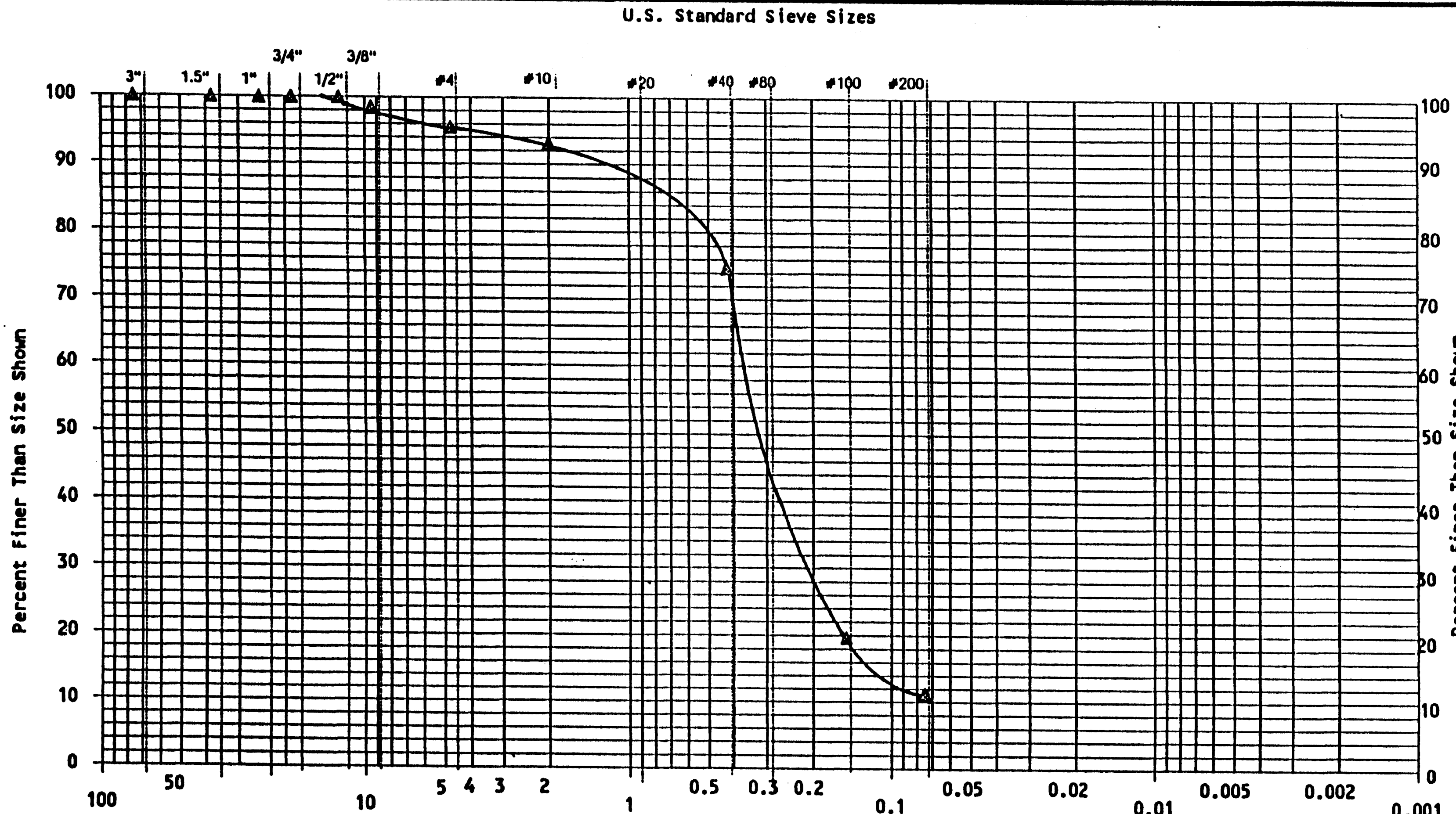
24 Hrs. Turn Around:	No
Washed Gradation:	Yes

Sieve Size	Weight Retained	% Retained	% Passing	Project Specification % Passing by Weight	Source of Specification
3"					
1 1/2"					
1"					
3/4"					
1/2"	0.0	0.0	100.0		
3/8"	8.8	1.5	98.5		
#4	17.6	2.9	95.6		
#10	14.6	2.4	93.2		
#40	110.8	18.4	74.8		
#100	330.6	55.0	19.8		
#200	50.8	8.4	11.4		

REVIEWED BY:	Timothy J. Ambrosini
DATE REVIEWED:	12-23-92

Remarks:

GRAIN SIZE DISTRIBUTION CURVE



Gravel		Sand			Silt	Clay
Coarse	Fine	Coarse	Medium	Fine		
	4.4%	2.4%	18.4%	63.4%		

Soil Classification: SAND W/ SILT, fine to medium grained, a little gravel, dark olive brown (SM-SP)

Location Sampled: Cell # 2			Elev. or Depth:	Date Sampled: 10/22/92
Sample Number: FL-CE-2			Sampled Moisture Content (%): 7.7	Report No.: CE-2
Sample Source: Hardy Pit			MC DONALD - MAAS ASSOCIATES	
Atterberg Limits:	LL=	PL=	PI=	Client: WDNR
Munsell Color Code: 2.5 YR. 3/3			Project: Florence Seepage Cells	Page: 2
Date Received: 10/26/92			Prepared by: Robert Rouse	Date: 12/3/92
Coefficients: Cc=	Cu=		Checked by: Timothy S Asbikosus	Date: 12/23/92

MC DONALD - MAAS ASSOCIATES

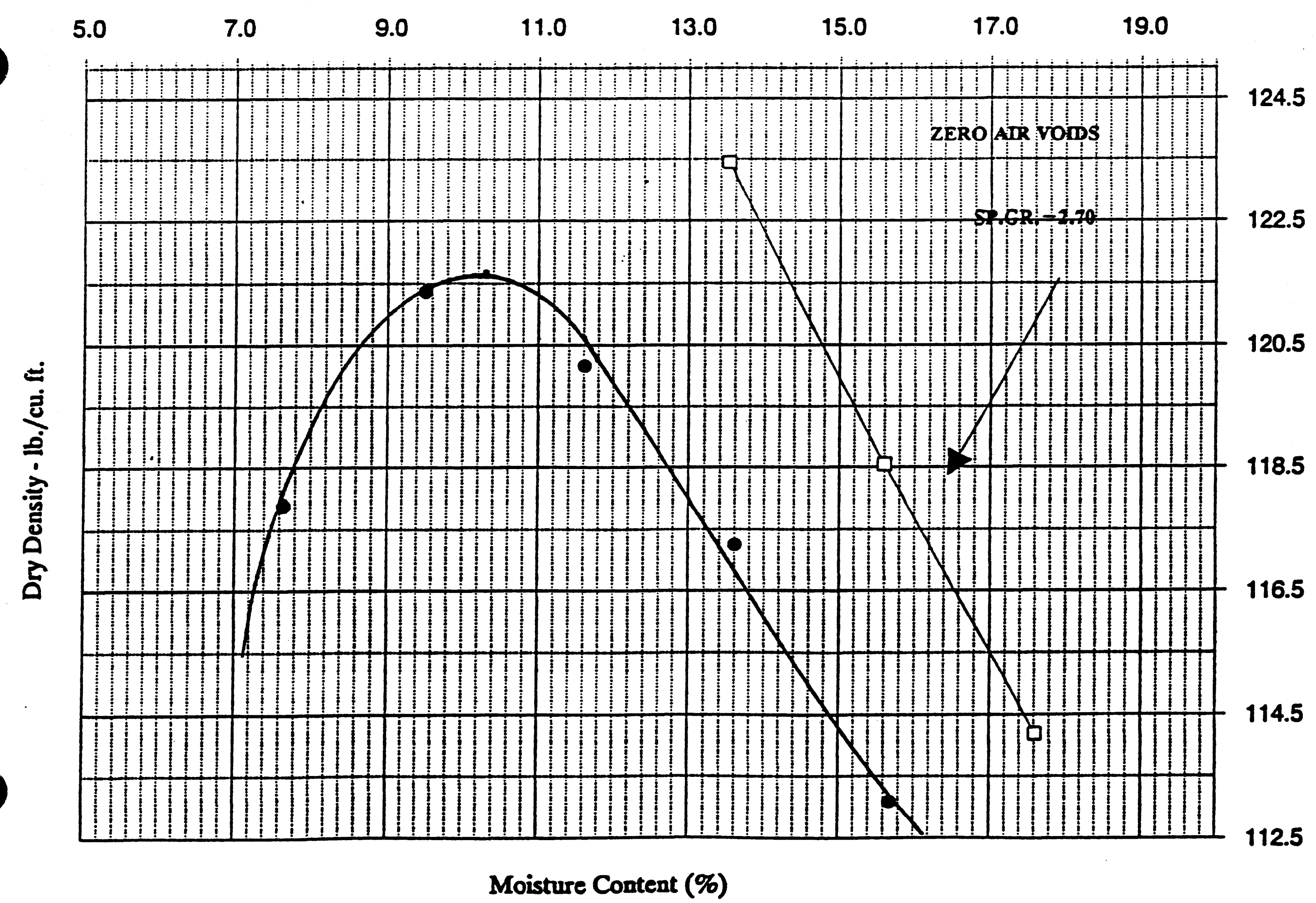
MOISTURE - DENSITY RELATIONS OF SOIL

GENERAL DATA:

Client:	WDNR		
Project:	Florence Seepage Cells - Cell #2		
Contractor:		**Sampled From:**	Hardy's
Sample No:	FL-CE-2	**Date Received:**	10/26/92
Tested By:	DJK	**Reviewed By:**	Timothy J. Ambuscus

LABORATORY DATA:

Soil Classification:	SAND W/ SILT, fine to medium grained, dark olive brown (SM-SP)				
Munsell Color Code:	2.5 YR. 3/3	**Atterberg Limits:**	**LL=**	**PL=**	**PI=**
Maximum Dry Density (lb/cu.ft.):	121.7	**Optimum Moisture (%):**	10.3	**Wet Density (lb/cu.ft.):**	134.2



MC DONALD - MAAS ASSOCIATES

SIEVE ANALYSIS OF COARSE TO FINE AGGREGATES (ASTM D422)

GENERAL DATA:

Client:	WDNR
Project:	Florence Seepage Cells
Location Sampled:	Cell #3
Sample No:	FL-CE-3
Depth of Sample:	
Date Received:	10/26/92
Sample Designated For:	Seepage Cell Experiment
Source of Sample:	Native Soil
Munsell Color Code:	2.5 YR. 4/8

LABORATORY DATA:

Date Tested:	October 28 - November 3, 1992
Test Performed By:	DJK

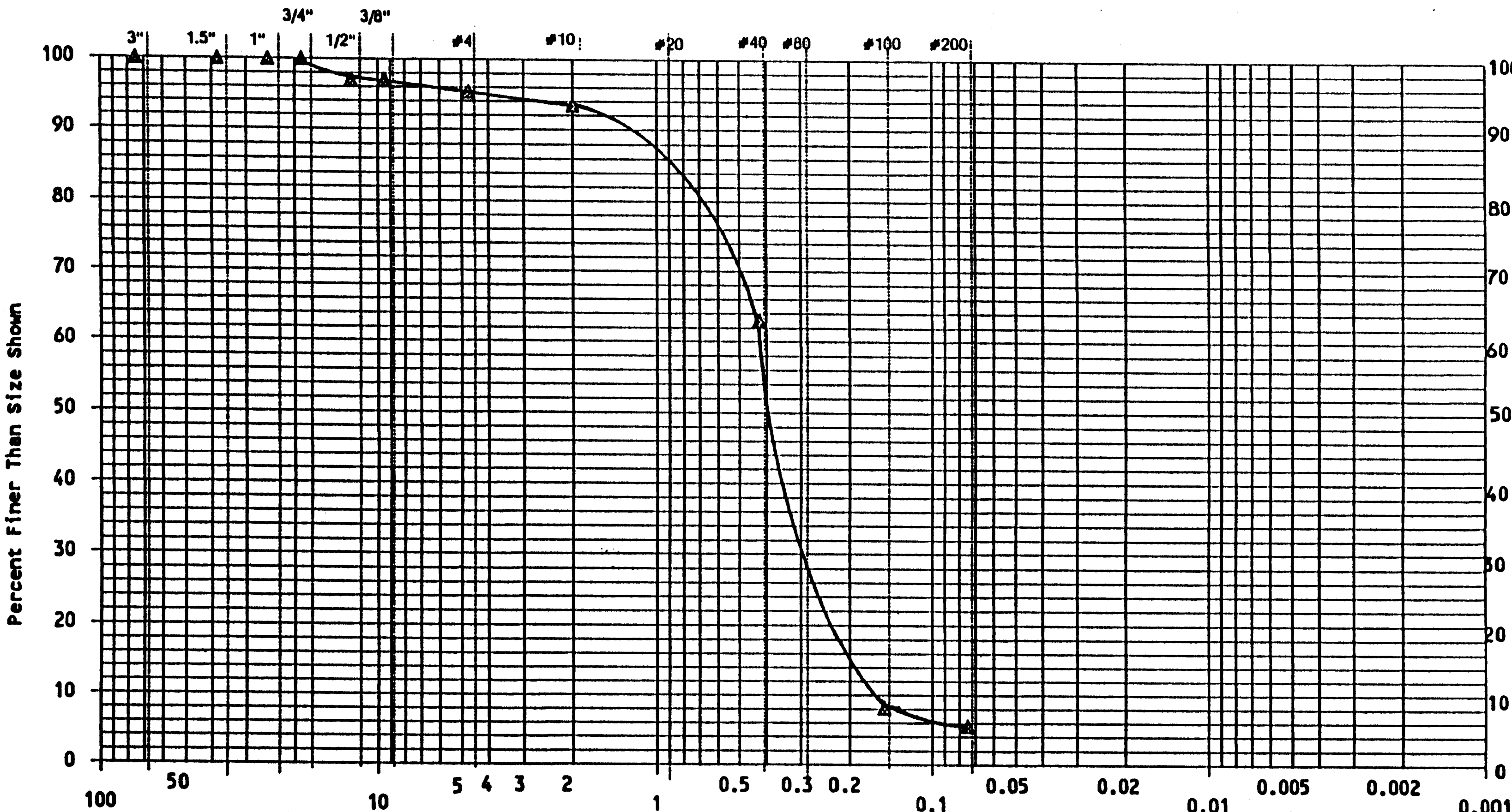
24 Hrs. Turn Around:	No
Washed Gradation:	Yes

Sieve Size	Weight Retained	% Retained	% Passing	Project Specification % Passing by Weight	Source of Specification
3"					
1 1/2"					
1"					
3/4"	0.0	0.0	100.0		
1/2"	17.8	2.9	97.1		
3/8"					
#4	10.4	1.7	95.4		
#10	12.0	1.9	93.5		
#40	190.1	30.5	63.0		
#100	341.7	54.8	8.2		
#200	16.3	2.6	5.6		

REVIEWED BY:	Timothy J. Asheson
DATE REVIEWED:	12-23-92

Remarks:

GRAIN SIZE DISTRIBUTION CURVE



Gravel		Sand			Silt	Clay
Coarse	Fine	Coarse	Medium	Fine		
	4.6%	1.9%	30.5%	57.4%	5.6%	

Soil Classification: SAND W/ SILT, fine to medium grained, a little grzvel, red (SP-SM)

Location Sampled: Cell #3		Elev. or Depth:	Date Sampled: 10/22/92
Sample Number: FL-CE-3		Sampled Moisture Content (%): 4.1	Report No.: CE-3
Sample Source: Native Soil		MC DONALD - MAAS ASSOCIATES	
Atterberg Limits: LL=	PL= PI=	Client: WDNR	
Munsell Color Code: 2.5 YR. 4/8		Project: Florence Seepage Cells	Page: 2
Date Received: 10/26/92		Prepared by: Robert Rouse	Date: 12/3/92
Coefficients: Cc=1.3	Cu=2.5	Checked by: Timothy J. Ambrosius	Date: 12/23/92

MC DONALD - MAAS ASSOCIATES

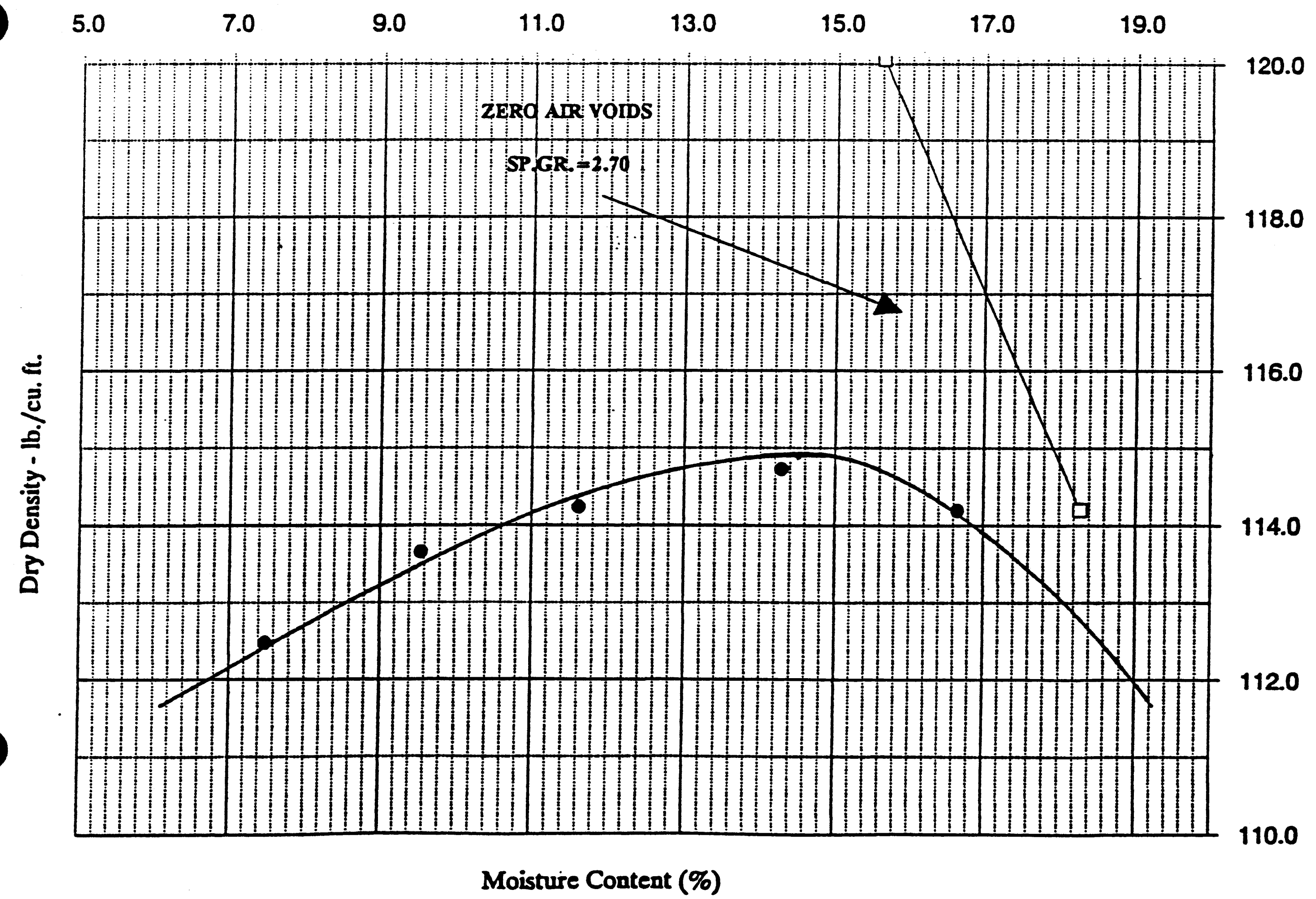
MOISTURE - DENSITY RELATIONS OF SOIL

GENERAL DATA:

Client:	WDNR		
Project:	Florence Seepage Cells - Cell #3		
Contractor:		**Sampled From:**	Native Soil
Sample No:	FL-CE-3	**Date Received:**	10/26/92
Tested By:	DJK	**Reviewed By:**	[signature]

LABORATORY DATA:

Soil Classification:	SAND W/ SILT, fine to medium grained, red (SP-SM)					
Munsell Color Code:	2.5 YR. 4/8		**Atterberg Limits:**	LL=	PL=	PI=NP
Maximum Dry Density (lb/cu.ft.):	114.9	**Optimum Moisture (%):**	14.5	**Wet Density (lb/cu.ft.):**	131.6	



MC DONALD - MAAS ASSOCIATES

SIEVE ANALYSIS OF COARSE TO FINE AGGREGATES (ASTM D422)

GENERAL DATA:

Client:	WDNR
Project:	Florence Seepage Cells
Location Sampled:	Cell # 4
Sample No:	FL-CE-4
Depth of Sample:	
Date Received:	10/26/92
Sample Designated For:	Seepage Cell Experiment
Source of Sample:	Golackner Site
Munsell Color Code:	10 YR. 4/6

LABORATORY DATA:

Date Tested:	October 28 - November 3, 1992
Test Performed By:	DJK

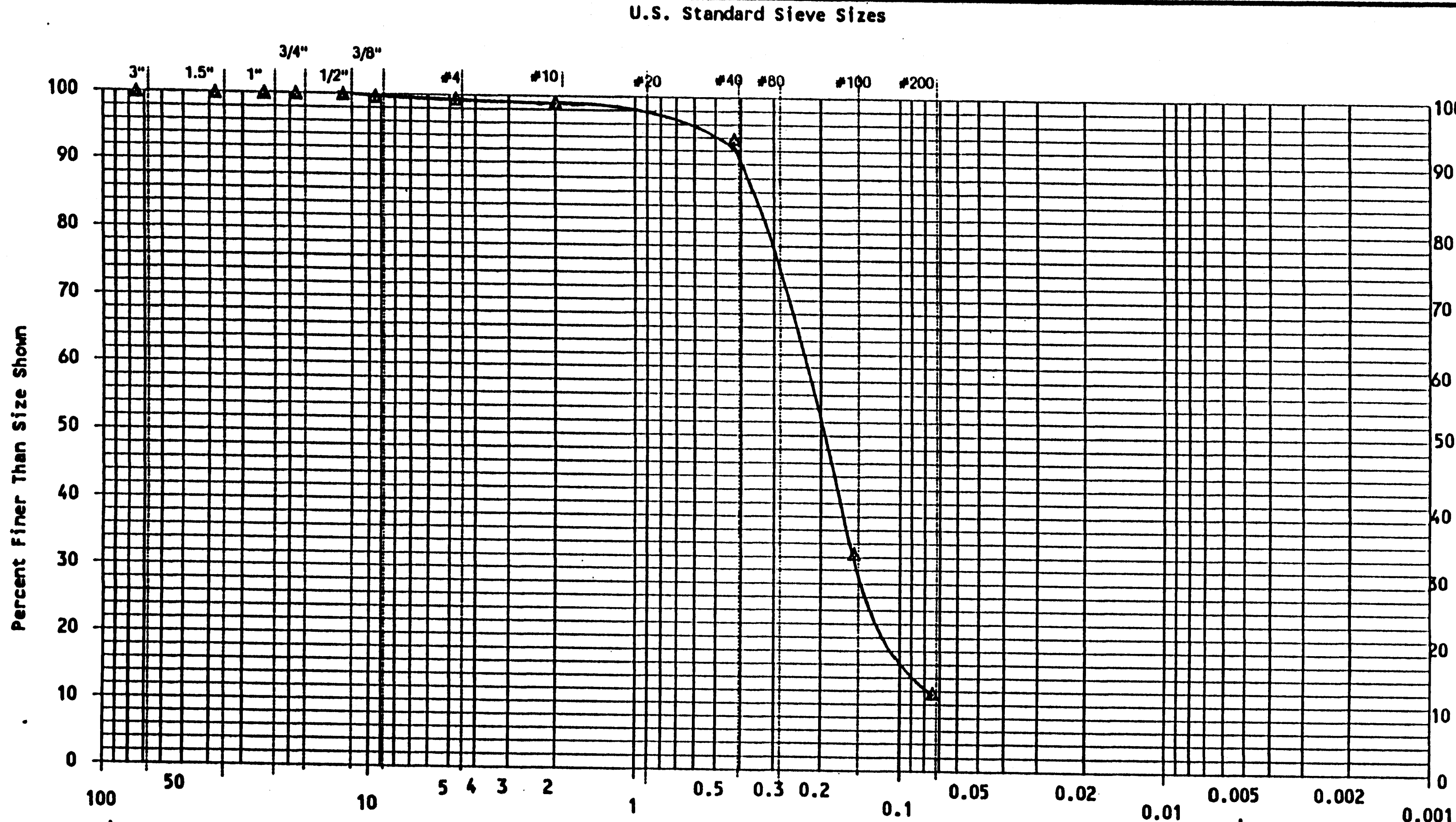
24 Hrs. Turn Around:	No
Washed Gradation:	Yes

Sieve Size	Weight Retained	% Retained	% Passing	Project Specification % Passing by Weight	Source of Specification
3"					
1 1/2"					
1"					
3/4"					
1/2"	0.0	0.0	100.0		
3/8"	2.1	0.3	99.7		
#4	1.3	0.2	99.5		
#10	1.8	0.3	99.2		
#40	32.4	5.3	93.9		
#100	371.5	61.2	32.7		
#200	126.5	20.8	11.9		

REVIEWED BY:	Timothy J. [signature]
DATE REVIEWED:	12-23-92

Remarks:

GRAIN SIZE DISTRIBUTION CURVE



Gravel		Sand			Silt	Clay
Coarse	Fine	Coarse	Medium	Fine		
	0.5%	0.3%	5.3%	82.0%		

Soil Classification: SAND W/ SILT, fine grained, dark yellowish brown (SM-SP)

Location Sampled: Cell # 4		Elev. or Depth:	Date Sampled: 10/22/92
Sample Number: FL-CE-4		Sampled Moisture Content (%): 6.3	Report No.: CE-4
Sample Source: Golackner Site		MC DONALD - MAAS ASSOCIATES	
Atterberg Limits: LL=	PL= PI=	Client: WDNR	
Munsell Color Code: 10 YR, 4/6		Project: Florence Seepage Cells	Page: 2
Date Received: 10/26/92		Prepared by: Robert Rouse	Date: 12/4/92
Coefficients: Cc=	Cu=	Checked by: Timothy J. [signature]	Date: 12/23/92

MC DONALD - MAAS ASSOCIATES

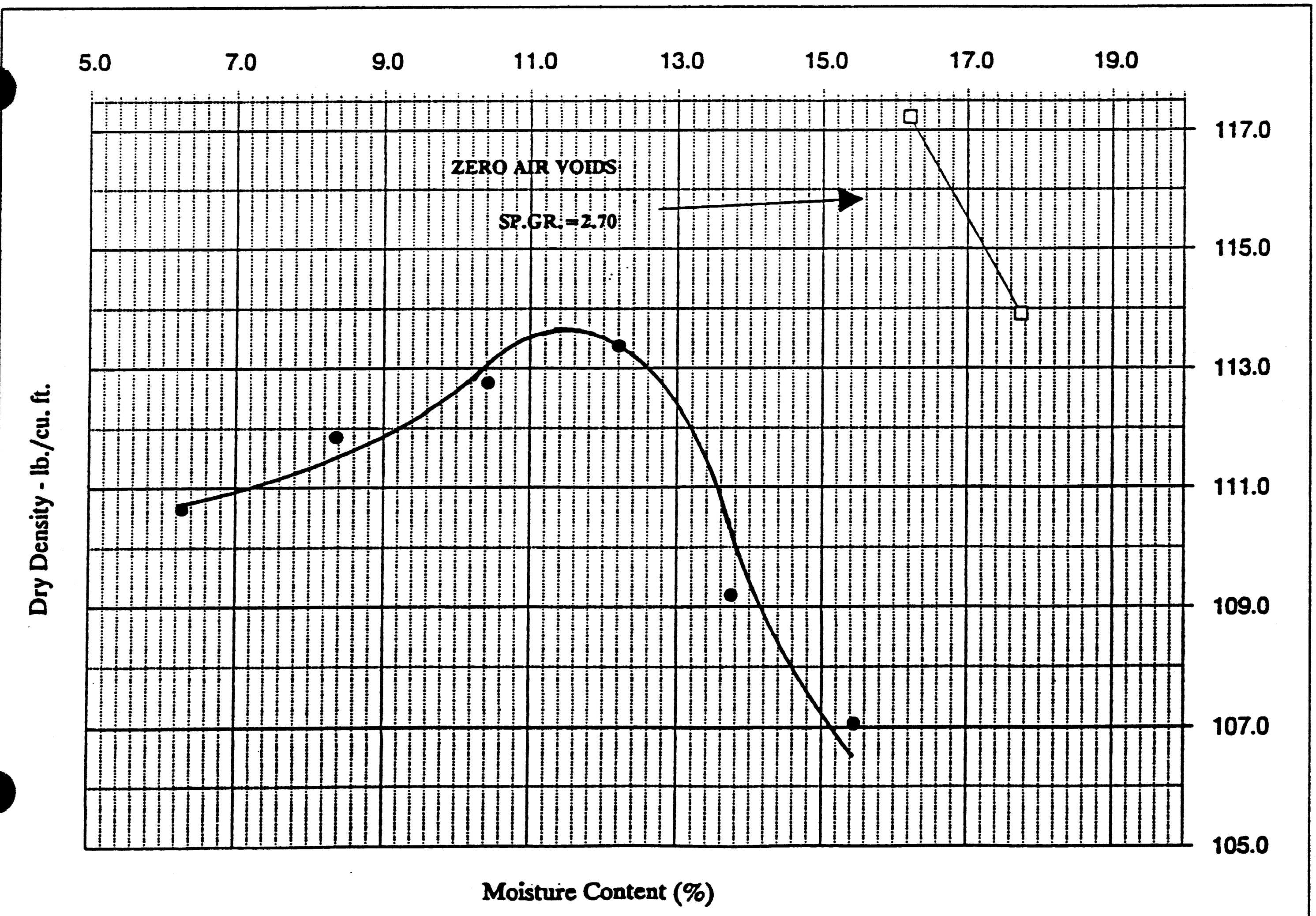
MOISTURE - DENSITY RELATIONS OF SOIL

GENERAL DATA:

Client:	WDNR		
Project:	Florence Seepage Cells - Cell # 4		
Contractor:		Sampled From:	Golackner Site
Sample No:	FL-CE-4	Date Received:	10/26/92
Tested By:	DJK	Reviewed By:	Timothy J [signature]

LABORATORY DATA:

Soil Classification:	SAND W/ SILT, fine grained, dark yellowish brown (SM-SP)				
Munsell Color Code:	10 YR. 4/6	Atterberg Limits:	LL=	PL=	PI=NP
Maximum Dry Density (lb/cu.ft.):	113.7	Optimum Moisture (%):	11.4	Wet Density (lb/cu.ft.):	126.7



MC DONALD - MAAS ASSOCIATES

SIEVE ANALYSIS OF COARSE TO FINE AGGREGATES (ASTM D422)

GENERAL DATA:

Client:	WDNR
Project:	Florence Seepage Cells
Location Sampled:	Cell # 5
Sample No:	FL-CE-5
Depth of Sample:	
Date Received:	10/26/92
Sample Designated For:	Seepage Cell Experiment
Source of Sample:	Golackner Site
Munsell Color Code:	10 YR. 3/6

LABORATORY DATA:

Date Tested:	October 28 - November 3, 1992
Test Performed By:	DJK

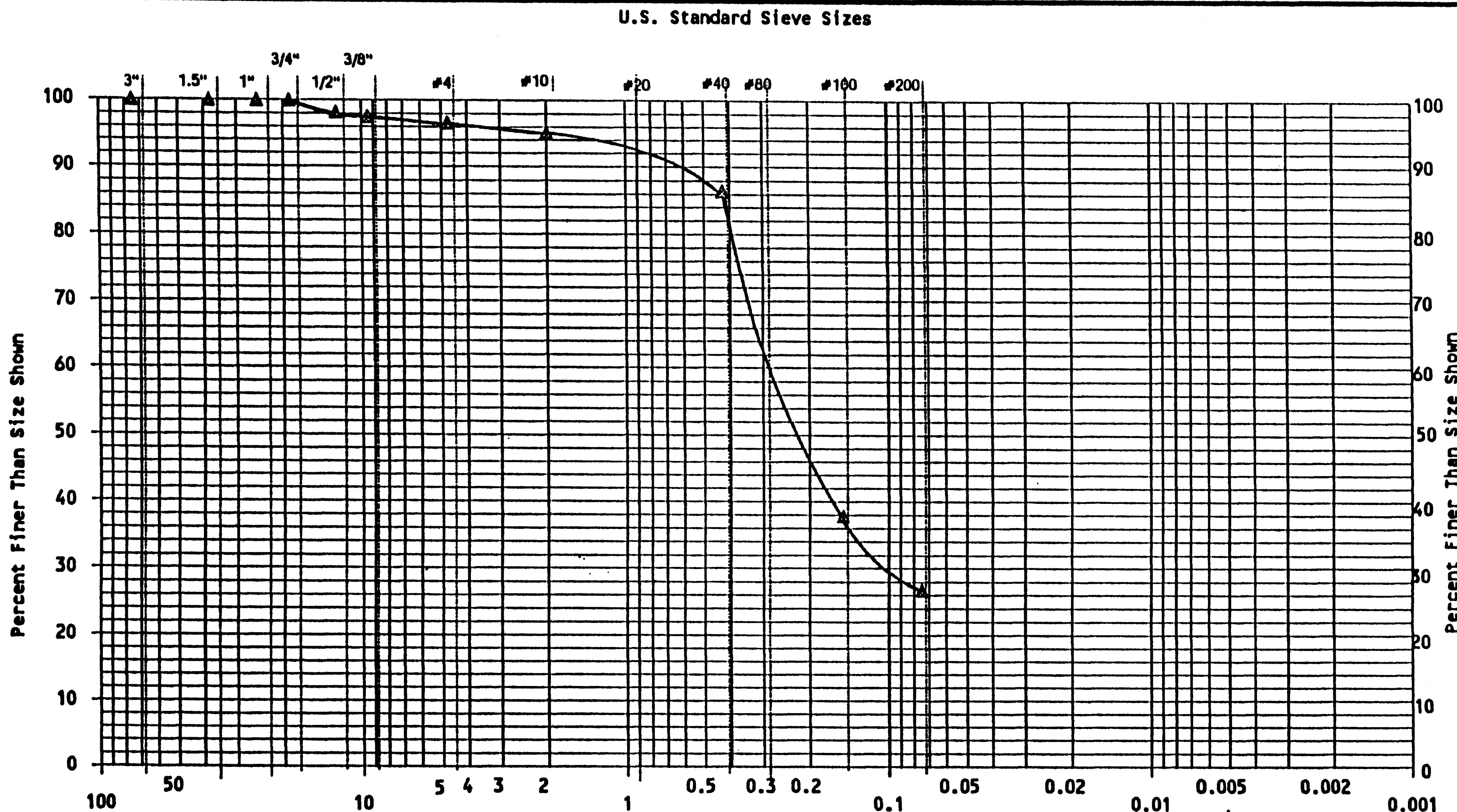
24 Hrs. Turn Around:	No
Washed Gradation:	Yes

Sieve Size	Weight Retained	% Retained	% Passing	Project Specification % Passing by Weight	Source of Specification
3"					
1 1/2"					
1"					
3/4"	0.0	0.0	100.0		
1/2"	10.3	1.8	98.2		
3/8"	3.6	0.6	97.6		
#4	5.5	0.9	96.7		
#10	8.9	1.5	95.2		
#40	50.8	8.7	86.5		
#100	283.9	48.6	37.9		
#200	65.1	11.1	26.8		

REVIEWED BY:	Timothy J. [illegible]
DATE REVIEWED:	12-23-92

Remarks:

GRAIN SIZE DISTRIBUTION CURVE



Gravel		Sand			Silt	Clay
Coarse	Fine	Coarse	Medium	Fine		
	3.3%	1.5%	8.7%	59.7%		

Soil Classification: SILTY SAND, fine grained, a little gravel, dark yellowish brown (SM)

Location Sampled: Cell # 5			Elev. or Depth:	Date Sampled: 10/22/92
Sample Number: FL-CE-5			Sampled Moisture Content (%): 11.1	Report No.: CE-5
Sample Source: Golackner Site			MC DONALD - MAAS ASSOCIATES	
Atterberg Limits:	LL=	PL=	PI=	Client: WDNR
Munsell Color Code: 10 YR, 3/6			Project: Florence Seepage Cells	Page: 2
Date Received: 10/26/92			Prepared by: Robert Rouse	Date: 12/4/92
Coefficients: Cc=	Cu=		Checked by: Timothy J Ambrose	Date: 12/23/92

MC DONALD - MAAS ASSOCIATES

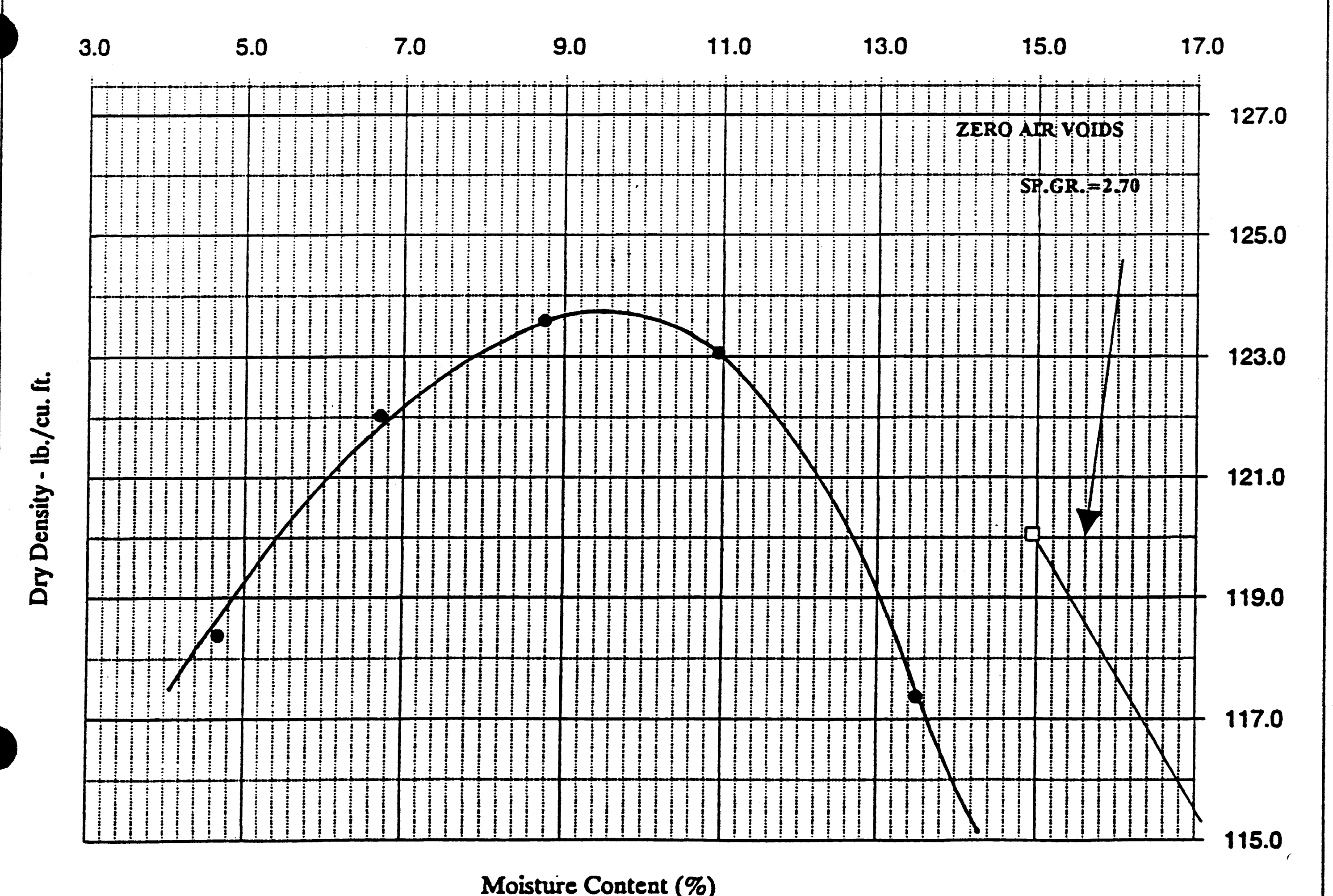
MOISTURE - DENSITY RELATIONS OF SOIL

GENERAL DATA:

Client:	WDNR		
Project:	Florence Seepage Cells - Cell # 5		
Contractor:		**Sampled From:**	Golackner Site
Sample No:	FL-CE-5	**Date Received:**	10/26/92
Tested By:	DJK	**Reviewed By:**	[signature]

LABORATORY DATA:

Soil Classification:	SILTY SAND, fine grained, dark yellowish brown (SM)				
Munsell Color Code:	10 YR. 3/6	**Atterberg Limits:**	LL=	PL=	PI=NP
Maximum Dry Density (lb/cu.ft.):	123.7	**Optimum Moisture (%):**	9.5	**Wet Density (lb/cu.ft.):**	135.5



APPENDIX 2

PUMP CALIBRATION DATA – 1992

VALVE OPEN FULL (UNTHROTTLED) – DISCHARGE RATE (gpm)

CELL	7/20	9/14	9/28					Average	Range
1	28.6								
2	28.6	32.0	34.3					31.6	28.6 to 34.3
3	29.0	32.7	35.6					32.4	29.0 to 35.6
4	27.8								
5	27.6	31.3	33.2					30.7	27.6 to 33.2

VALVE THROTTLED – DISCHARGE RATE (gpm)

CELL	7/20	8/4	9/14	9/28				Average	Range
1		64.8		60.8				62.8	
2		68.6		61.8				65.2	
3	56.0	66.4	61.6	62.0				61.5	
4		58.7		55.6				57.2	
5	54.5	56.3		53.4				54.7	

PUMP CALIBRATION DATA – 1993

VALVE OPEN FULL (UNTHROTTLED) – DISCHARGE RATE (gpm)

CELL	4/26	6/24	7/6	8/4	8/19	9/2	9/21	Average	Range
1	57.6	58.4	57.6	60.8	60.5	61.2	61.0	59.6	57.6 to 61.2
2	61.8	61.8	59.6	63.0	62.6	63.4	63.1	62.2	59.6 to 63.4
3	61.8	61.8	59.6	63.0	62.6	63.4	63.1	62.2	59.6 to 63.4
4	55.1	55.5	53.2	56.2	55.8	56.6	56.3	55.5	53.2 to 56.6
5	54.6	53.6	51.7	54.7	54.3	55.0	54.8	54.1	51.7 to 55.0

VALVE THROTTLED – DISCHARGE RATE (gpm)

CELL	4/26	6/24	7/6	8/4	8/19	9/2	9/21	Average	Range
1	35.7	29.5	35.6	39.9	30.2	32.4	32.9	33.7	29.5 to 39.9
2	36.8	30.0	36.0	40.3	30.5	32.7	33.2	34.2	30.0 to 40.3
3	37.4	30.3	36.6	41.0	31.0	33.3	33.8	34.8	30.3 to 41.0
4	36.2	29.3	35.4	39.6	30.0	32.2	32.7	33.6	29.3 to 39.6
5	34.7	28.6	34.5	38.7	29.2	31.4	31.9	32.7	28.6 to 38.7

CELL 3 Cell Area = 1872 ft²

	LOADING CYCLE	PUMP DISCHARGE START DATE	START TIME	END DATE	END TIME	DISCHARGE RATE (GPM)	VOLUME APPLIED FEET	VOLUME APPLIED GALLONS
1992:	1	8/25	3:00 P	8/26	6:00 A	66.4	4.27	59,760
		8/27	3:00 P	8/28	6:00 A	66.4	4.27	59,760
						Cycle Total:	8.54	119,520
	2	9/8	3:00 P	9/9	6:00 A	61.6	3.96	55,440
		9/10	3:00 P	9/11	6:00 A	61.6	3.96	55,440
						Cycle Total:	7.92	110,880
	3	9/21	3:00 P	9/22	6:00 A	61.6	3.96	55,440
		9/23	3:00 P	9/24	6:00 A	61.6	3.96	55,440
						Cycle Total:	7.92	110,880
	4	10/6	3:00 P	10/7	6:00 A	62.0	3.98	55,800
		10/8	3:00 P	10/9	6:00 A	62.0	3.98	55,800
						Cycle Total	7.97	111,600
	5	10/27	3:00 P	10/28	6:00 A	62.0	3.98	55,800
		10/29	3:00 P	10/30	6:00 A	62.0	3.98	55,800
						Cycle Total:	7.97	111,600
1993:	6	4/19	4:30 P	4/20	6:10 A	61.8	3.62	50,676
		4/21	5:00 P	4/22	6:15 A	61.8	3.51	49,131
						Cycle Total:	7.13	99,807
	7	5/5	3:00 P	5/6	6:15 A	61.8	4.04	56,547
						Cycle Total:	4.04	56,547
	8	5/17	3:30 P	5/18	6:15 A	61.8	3.91	54,693
		5/19	3:00 P	5/20	6:15 A	61.8	4.04	56,547
						Cycle Total:	7.94	111,240
	9	5/31	3:00 P	6/1	6:15 A	61.8	4.04	56,547
		6/2	2:30 P	6/3	6:15 A	61.8	4.17	58,401
						Cycle Total:	8.21	114,948
	10	6/14	3:00 P	6/15	6:15 A	61.8	4.04	56,547
		6/16	3:00 P	6/17	6:15 A	61.8	4.04	56,547
						Cycle Total:	8.08	113,094
	11	6/28	3:00 P	6/29	6:15 A	61.8	4.04	56,547
		6/30	3:00 P	7/1	6:15 A	61.8	4.04	56,547
						Cycle Total:	8.08	113,094

CELL 3 Cell Area = 1,872 ft²

LOADING CYCLE	PUMP DISCHARGE START DATE	START TIME	END DATE	END TIME	DISCHARGE RATE (GPM)	VOLUME APPLIED FEET	GALLONS
12	8/2	3:00 P	8/3	6:15 A	63.0	4.12	57,645
	8/4	3:00 P	8/5	6:15 A	63.0	4.12	57,645
					Cycle Total:	8.23	115,290
13	8/16	3:00 P	8/17	6:15 A	62.6	4.09	57,279
	8/18	3:00 P	8/19	6:15 A	62.6	4.09	57,279
					Cycle Total	8.18	114,558
14	8/30	3:00 P	8/31	6:15 A	62.6	4.09	57,279
	9/1	3:00 P	9/2	6:15 A	62.6	4.09	57,279
					Cycle Total:	8.18	114,558
15	9/20	3:00 P	9/21	6:15 A	63.1	4.12	57,737
					Cycle Total:	4.12	57,737
16	9/28	6:15 A	9/28	3:00 P	63.1	2.37	33,128
	9/30	6:15 A	9/30	3:00 P	63.1	2.37	33,128
					Cycle Total:	4.73	66,255
17	10/19	3:00 P	10/20	6:15 A	63.1	4.12	57,737
	10/21	6:15 A	10/22	6:15 A	34.8	3.58	50,112
					Cycle Total	7.70	107,849
18	10/25	3:00 P	10/26	6:00 A	62.4	4.01	56,160
	10/27	3:00 P	10/28	6:15 A	62.4	4.08	57,096
					Cycle Total:	8.09	113,256
19	11/15	6:15 A	11/16	6:30 A	62.4	6.48	90,792
	11/17	6:30 A	11/18	6:15 A	62.4	6.35	88,920
					Cycle Total:	12.83	179,712
20	11/29	3:00 P	11/30	7:10 A	62.4	4.32	60,528
	12/1	3:00 P	12/2	7:15 A	62.4	4.34	60,840
					Cycle Total	8.67	121,368

CELL 1 Cell Area = 1,944 ft²

LOADING CYCLE	PUMP DISCHARGE START DATE	START TIME	END DATE	END TIME	DISCHARGE RATE (GPM)	VOLUME APPLIED FEET	GALLONS
1992: 1	8/4	8:30 A	8/5	6:15 A	28.6	2.57	37,323
	8/6	6:15 A	8/7	6:15 A	28.6	2.83	41,184
	8/8	8:00 A	8/9	8:00 A	28.6	2.83	41,184
					Cycle Total:	8.23	119,691
2	9/2	6:00 A	9/3	6:15 A	28.6	2.86	41,613
	9/4	7:00 A	9/5	7:00 A	28.6	2.83	41,184
	9/6	7:00 A	9/7	7:30 A	28.6	2.89	42,042
					Cycle Total:	8.59	124,839
3	9/15	6:00 A	9/16	6:00 A	28.6	2.83	41,184
	9/17	6:00 A	9/18	6:45 A	28.6	2.92	42,471
	9/19	7:00 A	9/20	7:00 A	28.6	2.83	41,184
					Cycle Total:	8.59	124,839
4	9/29	6:00 A	9/30	6:00 A	28.6	2.83	41,184
	10/1	6:00 A	10/2	7:00 A	28.6	2.95	42,900
	10/3	8:00 A	10/4	7:30 A	28.6	2.77	40,326
					Cycle Total:	8.56	124,410
5	11/4	10:00 A	11/5	6:15 A	28.6	2.39	34,749
	11/9	11:00 A	11/10	6:15 A	36.6	2.91	42,273
					Cycle Total	5.30	77,022
1993: 6	4/19	7:00 A	4/19	4:30 P	57.6	2.26	32,832
	4/21	6:15 A	4/21	5:00 P	57.6	2.55	37,152
	4/23	6:15 A	4/24	6:15 A	33.7	3.34	48,528
	4/25	7:45 A	4/26	8:00 A	33.7	3.37	49,034
					Cycle Total:	11.52	167,546
7	5/5	6:15 A	5/5	3:00 P	57.6	2.08	30,240
	5/7	6:15 A	5/8	7:30 A	33.7	3.51	51,056
	5/9	7:00 A	5/10	6:15 A	33.7	3.23	47,012
					Cycle Total:	8.82	128,307
8	5/17	6:45 A	5/17	3:00 P	57.6	1.96	28,512
	5/19	6:15 A	5/19	3:30 P	57.6	2.20	31,968
	5/21	6:15 A	5/22	7:30 A	33.7	3.51	51,056
	5/23	7:15 A	5/24	6:15 A	33.7	3.20	46,506
					Cycle Total:	10.87	158,042

CELL 1

LOADING CYCLE	PUMP DISCHARGE START DATE	START TIME	END DATE	END TIME	DISCHARGE RATE (GPM)	VOLUME APPLIED FEET	VOLUME APPLIED GALLONS
9	5/31	6:00 A	5/31	3:00 P	57.6	2.14	31,104
	6/2	6:15 A	6/2	2:30 P	57.6	1.96	28,512
	6/4	6:15 A	6/5	7:30 A	33.7	3.51	51,056
	6/6	7:30 A	6/7	6:25 A	33.7	3.19	46,338
					Cycle Total:	10.80	157,009
10	6/14	6:20 A	6/14	3:00 P	57.6	2.06	29,952
	6/16	6:15 A	6/16	3:00 P	57.6	2.08	30,240
	6/18	6:15 A	6/19	7:30 A	33.7	3.51	51,056
	6/20	7:30 A	6/21	6:25 A	33.7	3.19	46,338
					Cycle Total:	10.84	157,585
11	6/28	6:15 A	6/28	3:00 P	58.4	2.11	30,660
	6/30	6:15 A	6/30	3:00 P	58.4	2.11	30,660
	7/2	6:15 A	7/3	7:30 A	33.7	3.51	51,056
	7/4	7:30 A	7/5	8:00 A	33.7	3.41	49,539
					Cycle Total:	11.13	161,915
12	8/2	6:15 A	8/2	3:00 P	60.8	2.20	31,920
	8/4	6:15 A	8/4	3:00 P	60.8	2.20	31,920
	8/6	6:15 A	8/7	7:30 A	33.7	3.51	51,056
	8/8	7:30 A	8/9	6:15 A	33.7	3.16	46,001
					Cycle Total:	11.06	160,896
13	8/16	6:15 A	8/16	3:00 P	60.5	2.18	31,763
	8/18	6:15 A	8/18	3:00 P	60.5	2.18	31,763
	8/20	6:15 A	8/21	7:30 A	33.7	3.51	51,056
	8/22	7:30 A	8/23	6:15 A	33.7	3.16	46,001
					Cycle Total:	11.04	160,581
14	8/30	6:15 A	8/30	3:00 P	61.2	2.21	32,130
	9/1	6:15 A	9/1	3:00 P	61.2	2.21	32,130
	9/3	6:15 A	9/4	7:30 A	33.7	3.51	51,056
	9/5	7:30 A	9/6	7:45 A	33.7	3.37	49,034
	9/8	6:15 A	9/8	3:00 P	61.2	2.21	32,130
	9/10	6:15 A	9/10	3:00 P	61.2	2.21	32,130
	9/13	6:15 A	9/13	3:00 P	61.2	2.21	32,130
	9/15	6:15 A	9/15	5:00 P	61.2	2.71	39,474
					Cycle Total:	20.64	300,213

CELL 1

LOADING CYCLE	PUMP DISCHARGE START DATE	START TIME	END DATE	END TIME	DISCHARGE RATE (GPM)	VOLUME APPLIED FEET	VOLUME APPLIED GALLONS
15	10/2	7:30A	10/3	7:30A	33.7	3.34	48,528
	10/4	6:15A	10/5	6:15A	33.7	3.34	48,528
	10/6	6:15A	10/6	1:30P	59.7	1.79	25,970
	10/7	3:00P	10/8	6:00A	59.7	3.70	53,730
	10/10	6:00A	10/11	6:15A	33.7	3.37	49,034
	10/12	3:00P	10/13	6:15A	61.2	3.85	55,998
	10/14	3:00P	10/15	6:15A	61.2	3.85	55,998
	10/17	7:30A	10/18	6:20A	33.7	3.18	46,169
					Cycle Total:	26.41	383,954
16	10/25	6:15A	10/25	3:00P	60.3	2.18	31,658
	10/27	6:15A	10/27	3:00P	60.3	2.18	31,658
	10/29	6:15A	10/30	7:30A	33.7	3.51	51,056
	10/31	7:30A	11/1	8:00A	33.7	3.41	49,539
	11/2	6:15A	11/2	3:00P	60.3	2.18	31,658
	11/3	3:00P	11/4	6:00A	60.3	3.73	54,270
	11/6	6:15A	11/7	6:15A	33.7	3.34	48,528
	11/9	6:15A	11/10	6:15A	33.7	3.34	48,528
	11/11	6:30A	11/11	3:00P	33.7	1.18	17,187
					Cycle Total:	25.04	364,080
17	11/29	6:30A	11/29	3:00P	60.3	2.11	30,753
	12/1	7:15A	12/1	3:00P	60.3	1.93	28,040
	12/3	7:15A	12/4	7:30A	33.7	3.37	49,034
	12/5	7:30A	12/6	7:20A	33.7	3.31	48,191
	12/7	7:20A	12/8	7:20A	33.7	3.33	48,528
					Cycle Total:	14.05	204,546

CELL 2 Cell Area = 1,872 ft²

LOADING CYCLE	PUMP DISCHARGE START DATE	START TIME	END DATE	END TIME	DISCHARGE RATE (GPM)	VOLUME APPLIED FEET	VOLUME APPLIED GALLONS
1992 – 1	8/4	8:30 A	8/5	6:15 A	28.6	2.67	37,323
	8/6	6:15 A	8/7	6:15 A	28.6	2.94	41,184
	8/8	8:00 A	8/9	8:00 A	28.6	2.94	41,184
					Cycle Total:	8.55	119,691
2	8/25	6:00 A	8/25	3:00 P	68.8	2.65	37,152
	8/27	6:00 A	8/27	3:00 P	68.8	2.65	37,152
	8/29	6:00 A	8/30	8:00 A	28.6	3.19	44,616
					Cycle Total:	8.49	118,920
3	9/8	6:00 A	9/8	3:00 P	68.8	2.65	37,152
	9/10	6:00 A	9/10	3:00 P	68.8	2.65	37,152
	9/12	6:00 A	9/13	8:00 A	32.0	3.57	49,920
					Cycle Total:	8.87	124,224
4	9/21	6:00 A	9/21	3:00 P	61.8	2.38	33,372
	9/23	6:00 A	9/23	3:00 P	61.8	2.38	33,372
	9/25	6:00 A	9/26	6:00 A	34.3	3.53	49,392
	9/27	8:00 A	9/28	6:00 A	34.3	3.23	45,276
					Cycle Total:	11.53	161,412
5	10/6	6:00 A	10/6	3:00 P	61.8	2.38	33,372
	10/8	6:00 A	10/8	3:00 P	61.8	2.38	33,372
	10/10	7:00 A	10/11	7:30 A	34.3	3.60	50,421
	10/12	6:15 A	10/13	6:00 A	34.3	3.49	48,878
					Cycle Total:	11.86	166,043
6	10/27	6:00 A	10/27	3:00 P	61.8	2.38	33,372
	10/29	6:00 A	10/29	3:00 P	61.8	2.38	33,372
	10/31	7:30 A	11/1	7:15 A	34.3	3.49	48,878
	11/2	6:15 A	11/3	6:15 A	34.3	3.53	49,392
					Cycle Total:	11.78	165,014
1993 – 7	4/27	6:10 A	4/28	6:15 A	34.2	3.53	49,419
	4/29	6:15 A	4/30	6:15 A	34.2	3.52	49,248
	5/1	6:30 A	5/2	7:30 A	34.2	3.66	51,300
					Cycle Total:	10.71	149,967
8	5/11	6:15 A	5/12	6:15 A	34.2	3.52	49,248
	5/13	6:15 A	5/14	6:15 A	34.2	3.52	49,248
					Cycle Total:	7.03	98,496

CELL 2

LOADING CYCLE	PUMP DISCHARGE START DATE	START TIME	END DATE	END TIME	DISCHARGE RATE (GPM)	VOLUME APPLIED FEET	GALLONS
9	5/25	6:15 A	5/26	6:15 A	34.2	3.52	49,248
	5/27	6:15 A	5/28	6:15 A	34.2	3.52	49,248
	5/29	7:30 A	5/30	7:30 A	34.2	3.52	49,248
					Cycle Total:	10.55	147,744
10	6/8	6:15 A	6/9	6:20 A	34.2	3.53	49,419
	6/10	6:15 A	6/11	6:15 A	34.2	3.52	49,248
	6/12	7:45 A	6/13	7:30 A	34.2	3.48	48,735
					Cycle Total:	10.53	147,402
11	6/22	6:15 A	6/23	6:15 A	34.2	3.52	49,248
	6/24	6:15 A	6/25	6:15 A	34.2	3.52	49,248
	6/26	7:30 A	6/27	7:30 A	34.2	3.52	49,248
					Cycle Total:	10.55	147,744
12	7/6	6:15 A	7/7	6:15 A	34.2	3.52	49,248
	7/8	6:15 A	7/9	6:15 A	34.2	3.52	49,248
					Cycle Total:	7.03	98,496
13	8/3	6:15 A	8/4	6:15 A	34.2	3.52	49,248
	8/5	6:15 A	8/6	6:15 A	34.2	3.52	49,248
	8/7	7:30 A	8/8	7:30 A	34.2	3.52	49,248
	8/9	6:15 A	8/10	6:15 A	34.2	3.52	49,248
					Cycle Total:	14.07	196,992
14	8/17	6:15 A	8/18	6:15 A	34.2	3.52	49,248
	8/19	6:15 A	8/20	6:15 A	34.2	3.52	49,248
	8/21	7:30 A	8/22	7:30 A	34.2	3.52	49,248
	8/23	6:15 A	8/24	6:15 A	34.2	3.52	49,248
					Cycle Total:	14.07	196,992
15	8/31	6:15 A	9/1	6:15 A	34.2	3.52	49,248
	9/2	6:15 A	9/3	6:15 A	34.2	3.52	49,248
	9/4	7:30 A	9/5	7:30 A	34.2	3.57	49,932
	9/6	6:15 A	9/7	6:15 A	34.2	3.52	49,248
	9/8	3:00 P	9/9	6:15 A	63.4	4.14	58,011
	9/10	3:00 P	9/11	6:45 A	63.4	4.28	59,913
	9/13	3:00 P	9/14	6:30 A	63.4	4.21	58,962
	9/15	5:00 P	9/16	6:15 A	63.4	3.60	50,403
					Cycle Total	30.35	424,965

CELL 2

LOADING CYCLE	PUMP DISCHARGE START DATE	START TIME	END DATE	END TIME	DISCHARGE RATE (GPM)	VOLUME APPLIED FEET	VOLUME APPLIED GALLONS
16	9/27	6:15 A	9/28	6:15 A	34.2	3.52	49,248
	9/29	6:15 A	9/30	6:15 A	34.2	3.52	49,248
	10/1	6:15 A	10/2	7:30 A	34.2	3.70	51,813
	10/3	7:30 A	10/4	6:15 A	34.2	3.33	46,683
	10/5	6:15 A	10/6	6:15 A	34.2	3.52	49,248
	10/7	6:00 A	10/7	3:00 P	61.8	2.38	33,372
	10/9	6:00 A	10/10	6:00 A	34.2	3.52	49,248
	10/11	3:00 P	10/12	3:00 P	34.2	3.52	49,248
	10/13	3:00 P	10/14	3:00 P	34.2	3.52	49,248
	10/16	7:30 A	10/17	7:30 A	34.2	3.52	49,248
	10/19	6:15 A	10/19	3:00 P	62.4	2.34	32,760
					Cycle Total:	36.38	509,364
17	10/26	6:00 A	10/27	6:15 A	34.2	3.55	49,761
	10/28	6:15 A	10/29	6:15 A	34.2	3.52	49,248
	10/30	7:30 A	10/31	7:30 A	34.2	3.52	49,248
	11/1	6:15 A	11/2	6:15 A	34.2	3.52	49,248
	11/3	6:15 A	11/3	3:00 P	62.4	2.34	32,760
	11/5	6:15 A	11/6	6:15 A	34.2	3.52	49,248
	11/8	6:15 A	11/9	6:15 A	34.2	3.52	49,248
	11/10	3:00 P	11/11	6:30 A	34.2	2.27	31,806
					Cycle Total:	25.75	360,567
18	11/30	7:10 A	12/1	7:15 A	34.2	3.53	49,419
	12/2	7:15 A	12/3	7:15 A	34.2	3.52	49,248
	12/4	7:30 A	12/5	7:30 A	34.2	3.52	49,248
	12/6	7:20 A	12/7	7:20 A	34.2	3.52	49,248
					Cycle Total:	14.08	197,163

CELL 5 Cell Area = 1,926 ft^2

	LOADING CYCLE	PUMP DISCHARGE START DATE	START TIME	END DATE	END TIME	DISCHARGE RATE (GPM)	VOLUME APPLIED FEET	VOLUME APPLIED GALLONS
1992:	1	8/5	6:15 A	8/6	6:15 A	19.9	1.99	28,656
		8/7	6:15 A	8/8	8:00 A	31.3	3.36	48,359
		8/9	8:00 A	8/10	12:00 A	31.3	3.65	52,584
						Cycle Total:	9.00	129,599
	2	8/24	6:15 A	8/25	6:00 A	56.3	5.57	80,228
		8/26	6:00 A	8/27	6:00 A	27.6	2.76	39,744
		8/28	6:00 A	8/29	6:00 A	27.6	2.76	39,744
		8/30	8:00 A	8/31	6:00 A	27.6	2.53	36,432
						Cycle Total:	13.62	196,148
	3	9/7	7:30 A	9/8	6:00 A	31.3	2.93	42,255
		9/9	6:00 A	9/10	6:00 A	31.3	3.13	45,072
		9/11	6:00 A	9/12	6:00 A	31.3	3.13	45,072
		9/13	8:00 A	9/14	6:00 A	31.3	2.87	41,316
						Cycle Total:	12.06	173,715
	4	9/22	6:00 A	9/23	6:00 A	31.3	3.13	45,072
		9/24	6:00 A	9/25	6:00 A	31.3	3.13	45,072
		9/26	6:00 A	9/27	8:00 A	31.3	3.39	48,828
		9/28	8:00 A	9/29	6:00 A	31.3	2.87	41,316
						Cycle Total:	12.51	180,288
	5	10/7	6:00 A	10/8	6:00 A	33.2	3.32	47,808
		10/9	6:00 A	10/10	7:00 A	33.2	3.46	49,800
		10/11	7:30 A	10/12	6:15 A	33.2	3.15	45,318
		10/13	6:00 A	10/14	6:15 A	33.2	3.35	48,306
						Cycle Total:	13.27	191,232
	6	10/28	6:00 A	10/29	6:00 A	33.2	3.32	47,808
		10/30	6:00 A	10/31	7:30 A	33.2	3.53	50,796
		11/1	7:15 A	11/2	6:15 A	33.2	3.18	45,816
		11/3	6:15 A	11/4	6:15 A	33.2	3.32	47,808
						Cycle Total:	13.34	192,228
1993:	7	4/20	6:10 A	4/21	6:15 A	32.7	3.28	47,252
		4/22	6:15 A	4/23	6:15 A	32.7	3.27	47,088
		4/24	6:15 A	4/25	7:45 A	32.7	3.47	50,031
		4/26	8:00 A	4/27	6:10 A	32.7	3.02	43,491
						Cycle Total:	13.04	187,862

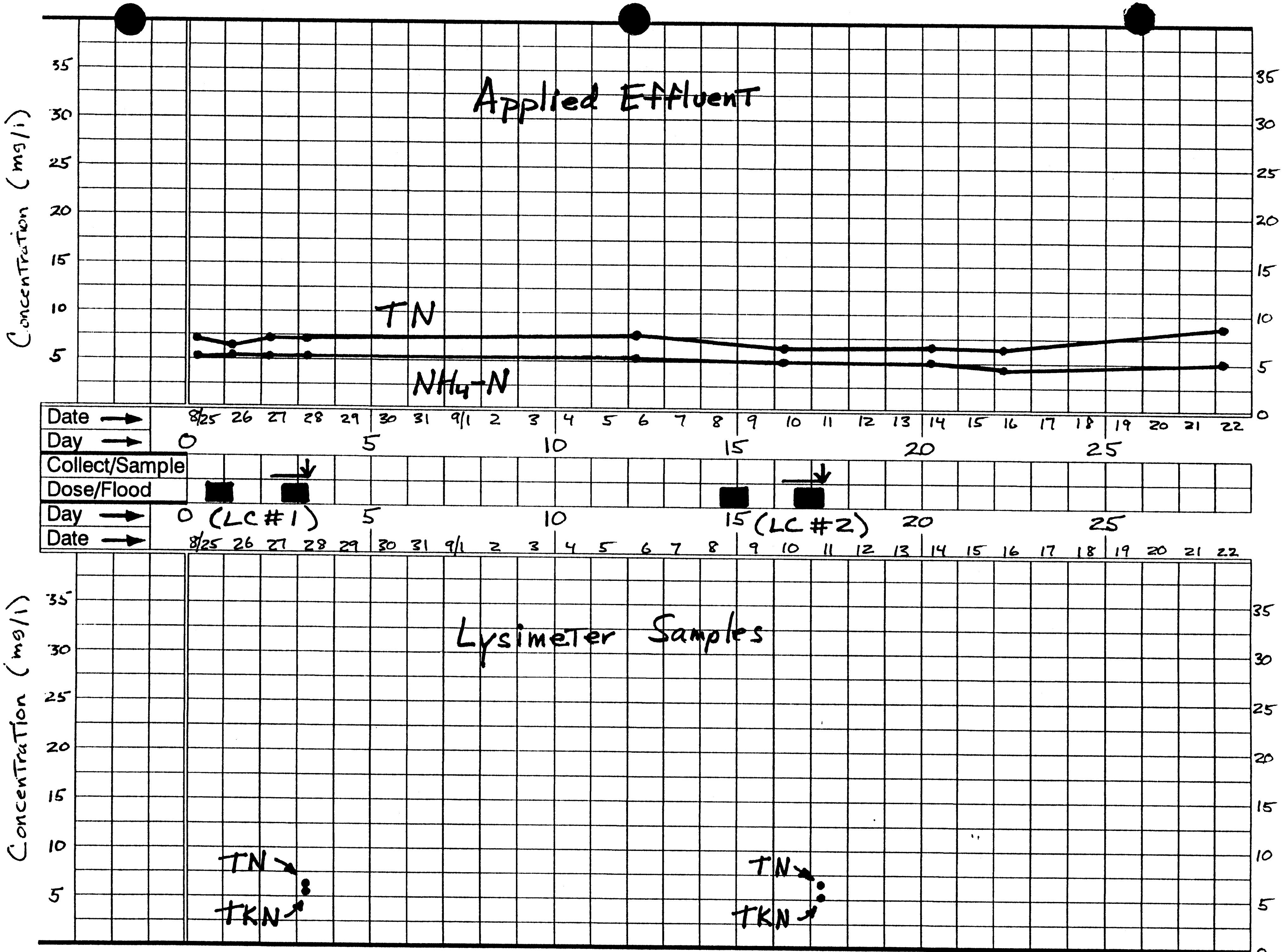
CELL 5

LOADING CYCLE	PUMP DISCHARGE START DATE	START TIME	END DATE	END TIME	DISCHARGE RATE (GPM)	VOLUME APPLIED FEET	VOLUME APPLIED GALLONS
8	5/4	10:00 A	5/5	6:15 A	32.7	2.76	39,731
	5/6	6:15 A	5/7	6:15 A	32.7	3.27	47,088
	5/8	7:30 A	5/9	7:00 A	32.7	3.20	46,107
	5/10	6:15 A	5/11	6:15 A	32.7	3.27	47,088
					Cycle Total:	12.50	180,014
9	5/18	6:15 A	5/19	6:15 A	32.7	3.27	47,088
	5/20	6:15 A	5/21	6:15 A	32.7	3.27	47,088
	5/22	7:30 A	5/23	7:15 A	32.7	3.23	46,598
	5/24	6:15 A	5/25	6:15 A	32.7	3.27	47,088
					Cycle Total:	13.04	187,862
10	6/1	6:15 A	6/2	6:15 A	32.7	3.27	47,088
	6/3	6:15 A	6/4	6:15 A	32.7	3.27	47,088
	6/5	7:30 A	6/6	7:20 A	32.7	3.27	47,088
	6/7	6:25 A	6/8	6:20 A	32.7	3.26	46,925
					Cycle Total:	13.06	188,189
11	6/15	6:15 A	6/16	6:15 A	32.7	3.27	47,088
	6/17	6:15 A	6/18	6:15 A	32.7	3.27	47,088
	6/19	7:30 A	6/20	7:30 A	32.7	3.27	47,088
	6/21	6:15 A	6/22	6:15 A	32.7	3.27	47,088
					Cycle Total:	13.07	188,352
12	6/29	6:15 A	6/30	6:15 A	32.7	3.27	47,088
	7/1	6:15 A	7/2	6:15 A	32.7	3.27	47,088
	7/3	7:30 A	7/4	7:30 A	32.7	3.27	47,088
	7/5	8:00 A	7/6	6:15 A	32.7	3.03	43,655
					Cycle Total:	12.84	184,919
13	8/10	6:15 A	8/11	6:15 A	32.7	3.27	47,088
	8/12	6:15 A	8/13	6:15 A	32.7	3.27	47,088
	8/14	7:30 A	8/15	7:30 A	32.7	3.27	47,088
					Cycle Total:	9.81	184,919
14	8/24	6:15 A	8/25	6:15 A	32.7	3.27	47,088
	8/26	6:15 A	8/27	6:15 A	32.7	3.27	47,088
	8/28	7:30 A	8/29	7:30 A	32.7	3.27	47,088
					Cycle Total:	9.81	184,919

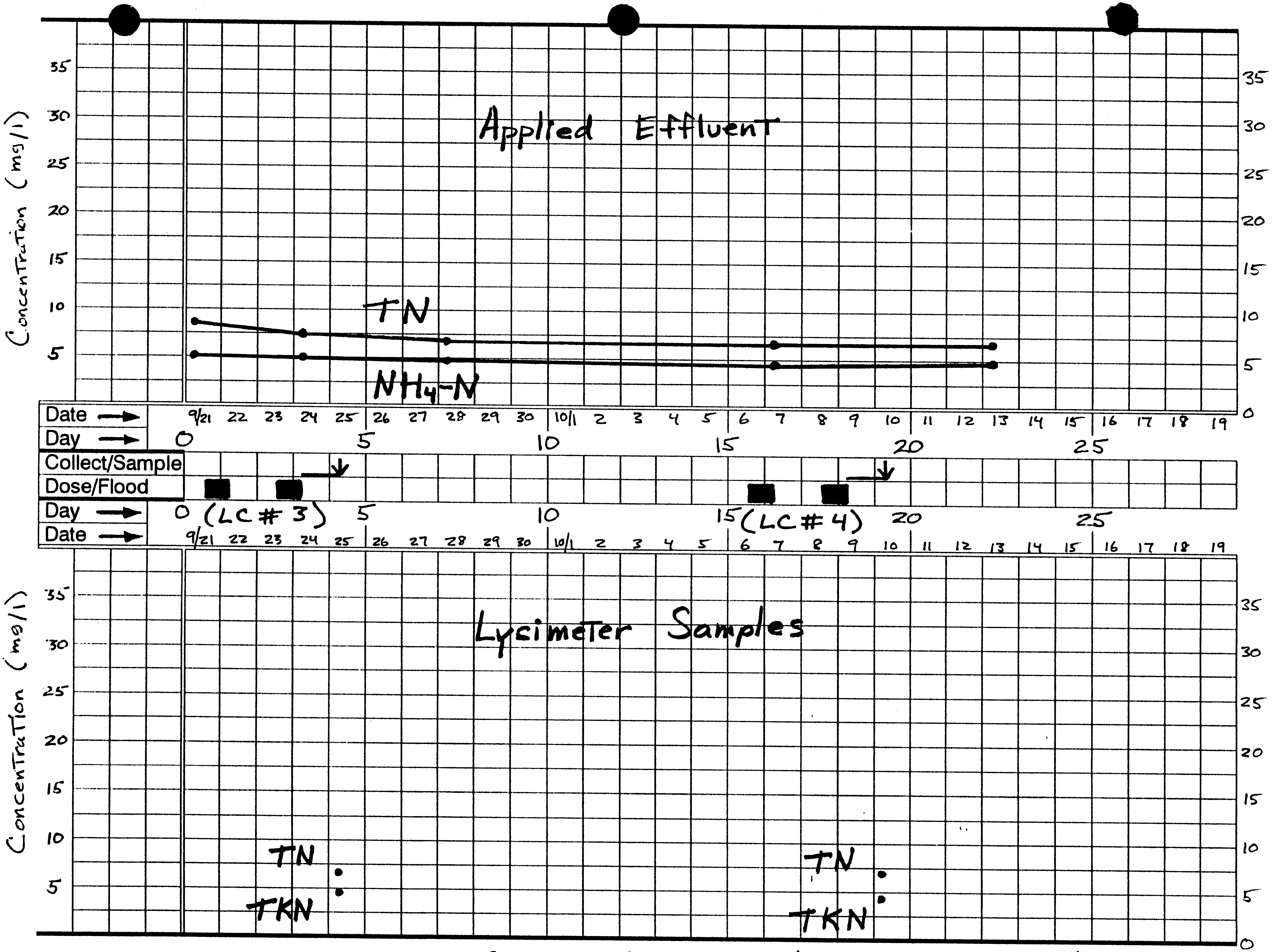
CELL 5

LOADING CYCLE	PUMP DISCHARGE START DATE	START TIME	END DATE	END TIME	DISCHARGE RATE (GPM)	VOLUME APPLIED FEET	GALLONS
15	9/7	6:15A	9/8	6:15A	32.7	3.27	47,088
	9/9	6:15A	9/10	6:15A	32.7	3.27	47,088
	9/11	6:45A	9/12	6:45A	32.7	3.27	47,088
	9/14	6:30A	9/15	6:15A	32.7	3.23	46,598
	9/16	6:15A	9/17	6:30A	32.7	3.30	47,579
	9/18	7:30A	9/19	7:30A	32.7	3.27	47,088
	9/21	6:15A	9/22	3:00P	54.8	7.47	107,682
					Cycle Total:	27.08	390,210
16	10/6	1:30P	10/7	6:00A	53.6	3.68	53,064
	10/8	6:00A	10/9	6:00A	32.7	3.27	47,088
	10/11	6:00A	10/11	3:00P	53.6	2.01	28,944
	10/13	6:15A	10/13	3:00P	53.6	1.95	28,140
	10/15	6:15A	10/16	7:30A	32.7	3.44	49,541
	10/18	6:20A	10/19	6:15A	32.7	3.26	46,925
	10/20	6:15A	10/21	6:15A	32.7	3.27	47,088
	10/22	6:15A	10/23	7:30A	32.7	3.44	49,541
	10/24	7:30A	10/25	6:15A	32.7	3.10	44,636
					Cycle Total:	27.41	394,966
17	11/2	3:00P	11/3	6:15A	54.2	3.44	49,593
	11/4	6:15A	11/5	6:15A	32.7	3.27	47,088
	11/7	6:15A	11/8	6:15A	32.7	3.27	47,088
	11/10	6:15A	11/10	3:00P	54.2	1.98	28,455
	11/11	3:00P	11/12	3:00P	32.7	3.27	47,088
	11/14	7:30A	11/15	6:15A	32.7	3.10	44,636
	11/16	6:30A	11/17	6:30A	32.7	3.27	47,088
	11/18	6:15A	11/19	6:15A	32.7	3.27	47,088
					Cycle Total:	24.86	358,124

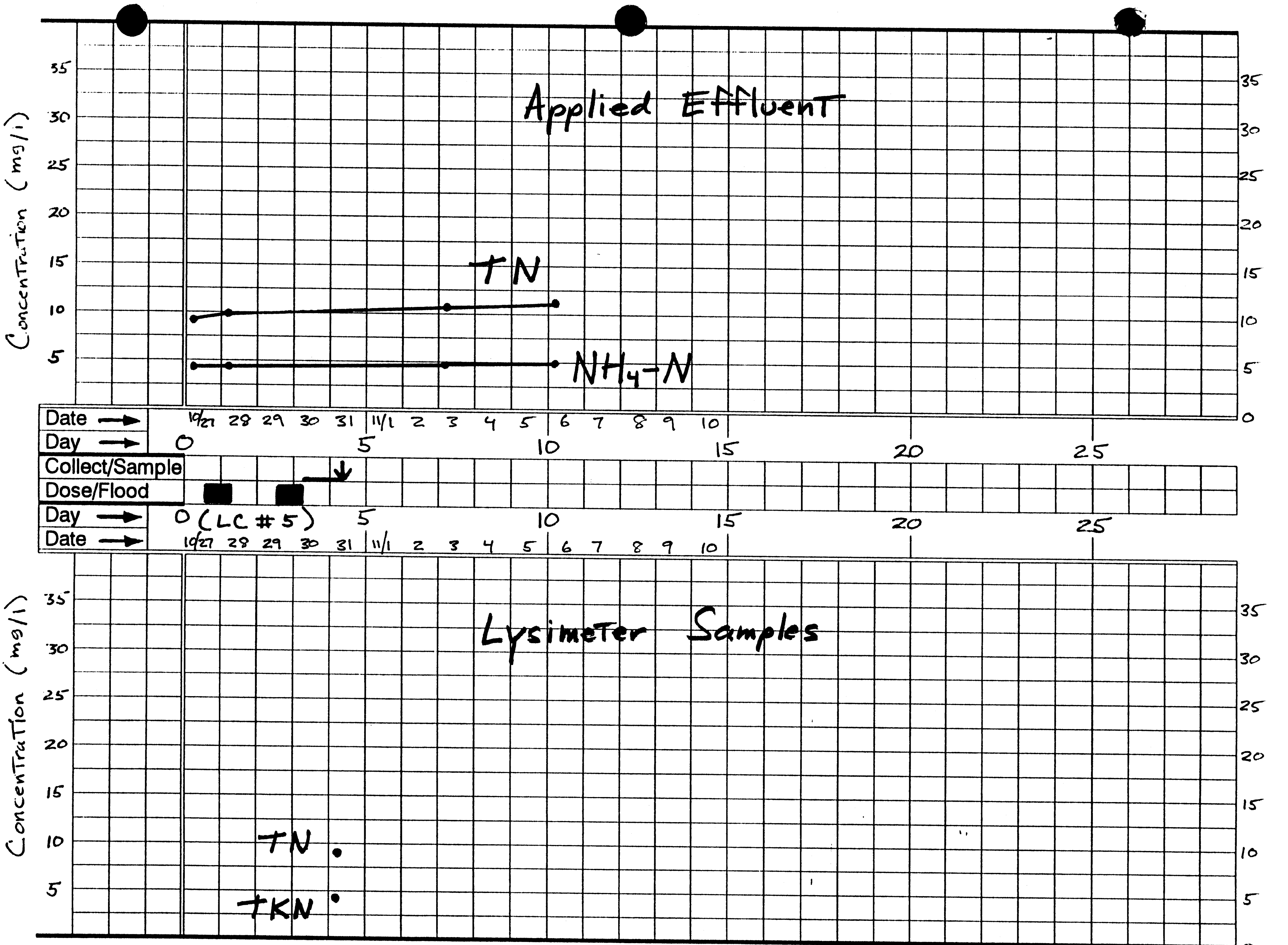
APPENDIX 3



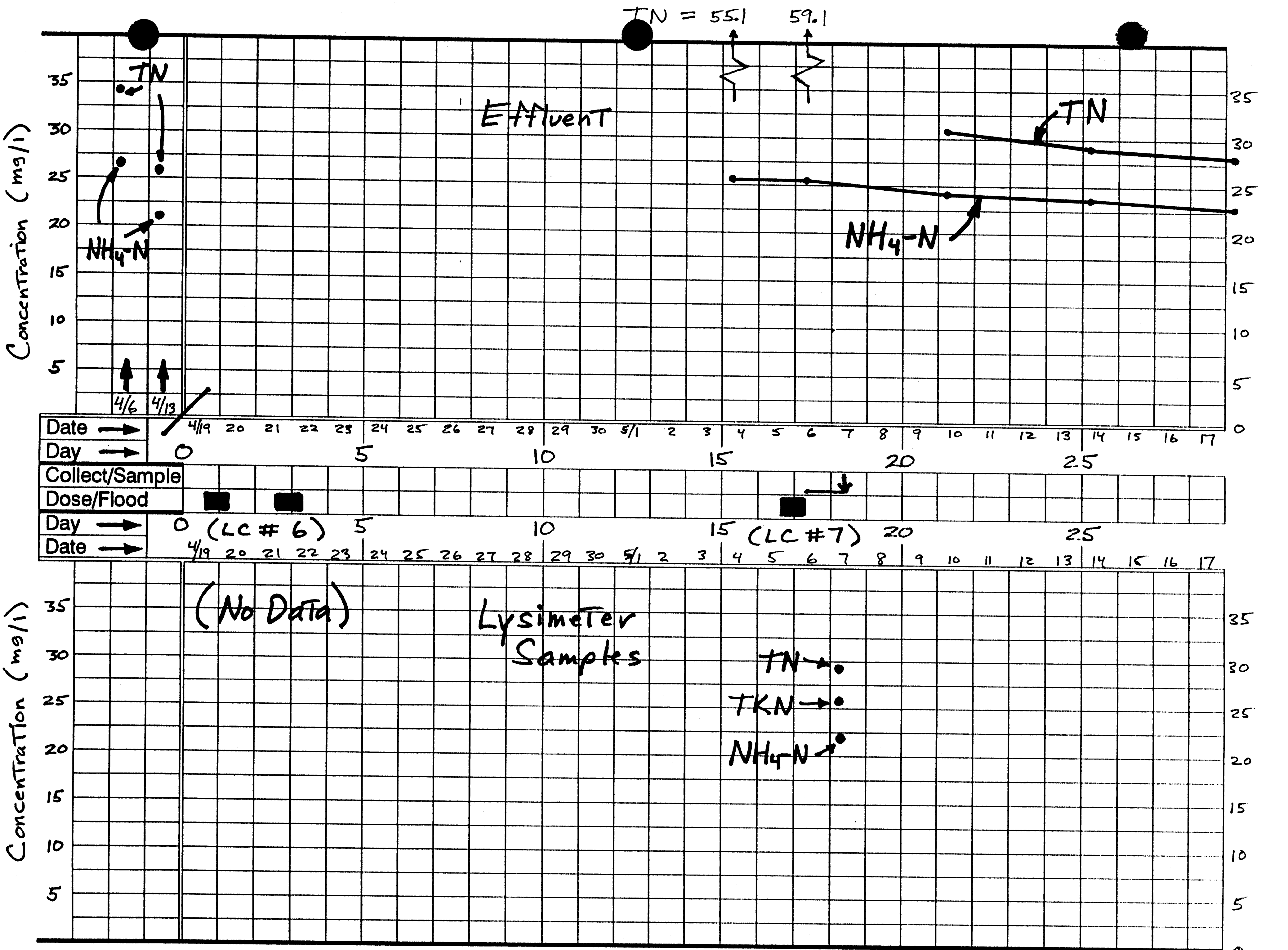
Cell 3 8/25 to 9/20/92



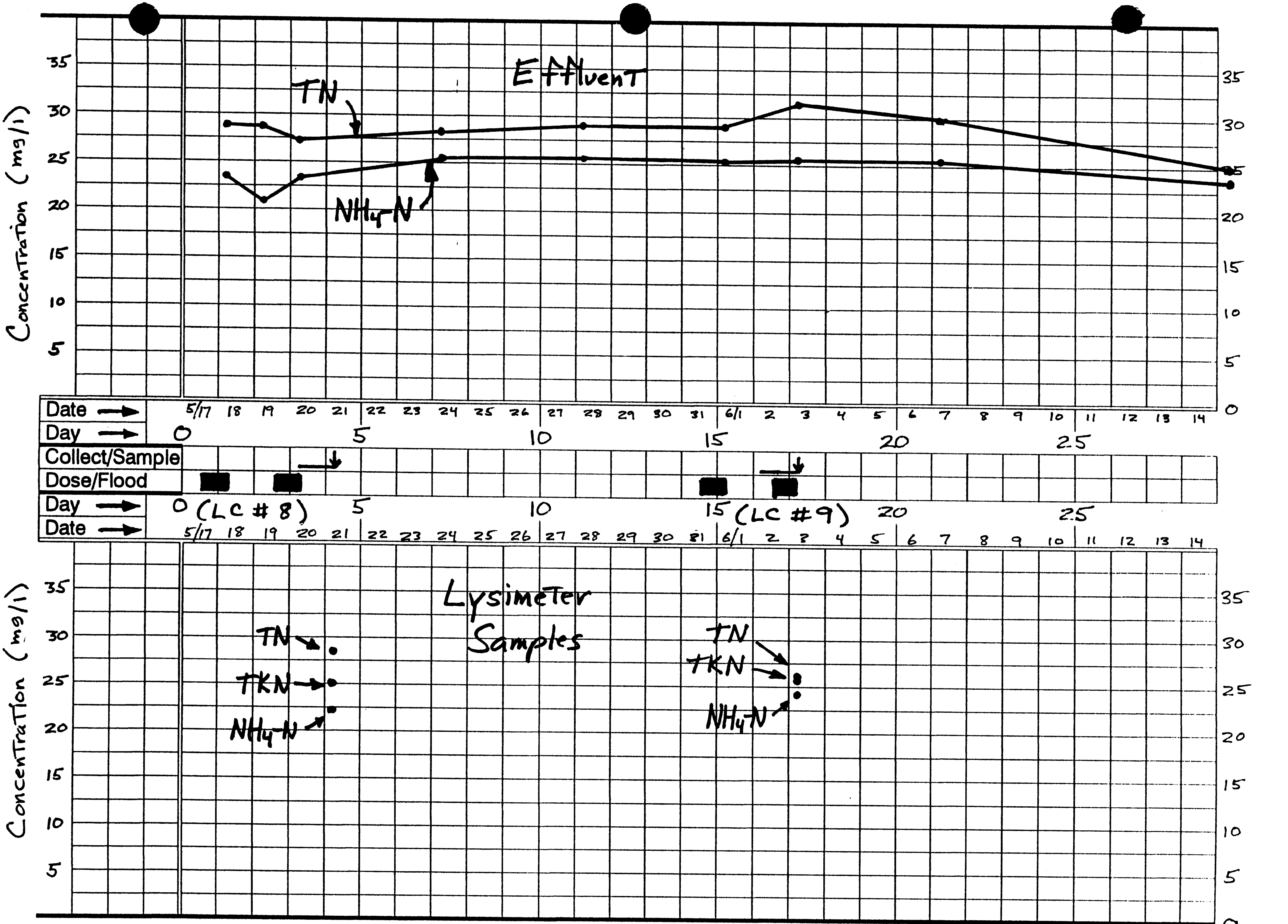
Cell 3 9/21 to 10/19/97



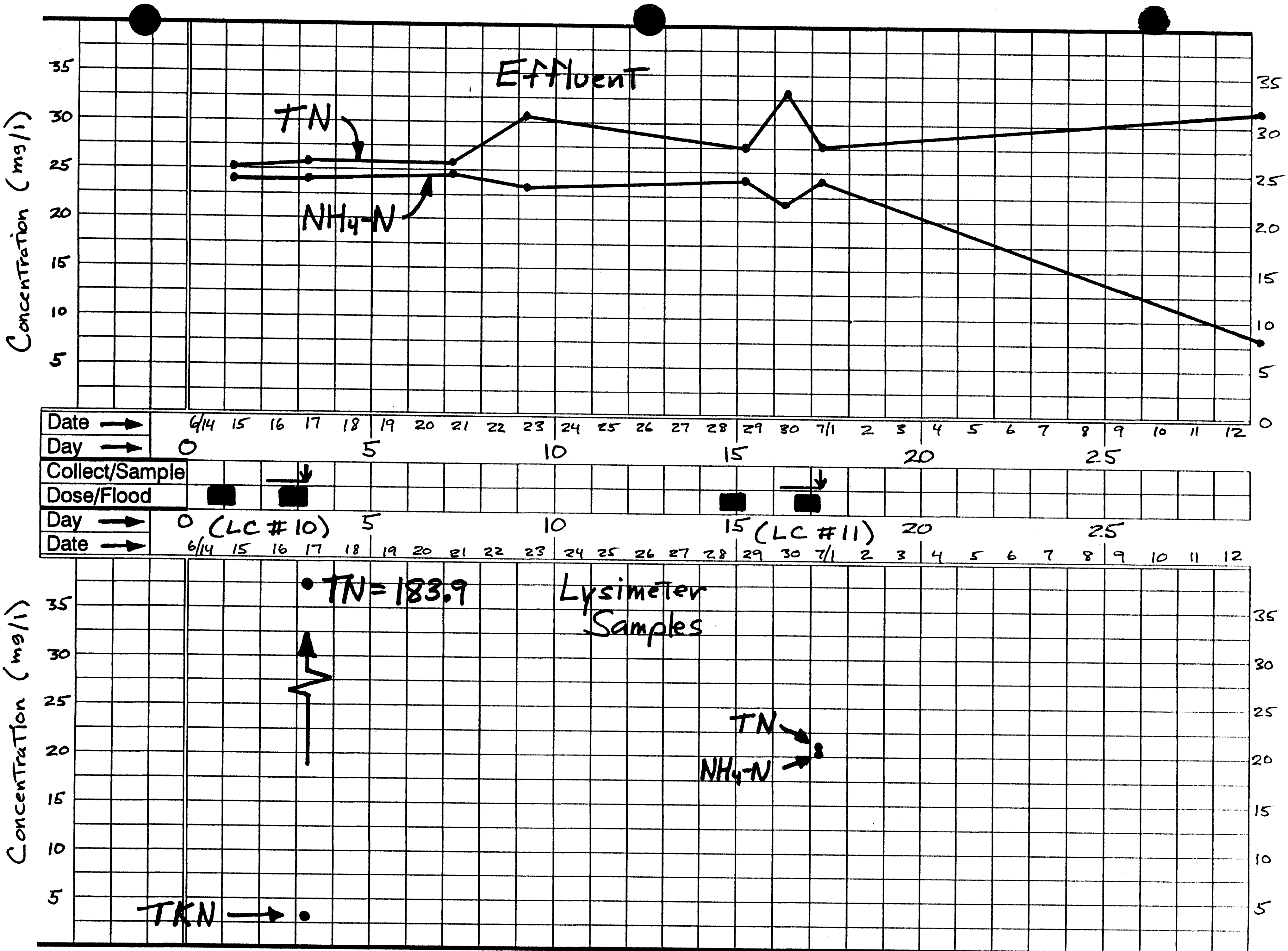
Cell 3 10/27 to END (1997)



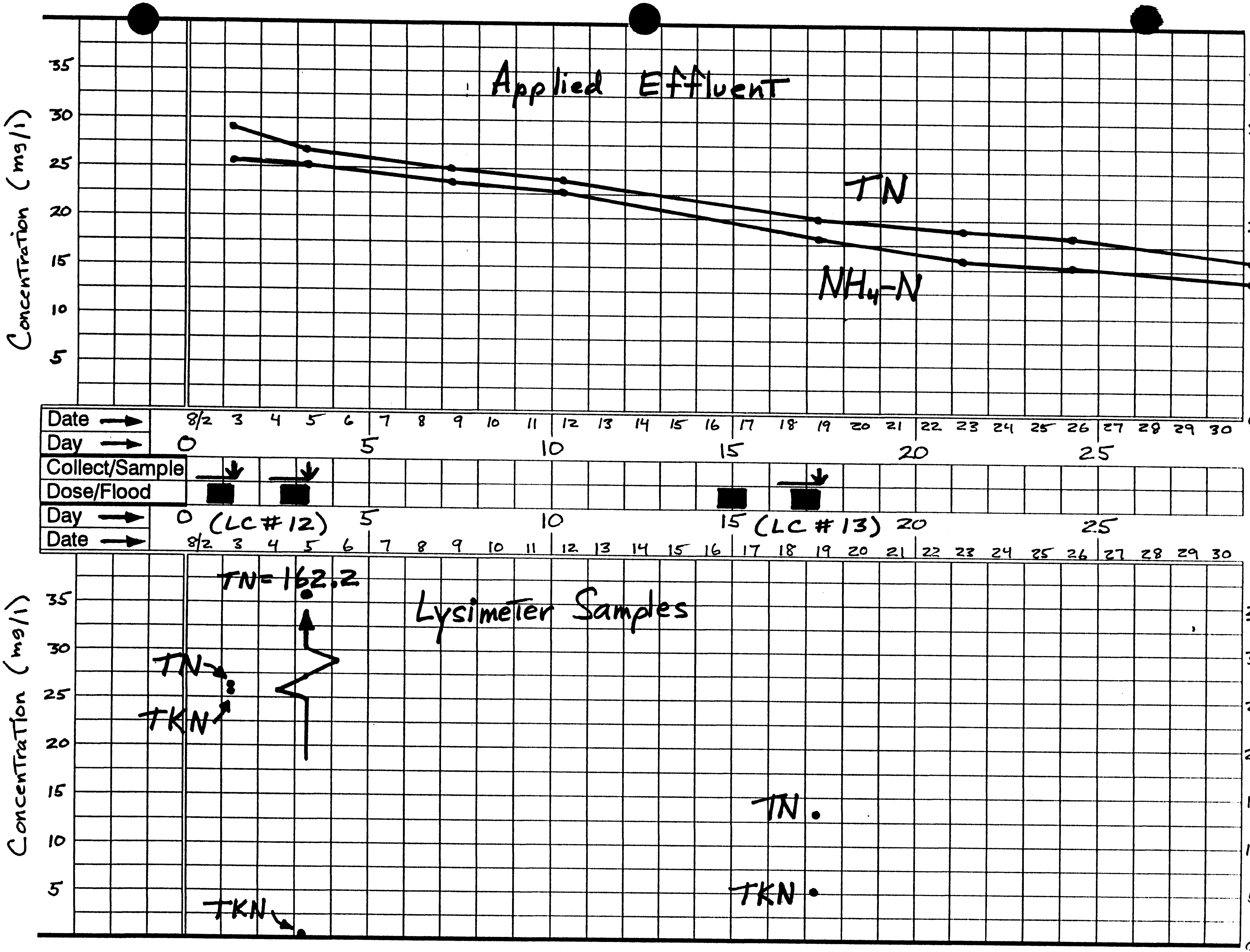
Cell 3 4/19 to 5/16/93



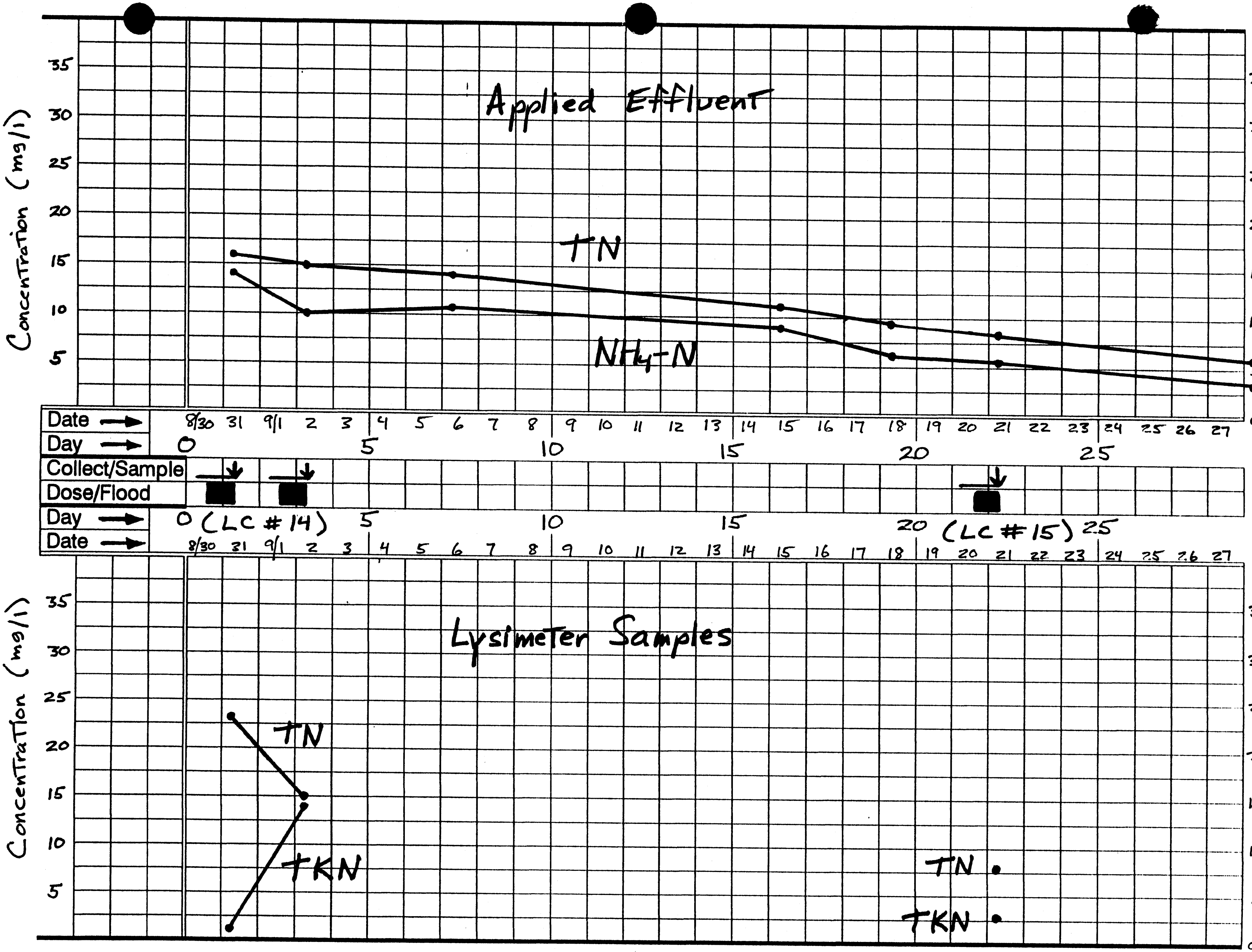
Cell 3 5/17 to 6/13/93



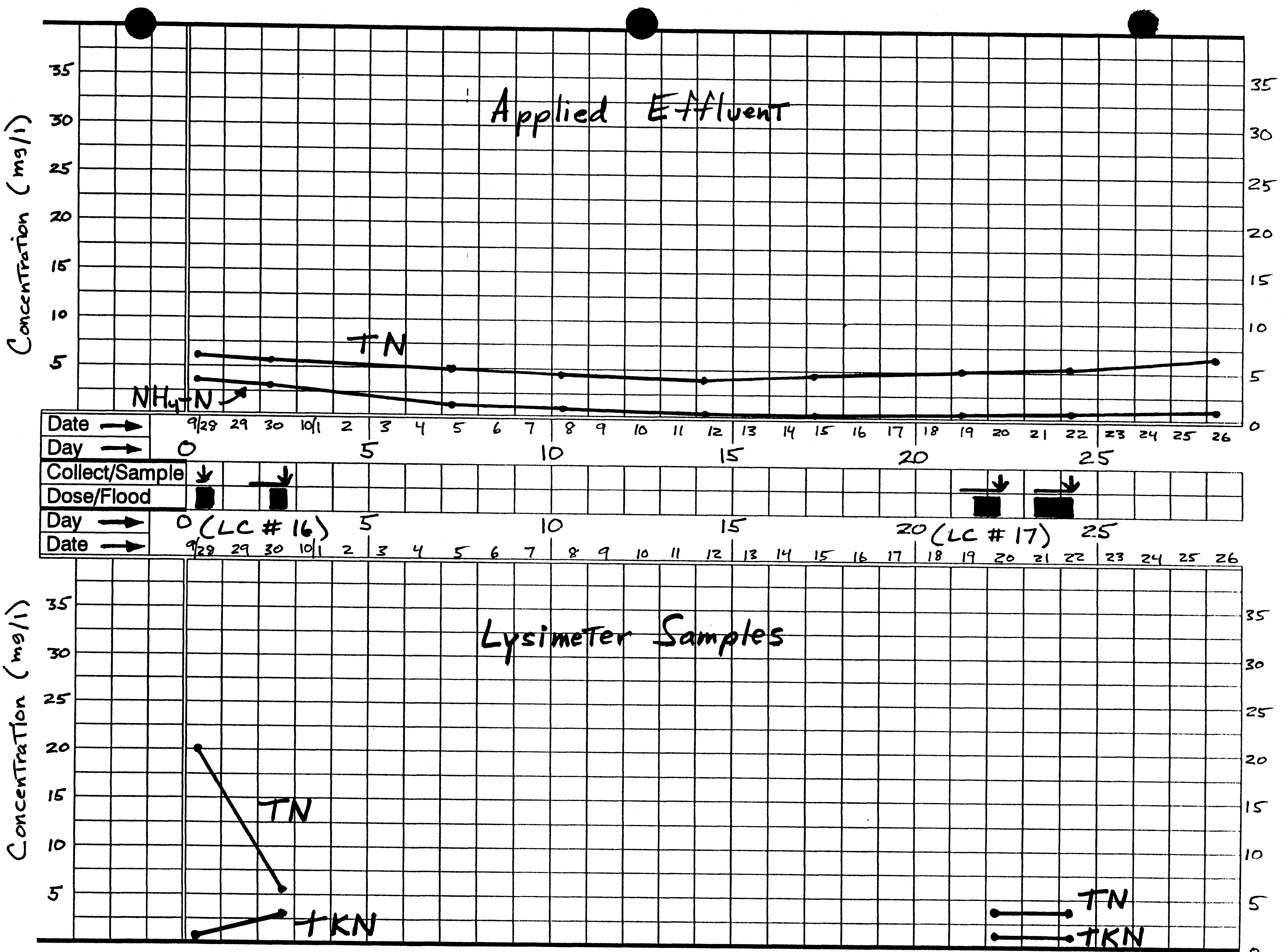
Cell 3 6/14 to 7/12/93



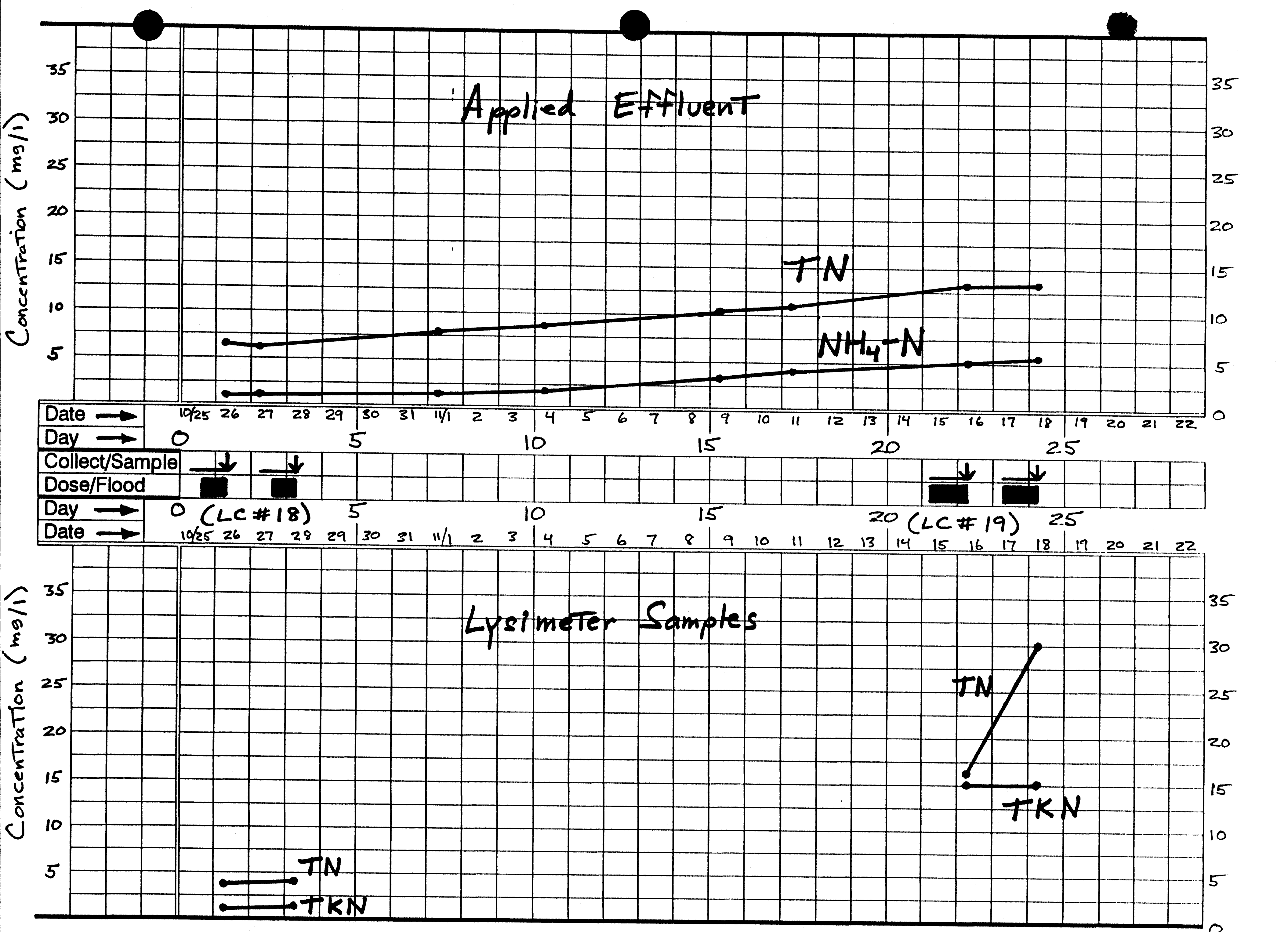
Cell 3 8/2 to 8/29/93



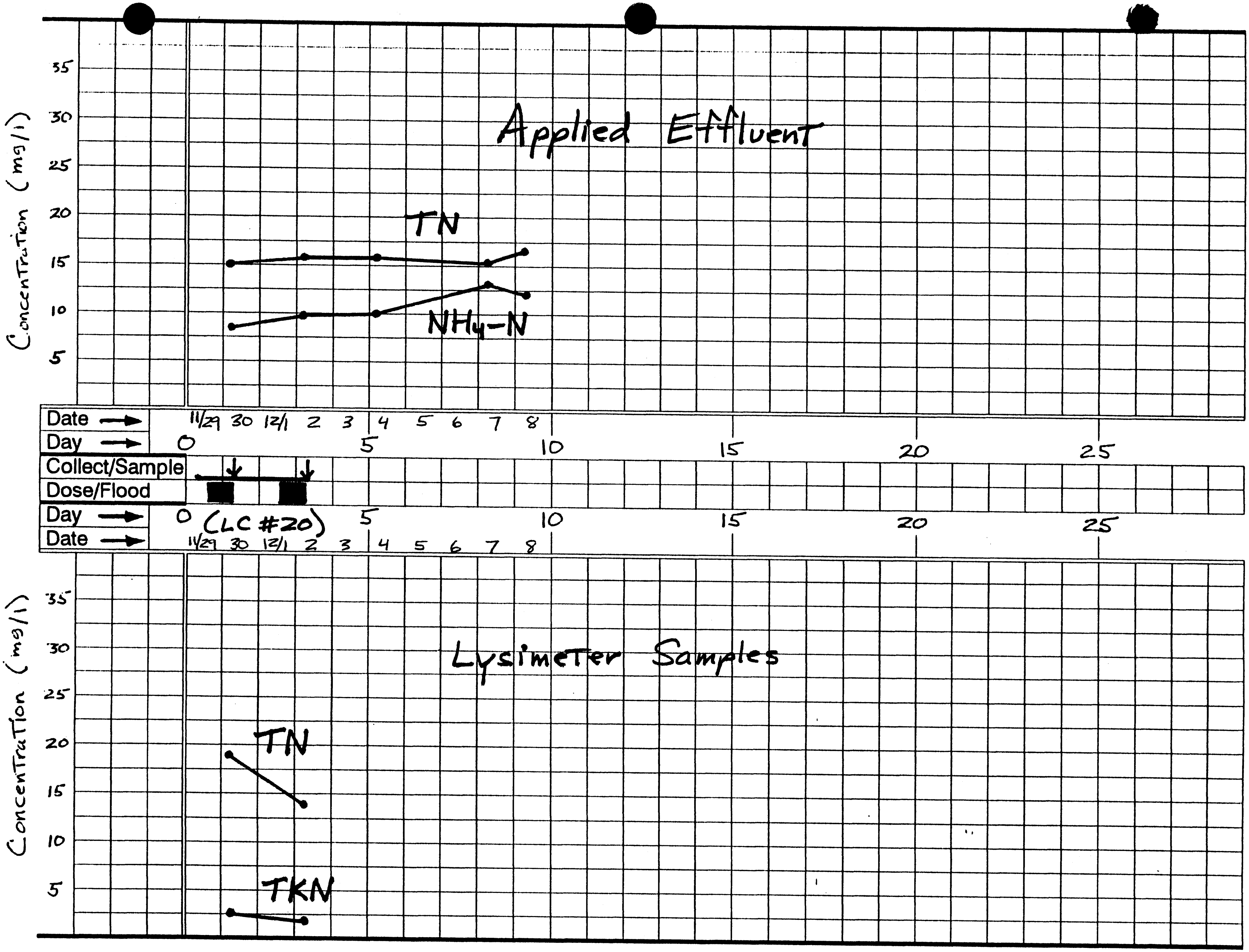
Cell 3 8/30 to 9/27/93



Cell 3 9/28 to 10/24/93



Cell 3 10/25 to 11/22/93



Cell 3 11/29 TO END (1993)

CELL: 3

	DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	TIME OF COLLECTION (DAYS)	TIME FROM DOSE START (DAYS)	SAMPLE SIZE (QT.)	SAMPLE TEMP. (°C)	EFFLUENT TEMP. (°C)	SAMPLE pH (S.U.)	EFFLUENT pH (S.U.)	AVERAGE INFILTRATION RATE (IN./D.)
1992:	1	8-25 TO 9-7	8-28	1	3	12	17.4	18.7	7.6	7.54	>81.9
	2	9-8 TO 9-20	9-11	1	3	12	13.5	15.8	7.53	7.51	>76.0
	3	9-21 TO 10-5	9-25	1	4	12	14.0	14.3	7.40	7.54	>76.0
	4	10-6 TO 10-26	10-10	1	4	12	13.7	13.1	7.44	7.60	>76.5
	5	10-27 TO END	10-31	1	4	12		7.7		7.59	>76.5
1993:	6	4-19 TO 5-4	—	—	—	—	—	—	—	—	>76.3
	7	5-5 TO 5-16	5-7	1	2	12		11.9		7.50	>76.3
	8	5-17 TO 5-30	5-21	1	4	12		13.6		7.35	>76.3
	9	5-31 TO 6-13	6-3	1	3	—		13.1		7.55	>76.3
	10	6-14 TO 6-27	6-17	1	4	12		18.6		7.45	>76.3
	11	6-28 TO 8-1	7-1	1	3	12		19.3		7.50	>76.3
	12	8-2 TO 8-15	8-3	1	1	12		20.2		7.55	>77.7
			8-5	1	3	—	18.1	↓		↓	
	13	8-16 TO 8-29	8-19	1	3	12	22.2	20.2	7.33	7.50	>77.3
	14	8-30 TO 9-19	8-31	1	1	6	18.5	19.2	7.75	7.70	>77.3
			9-2	1	3	12	19.1	↓	7.66	↓	

CELL: 3

DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	TIME OF COLLECTION (DAYS)	TIME FROM DOSE START (DAYS)	SAMPLE SIZE (QT.)	SAMPLE TEMP. (°C)	EFFLUENT TEMP. (°C)	SAMPLE pH (S.U.)	EFFLUENT pH (S.U.)	AVERAGE INFILTRATION RATE (IN/D.)
15	9-20 to 9-27	9-21	1	1	12	15.6	15.9	7.51	7.55	>77.9
16	9-28 to 10-18	9-28	.021	.021	4	12.6	13.2	7.61	7.45	>77.9
		9-30	1	2	9		↓		↓	
17	10-19 to 10-24	10-20	1	1	12	9.6	10.2	7.64	7.70	>56.5
		10-22	1	3	12	9.3	↓	7.73	↓	
18	10-25 to 11-14	10-26	1	1	12	0.0	9.85		7.7	>77.0
		10-28	1	3	12	8.1	↓	7.58	↓	
19	11-15 to 11-28	11-16	1	1	12	4.3	3.45	7.70	7.85	>77.0
		11-18	1	3	12	5.0	↓	7.66	↓	
20	11-29 to END	11-30	1	1	8	2.10	2.75	7.25	7.75	>77.0
		12-2	2	3	12	4.90	↓	7.55	↓	

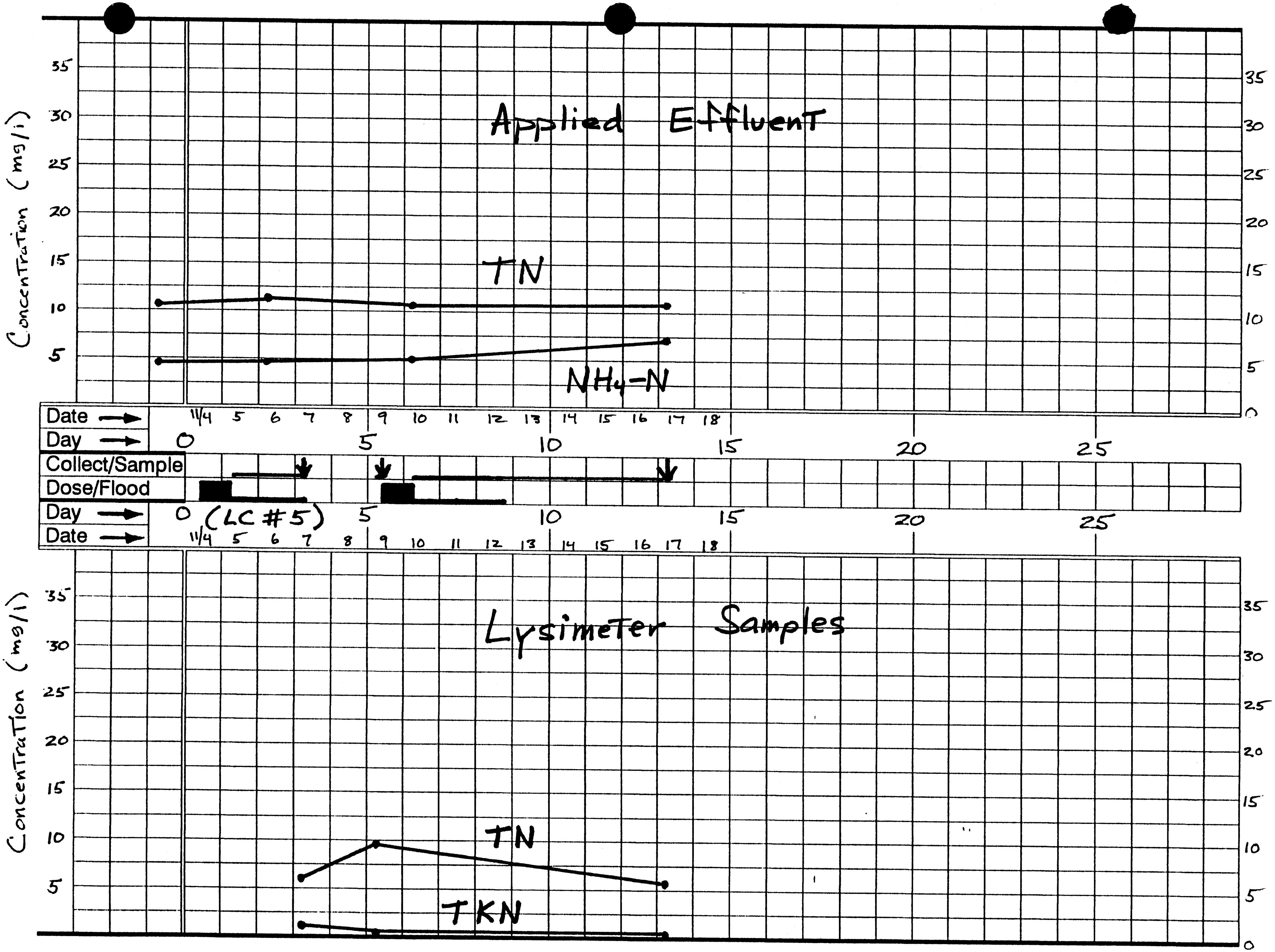
CELL: 3

	DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	APPLIED NH4-N (DOSE AVG.) (mg/l)	APPLIED TN (DOSE AVG.) (mg/l)	DISCHARGED TN PER SAMPLE (mg/l)	DISCHARGED TN (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) %	DISCHARGED NO3-N PER SAMPLE (mg/l)	DISCHARGED NO3-N (DOSE AVG.) (mg/l)
1992:	1	8-25 TO 9-7	8-28	5.42	7.07	6.84	6.84	0.23	3.3	0.84	0.84
	2	9-8 TO 9-20	9-11	5.22	7.23	6.80	6.80	0.43	6.0	1.40	1.40
	3	9-21 TO 10-5	9-25	5.05	8.02	6.89	6.89	1.13	14.1	2.49	2.49
	4	10-6 TO 10-26	10-10	4.56	7.07	7.22	7.22	-0.15	-2.1	3.12	3.12
	5	10-27 TO END	10-31	4.16	9.48	8.78	8.78	0.7	7.4	4.68	4.68
1993:	6	4-19 TO 5-4	—								
	7	5-5 TO 5-16	5-7	25.4	57.1	29.0	29.0	28.1	49.1	3.03	3.03
	8	5-17 TO 5-30	5-21	22.4	27.8	28.5	28.5	-0.8	-2.8	3.54	3.54
	9	5-31 TO 6-13	6-3	25.8	30.6	26.8	26.8	3.8	12.5	0.82	0.82
	10	6-14 TO 6-27	6-17	24.4	25.6	184	184	-158	-618	182	182
	11	6-28 TO 8-1	7-1	22.2	25.5	21.8	21.8	3.7	14.5	0.76	0.76
	12	8-2 TO 8-15	8-3	25.9	28.1	26.7	94.4	-66.4	-236.5	0.68	81.3
			8-5	↓	↓	162.2	↓			162	↓
	13	8-16 TO 8-29	8-19	20.6	22.2	13.1	13.1	9.1	40.9	7.89	7.89
	14	8-30 TO 9-19	8-31	12.2	15.6	22.9	19.0	-3.4	-21.7	21.7	11.4
			9-2	↓	↓	15.1	↓			1.05	↓

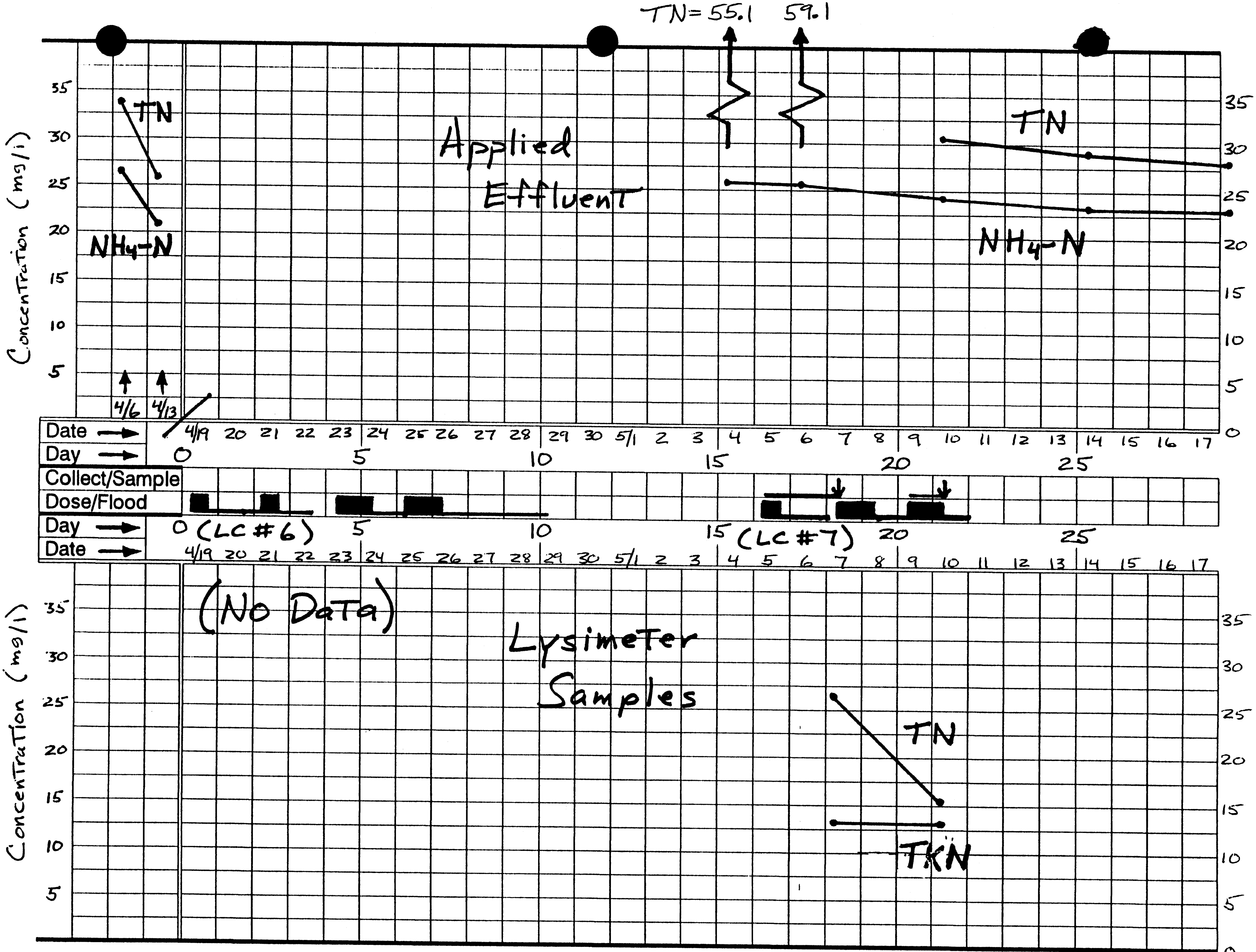
CELL: 3

DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	APPLIED NH4-N (DOSE AVG.) (mg/l)	APPLIED TN (DOSE AVG.) (mg/l)	DISCHARGED TN PER SAMPLE (mg/l)	DISCHARGED TN (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) %	DISCHARGED NO3-N PER SAMPLE (mg/l)	DISCHARGED NO3-N (DOSE AVG.) (mg/l)
15	9-20 TO 9-27	9-21	6.39	9.05	7.8	7.8	1.2	13.8	4.9	4.9
16	9-28 TO 10-18	9-28	3.44	5.93	20.3	13.0	-7.1	-119.0	19.3	11.0
		9-30	↓	↓	5.67	↓			2.67	↓
17	10-19 TO 10-24	10-20	0.88	5.03	3.54	3.56	1.5	29.3	2.04	2.11
		10-22	↓	↓	3.57	↓			2.17	↓
18	10-25 TO 11-14	10-26	1.22	6.23	3.67	3.85	2.38	38.2	2.07	2.21
		10-28	↓	↓	4.04	↓			2.34	↓
19	11-15 TO 11-28	11-16	5.40	13.2	16.7	23.4	-10.2	-77.3	1.73	8.37
		11-18	↓	↓	30.0	↓			15.0	↓
20	11-29 TO END	11-30	9.12	15.5	19.3	16.6	-1.09	-7.03	16.6	14.4
		12-2	↓	↓	13.9				12.1	↓

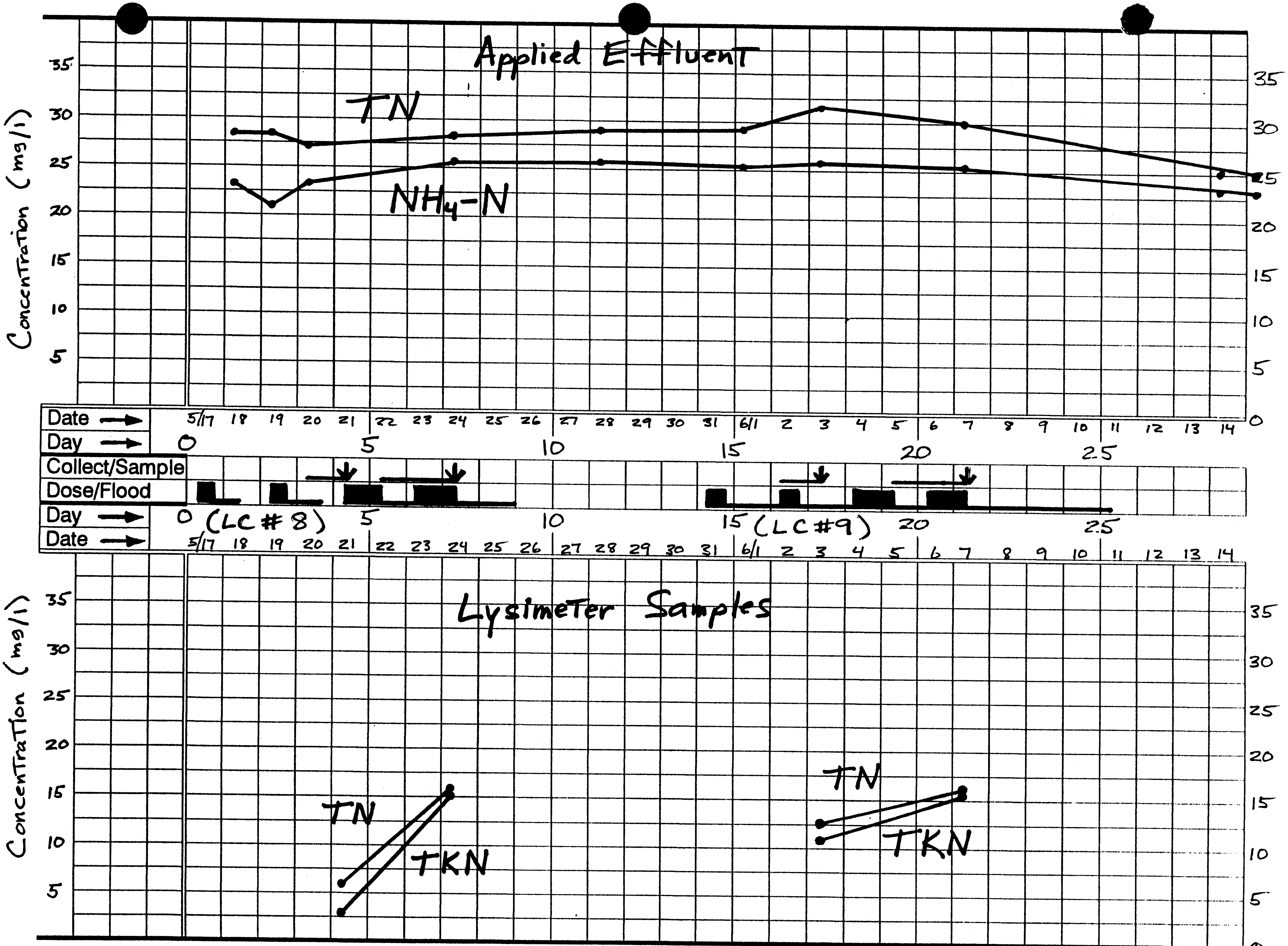
APPENDIX 4



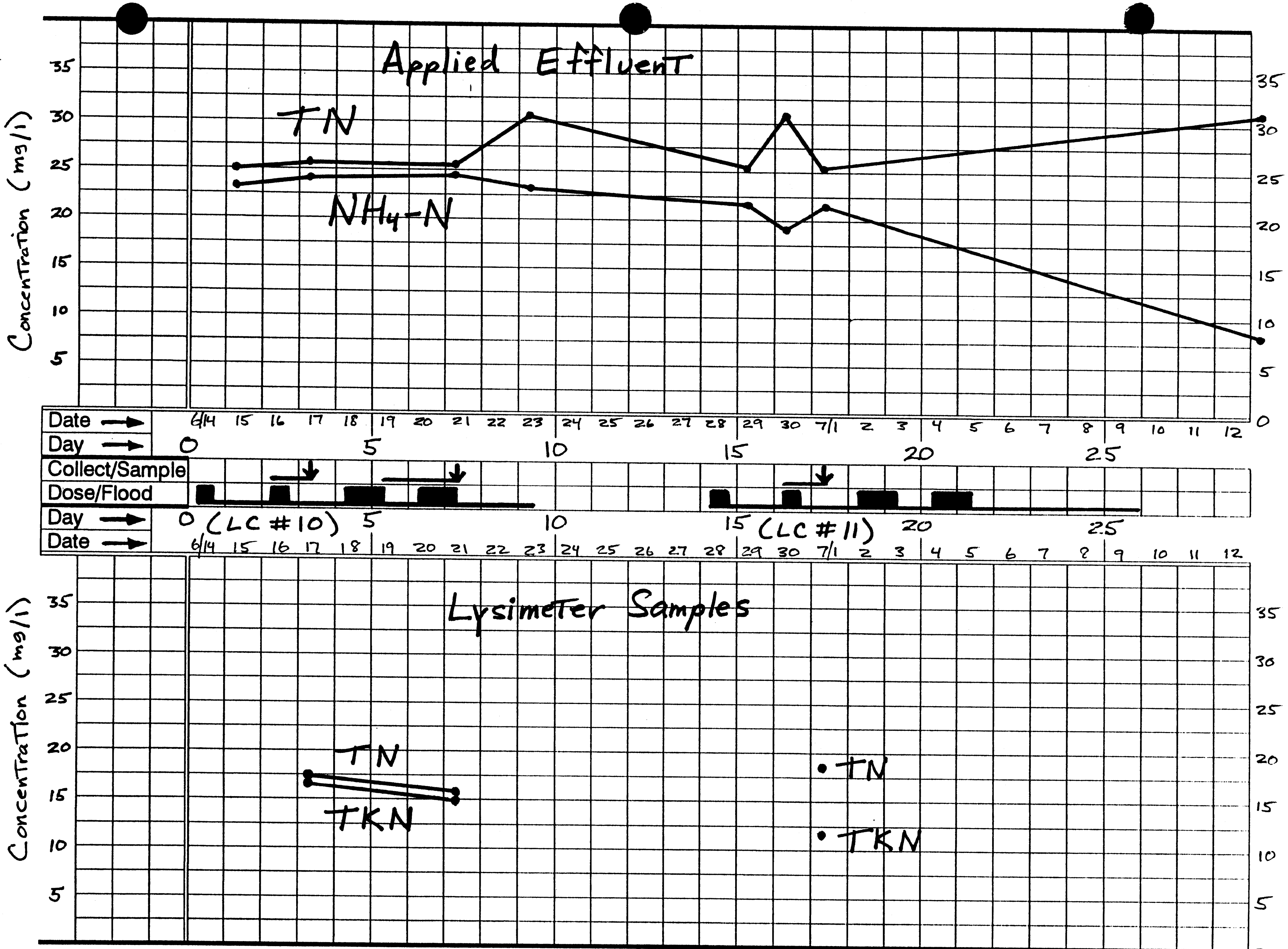
Cell 1 11/4 TO END (1992)



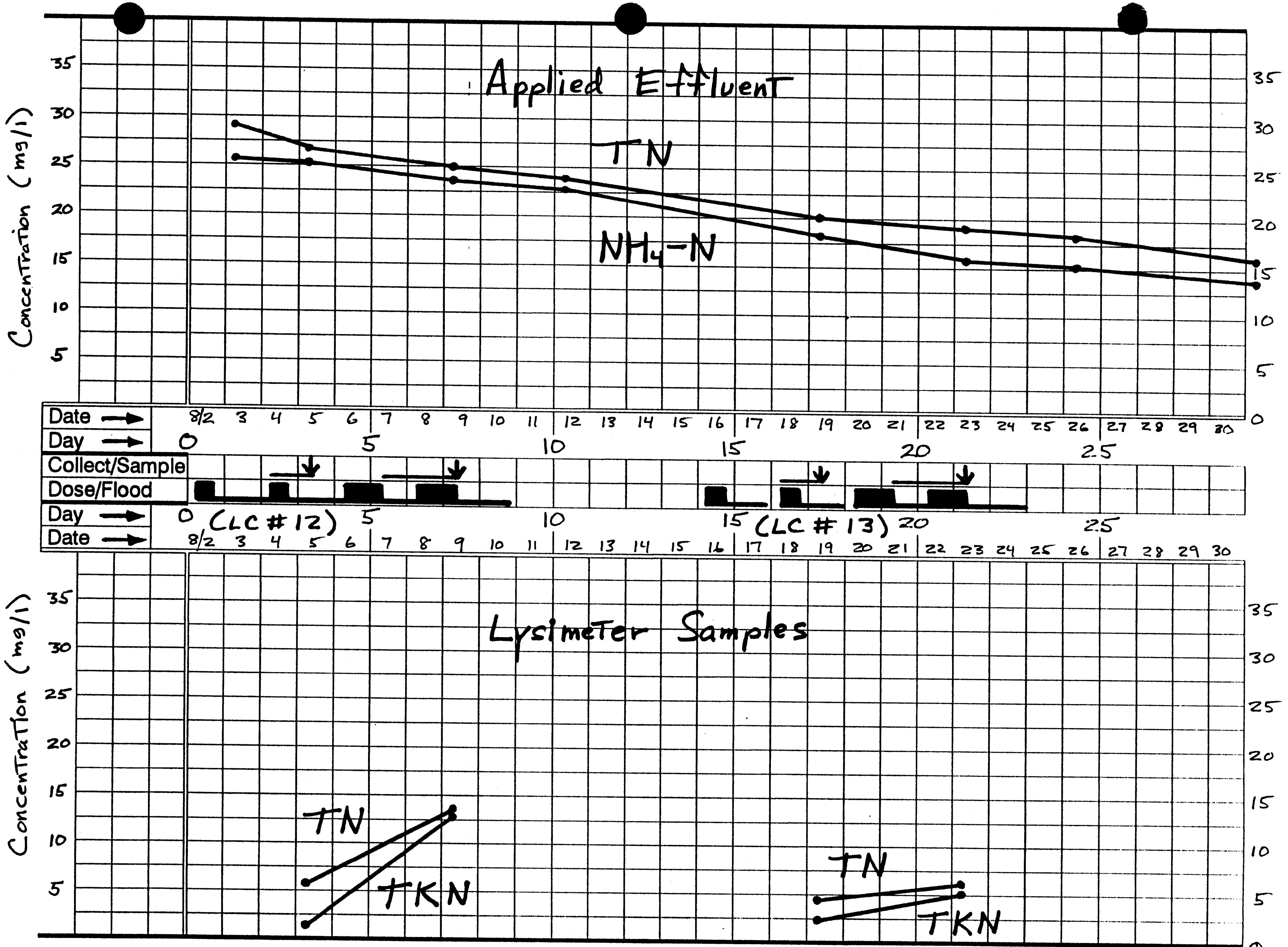
Cell 1 4/19 to 5/16/93



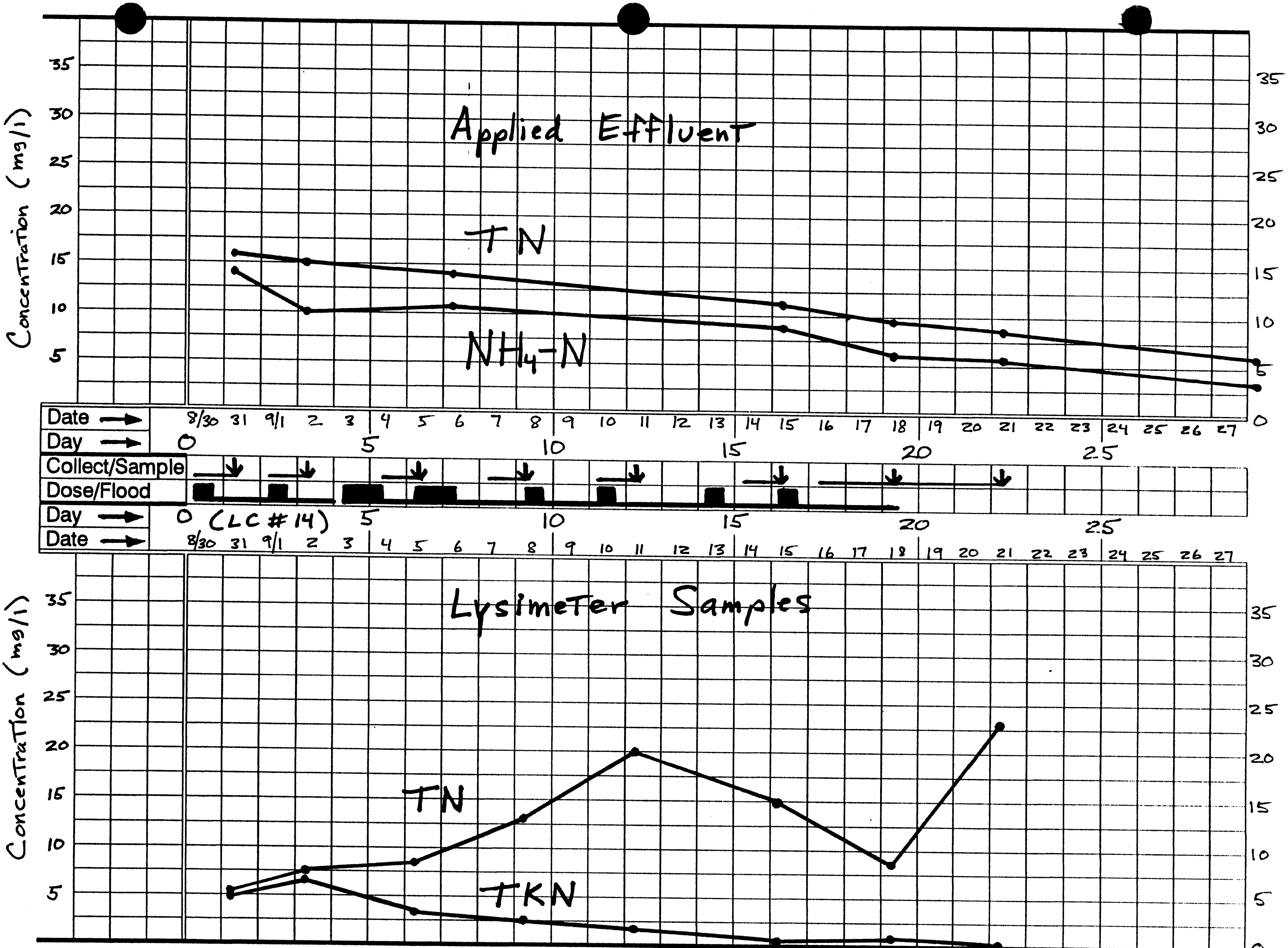
Cell 1 5/17 to 6/13/93



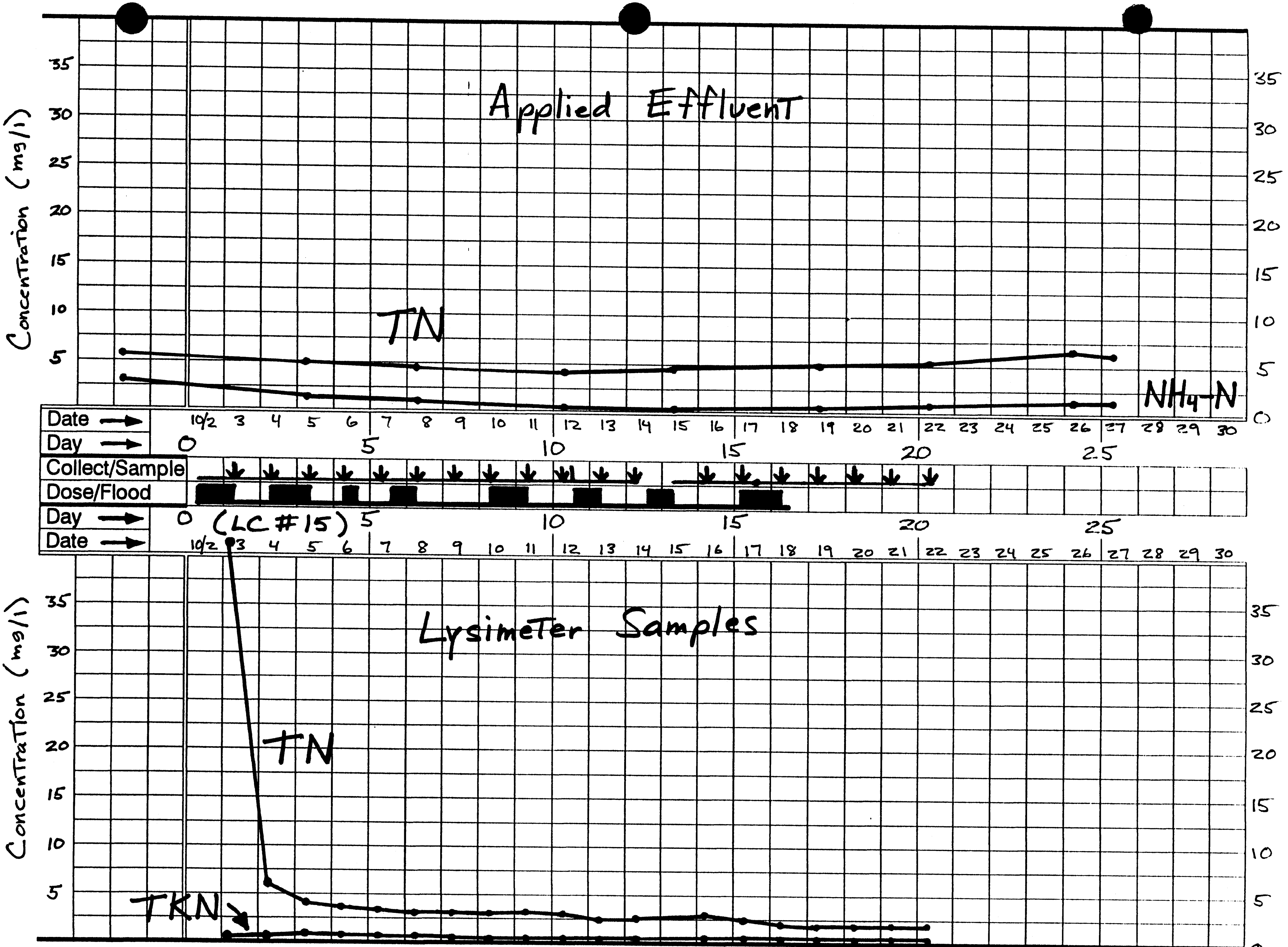
Cell 1 6/14 To 7/12/93



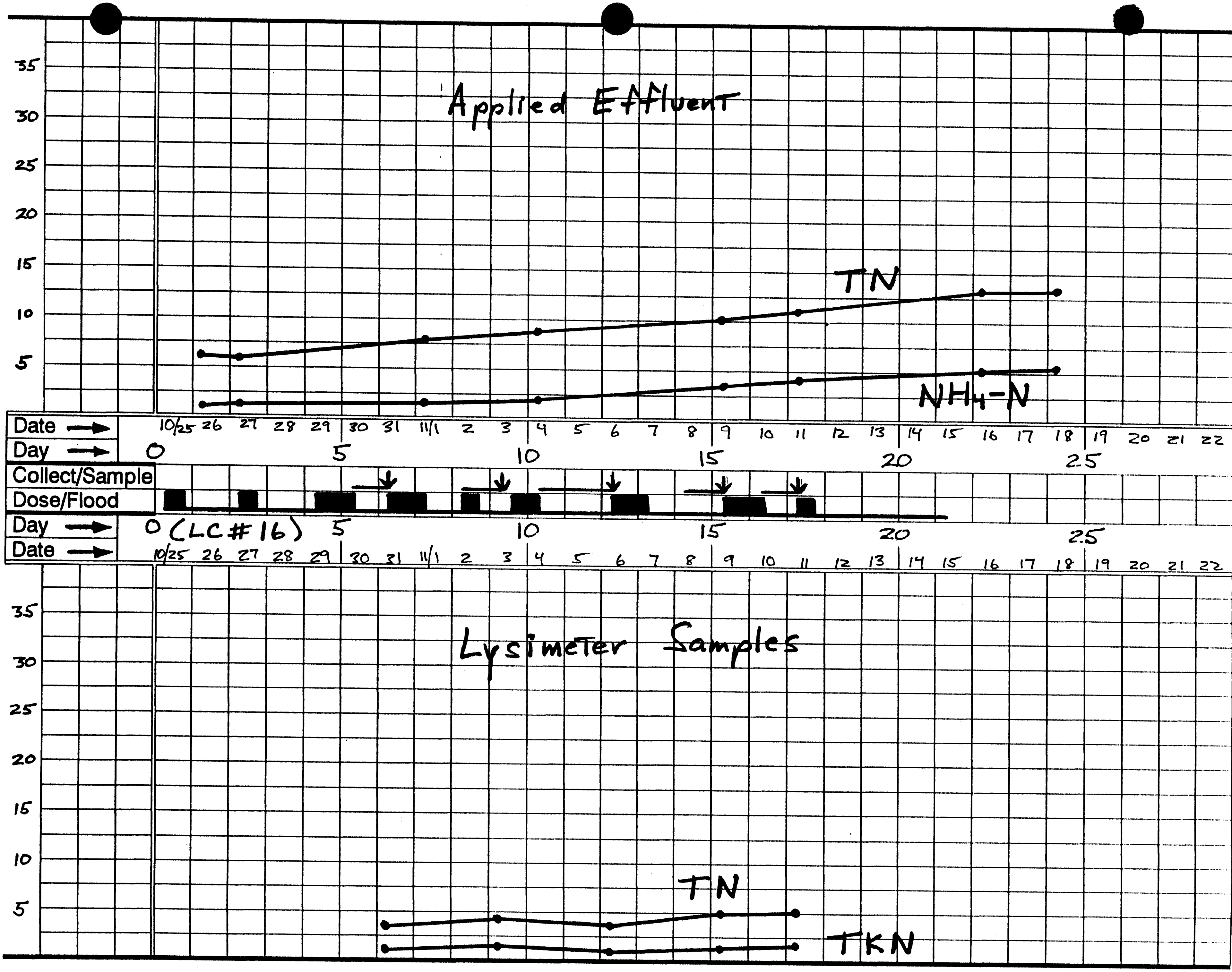
Cell 1 8/2 to 8/29/93



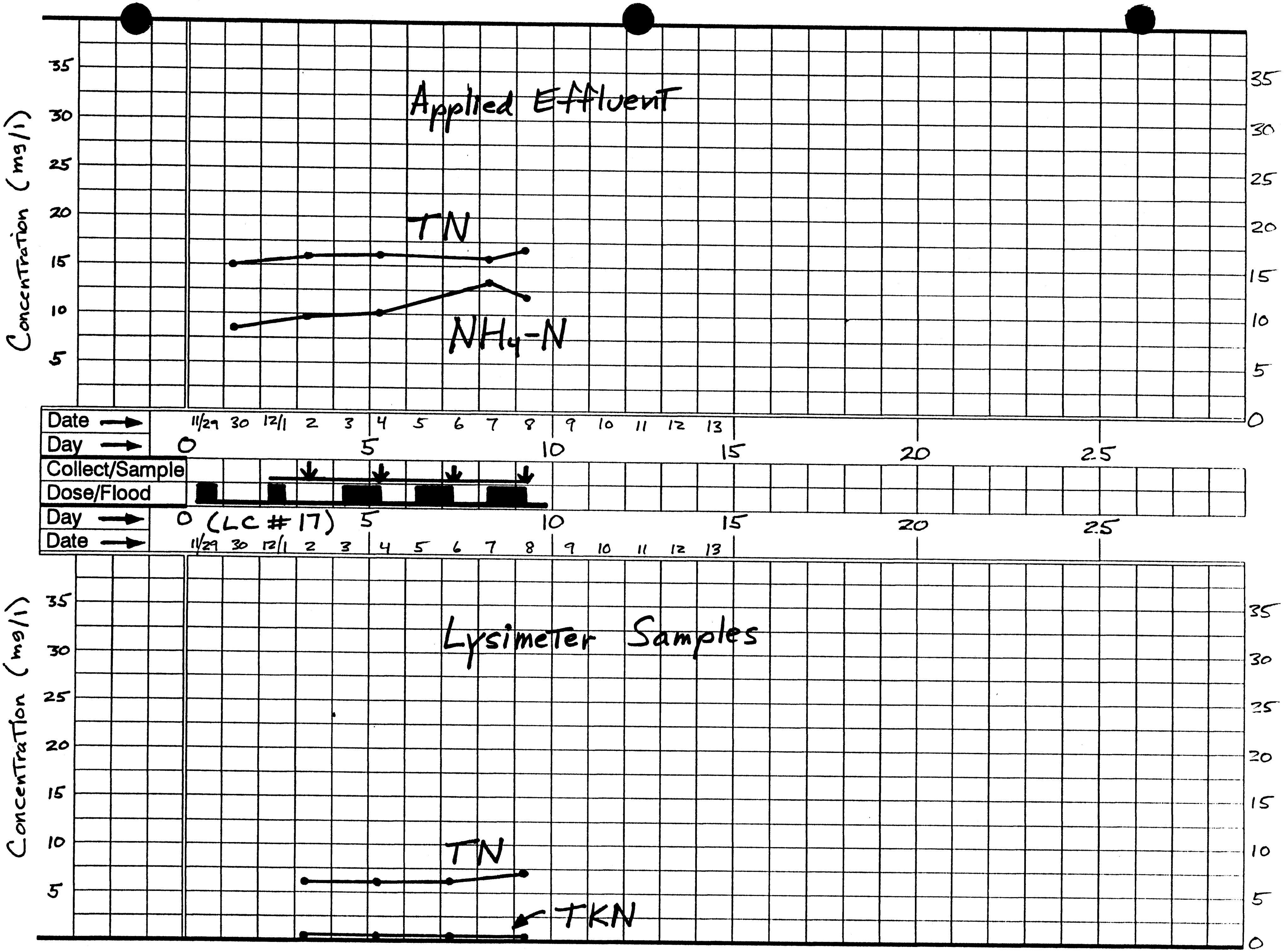
Cell 1 8/30 to 9/27/93



Cell 1 10/7 to 10/24/93



Cell 1 10/25 to 11/22/93



Cell 1 11/29 to END (1993)

CELL: 1

DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	TIME OF COLLECTION (DAYS)	TIME FROM DOSE START (DAYS)	SAMPLE SIZE (QT.)	SAMPLE TEMP. (°C)	EFFLUENT TEMP. (°C)	SAMPLE pH (S.U.)	EFFLUENT pH (S.U.)	AVERAGE INFILTRATION RATE (IN/D.)
	1992:									
1	8-4 TO 9-1	—	—	—	—	—	—	—	—	19.1
2	9-2 TO 9-14	—	—	—	—	—	—	—	—	16.7
3	9-15 TO 9-28	—	—	—	—	—	—	—	—	16.8
4	9-29 TO 11-3	—	—	—	—	—	—	—	—	15.0
5	11-4 TO END	11-7	2	3	0.25	?	4.85	?	7.65	8.68 (?)
		11-9	0.1	5	4.0	?	↓	?	↓	
		11-17	7	13	?	4.0		7.75		
	1993:									
6	4-19 TO 5-4	—								14.7
7	5-5 TO 5-16	5-7	2	2	12.0	?	12.8	?	7.53	19.2
		5-10	1	5	12.0	?	↓	?	↓	
8	5-17 TO 5-30	5-21	1	4	12	?	13.8	?	7.35	17.7
		5-24	2	7	12	?	↓	?	↓	
9	5-31 TO 6-13	6-3	1	3	12	?	13.7	?	7.5	11.9
		6-7	2	7	12	?	↓	?	↓	
10	6-14 TO 6-27	6-17	1	3	12	?	18.2	?	7.43	14.1
		6-21	2	7	12	?	↓	?	↓	
11	6-28 TO 8-1	7-1	1	3	12	?	19.3	?	7.5	11.4
12	8-2 TO 8-15	8-5	1	3	?	19.7	20.2	6.33	7.53	15.6
		8-9	2	7	12	20.3	↓	?	↓	

CELL: 1

DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	TIME OF COLLECTION (DAYS)	TIME FROM DOSE START (DAYS)	SAMPLE SIZE (QT.)	SAMPLE TEMP. (°C)	EFFLUENT TEMP. (°C)	SAMPLE pH (S.U.)	EFFLUENT pH (S.U.)	AVERAGE INFILTRATION RATE (IN/D.)
13	8-16 TO 8-29	8-19	1	3	12	22.5	20.4	6.75	7.43	16.1
		8-23	2	7	12	21.5	↓	7.18	↓	
14	8-30 TO 10-1	8-31	1	1	12	20.5	18.1	6.80	7.62	15.8
		9-2	1	3	11	19.5		7.03		
		9-5	1	6	11	19.5		7.75		
		9-8	1	9	12	16.0		7.15		
		9-11	1	12	?	17.6		7.85		
		9-15	1	16	10	15.6		7.86		
		9-18	2	19	12	15.9		7.17		
		9-21	3	22	11	15.4	↓	7.81	↓	
15	10-2 TO 10-24	10-3	1	1	2	13.1	10.8	7.85	7.63	19.5
		10-4	1	2	12	11.6		6.86		
		10-5	1	3	12	11.7		6.88		
		10-6	1	4	?	10.6		7.24		
		10-7	1	5	?	12.3		7.15		
		10-8	1	6	?	12.9		7.66		
		10-9	1	7	?	10.5		7.44		
		10-10	1	8	?					
		10-11	1	9	12	9.7		7.05		
		10-12	1	10	12	9.0		7.26		
		10-13	1	11	12	9.6		7.17		
		10-14	1	12	12	8.6		7.25		
		10-16	1	14	12	8.6		7.61		
		10-17	1	15	12	8.7		7.63		
		10-18	1	16	12	9.3		7.30		
		10-19	1	17	?	10.6		7.26		
		10-20	1	18	12	8.1		7.40		
		10-21	1	19	12	11.6		7.84		
		10-22	1	20	12	9.1	↓	7.84	↓	

CELL: 1

DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	TIME OF COLLECTION (DAYS)	TIME FROM DOSE START (DAYS)	SAMPLE SIZE (QT.)	SAMPLE TEMP. (°C)	EFFLUENT TEMP. (°C)	SAMPLE pH (S.U.)	EFFLUENT pH (S.U.)	AVERAGE INFILTRATION RATE (IN/D.)
16	10-25 TO 11-28	10-31	1	6	12	7.7	6.87	7.58	7.85	14.2
		11-3	1	9	?	4.5	↓	7.80	↓	
		11-6	2	12	?	3.6	↓	7.83	↓	
		11-9	1	15	12	4.5	↓	7.05	↓	
		11-11	1	17	12	5.7	↓	7.09	↓	
17	11-29 TO END	12-2	1	3	4	5.0	3.2	8.25	7.78	17.0
		12-4	2	5	3	1.5	↓	7.87	↓	
		12-6	2	7	?	3.6	↓	8.13	↓	
		12-8	2	9	0.5	4.8	↓	7.77	↓	

CELL: 1

DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	APPLIED NH4-N (DOSE AVG.) (mg/l)	APPLIED TN (DOSE AVG.) (mg/l)	DISCHARGED TN PER SAMPLE (mg/l)	DISCHARGED TN (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) %	DISCHARGED NO3-N PER SAMPLE (mg/l)	DISCHARGED NO3-N (DOSE AVG.) (mg/l)
	1992:									
1	8-4 TO 9-1	—								
2	9-2 TO 9-14	—								
3	9-15 TO 9-28	—								
4	9-29 TO 11-3	—								
5	11-4 TO END	11-7	4.88	11.2	5.88	7.14	4.04	36.1	4.68	6.60
		11-9	↓	↓	9.56	↓			9.53	↓
		11-17			5.99				5.59	
	1993:									
6	4-19 TO 5-4	—								
7	5-5 TO 5-16	5-7	25.1	48.4	26.8	21.1	27.3	56.4	13.8	8.12
		5-10	↓	↓	15.4	↓			2.44	↓
8	5-17 TO 5-30	5-21	24.0	28.2	6.43	11.2	17.0	60.3	3.63	1.85
		5-24	↓	↓	16.1	↓			0.06	↓
9	5-31 TO 6-13	6-3	25.9	30.1	12.7	14.7	15.4	51.1	1.74	1.23
		6-7	↓	↓	16.7	↓			0.72	↓
10	6-14 TO 6-27	6-17	24.5	25.8	17.1	16.6	9.1	35.5	0.15	0.62
		6-21	↓	↓	16.1	↓			1.08	↓
11	6-28 TO 8-1	7-1	21.1	27.4	18.5	18.5	9.0	32.7	6.48	6.48
12	8-2 TO 8-15	8-5	25.2	27.1	5.95	9.76	17.3	64.0	4.15	2.36
		8-9	↓	↓	13.6				0.57	↓

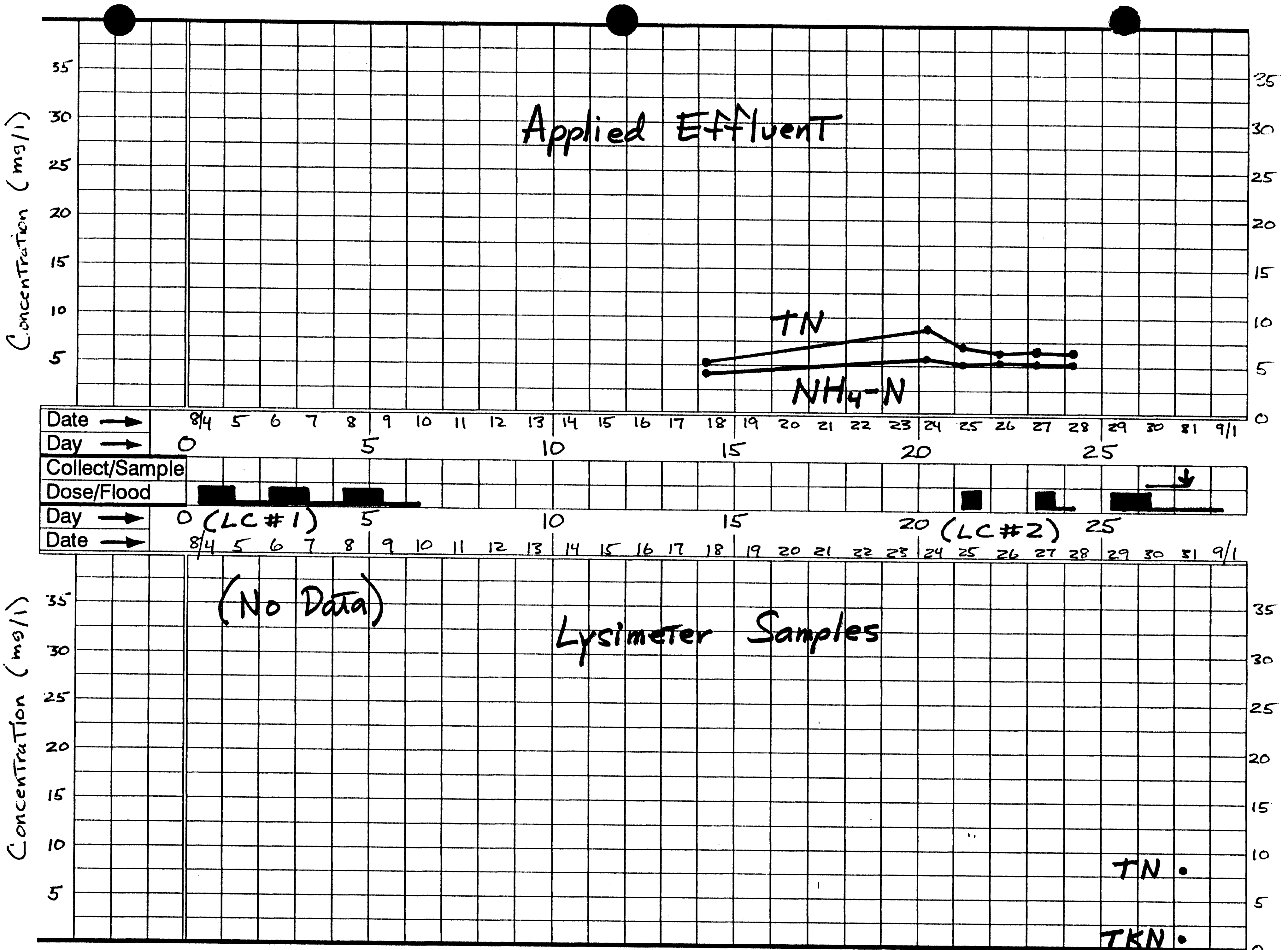
CELL: 1

DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	APPLIED NH4-N (DOSE AVG.) (mg/l)	APPLIED TN (DOSE AVG.) (mg/l)	DISCHARGED TN PER SAMPLE (mg/l)	DISCHARGED TN (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) %	DISCHARGED NO3-N PER SAMPLE (mg/l)	DISCHARGED NO3-N (DOSE AVG.) (mg/l)
13	8-16 TO 8-29	8-19	19.1	21.1	4.44	5.46	15.7	74.1	2.14	1.61
		8-23	↓	↓	6.48	↓			1.08	↓
14	8-30 TO 10/1	8-31	11.2	14.2	5.37	12.6	1.6	11.3	0.37	9.94
		9-2	↓	↓	7.53	↓			0.93	↓
		9-5			8.45				5.05	
		9-8			13.0				10.5	
		9-11			20.3				18.4	
		9-15			14.8				14.0	
		9-18			8.44				7.34	
		9-21			23.0				22.9	
15	10-2 TO 10-24	10-3	1.35	4.77	42.0	5.03	-0.3	-5.5	41.2	4.3
		10-4	↓	↓	6.54	↓			5.74	↓
		10-5			4.04				3.04	
		10-6			3.73				2.83	
		10-7			3.29				2.39	
		10-8			2.94				2.14	
		10-9			2.98				2.38	
		10-10			3.08				2.38	
		10-11			3.40				2.80	
		10-12			2.86				2.26	
		10-13			2.36				1.76	
		10-14			2.62				1.82	
		10-16			2.73				1.83	
		10-17			2.45				1.65	
		10-18			2.35				1.45	
		10-19			2.11				1.41	
		10-20			2.04				1.34	
		10-21			1.96				1.36	
		10-22			2.07				1.47	

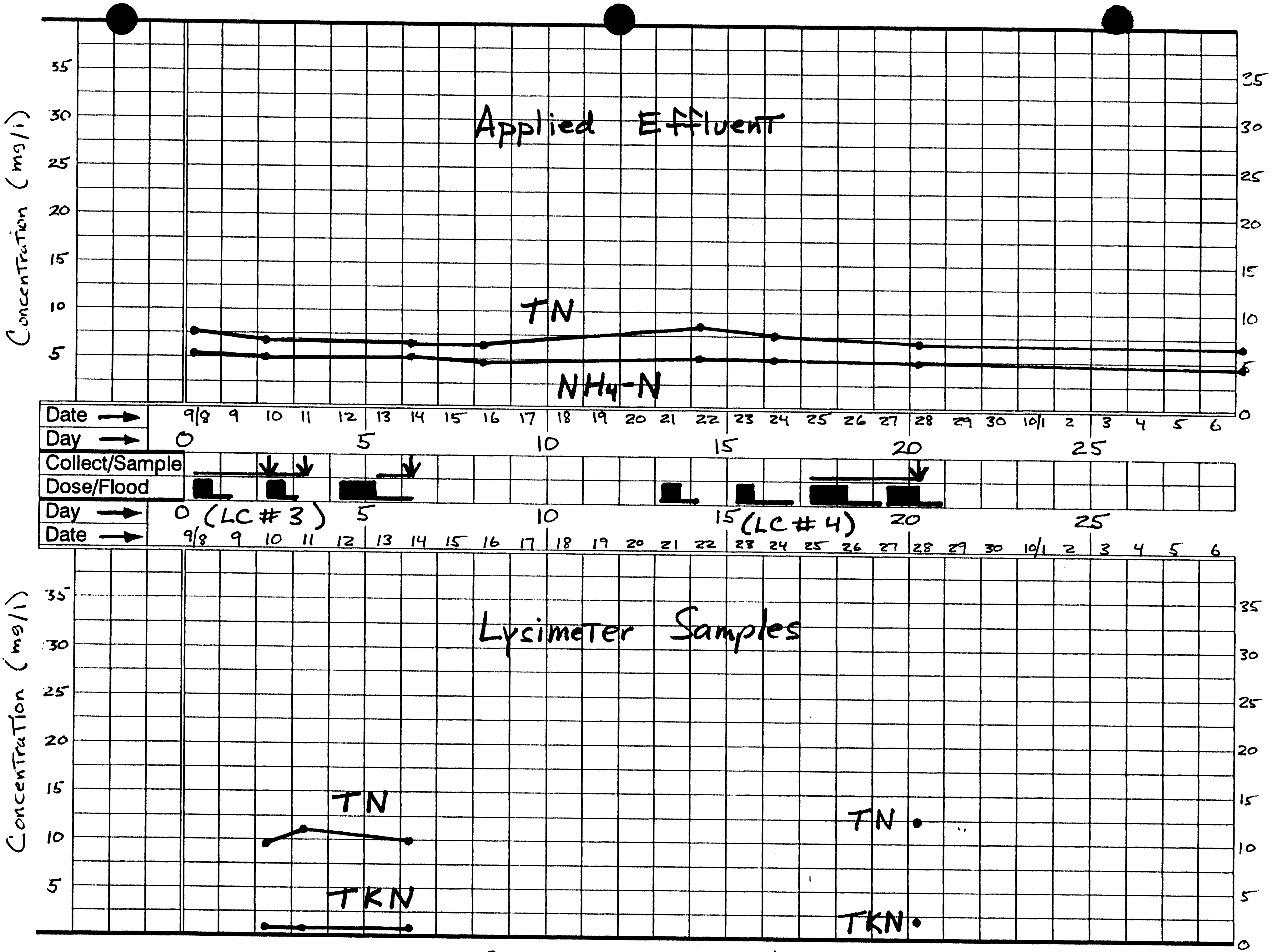
CELL: 1

DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	APPLIED NH4-N (DOSE AVG.) (mg/l)	APPLIED TN (DOSE AVG.) (mg/l)	DISCHARGED TN PER SAMPLE (mg/l)	DISCHARGED TN (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) %	DISCHARGED NO3-N PER SAMPLE (mg/l)	DISCHARGED NO3-N (DOSE AVG.) (mg/l)
16	10-25 TO 11-28	10-31	2.12	7.90	3.33	4.25	3.6	46.1	2.23	2.81
		11-3	↓	↓	4.26	↓			2.56	↓
		11-6			3.64				2.64	
		11-9			4.93				3.43	
		11-11			5.10				3.20	
17	11-29 TO END	12-2	10.7	15.9	6.31	6.64	9.3	58.2	5.71	6.04
		12-4	↓	↓	6.39	↓			5.79	↓
		12-6			6.61				6.01	
		12-8			7.24				6.64	

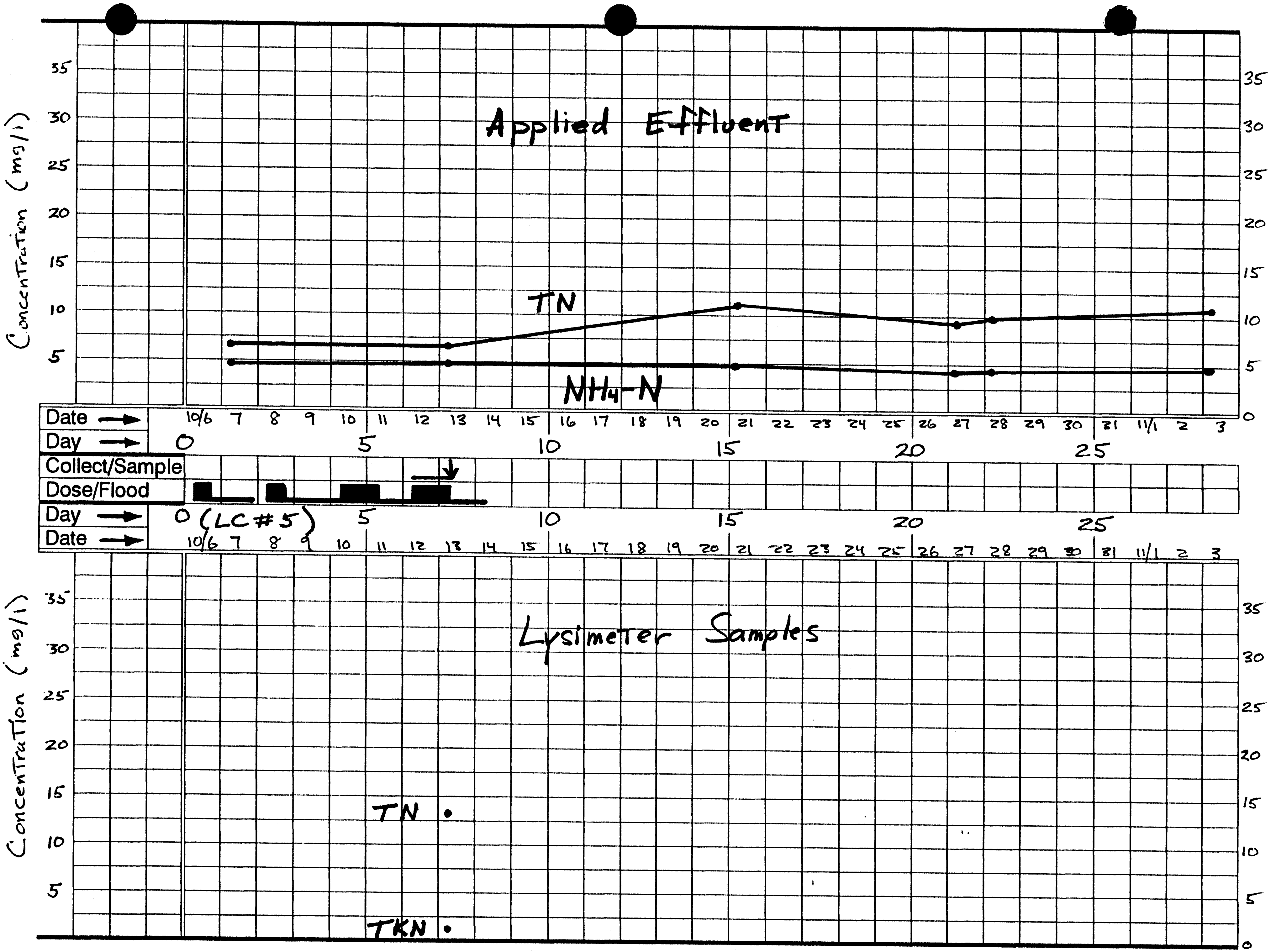
APPENDIX 5



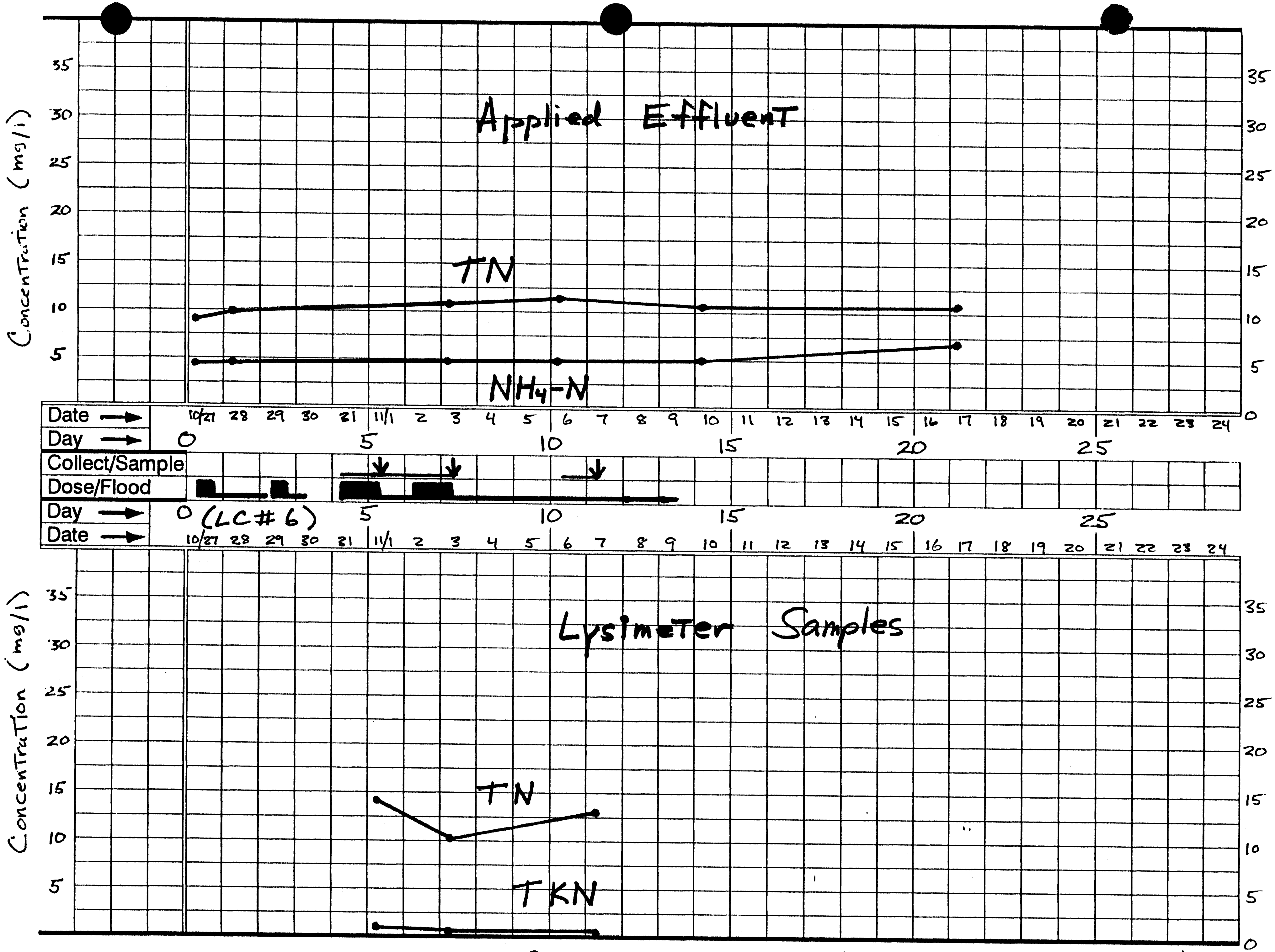
Cell 7 8/4 to 9/1/92



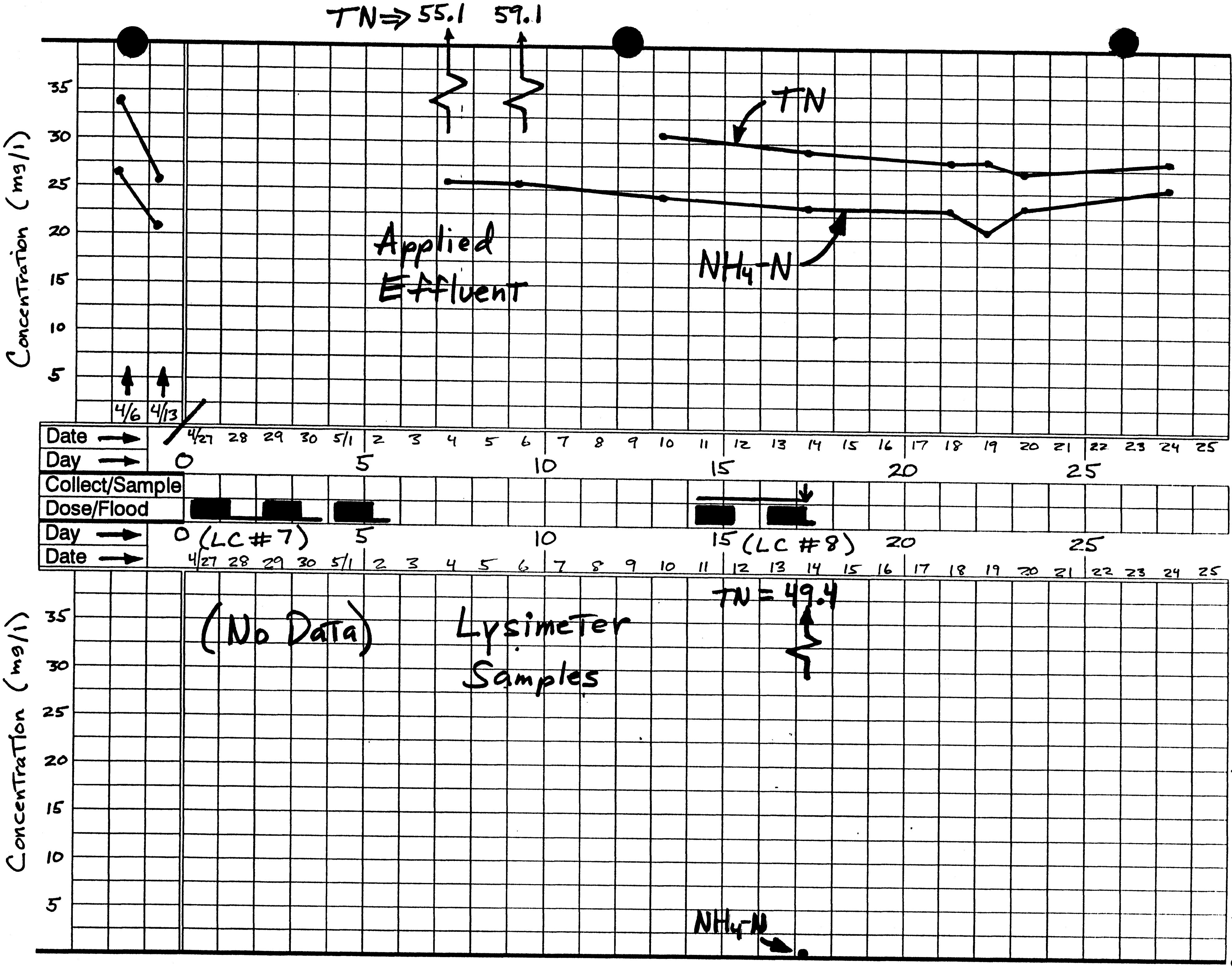
Cell 7 9/8 to 10/5/97



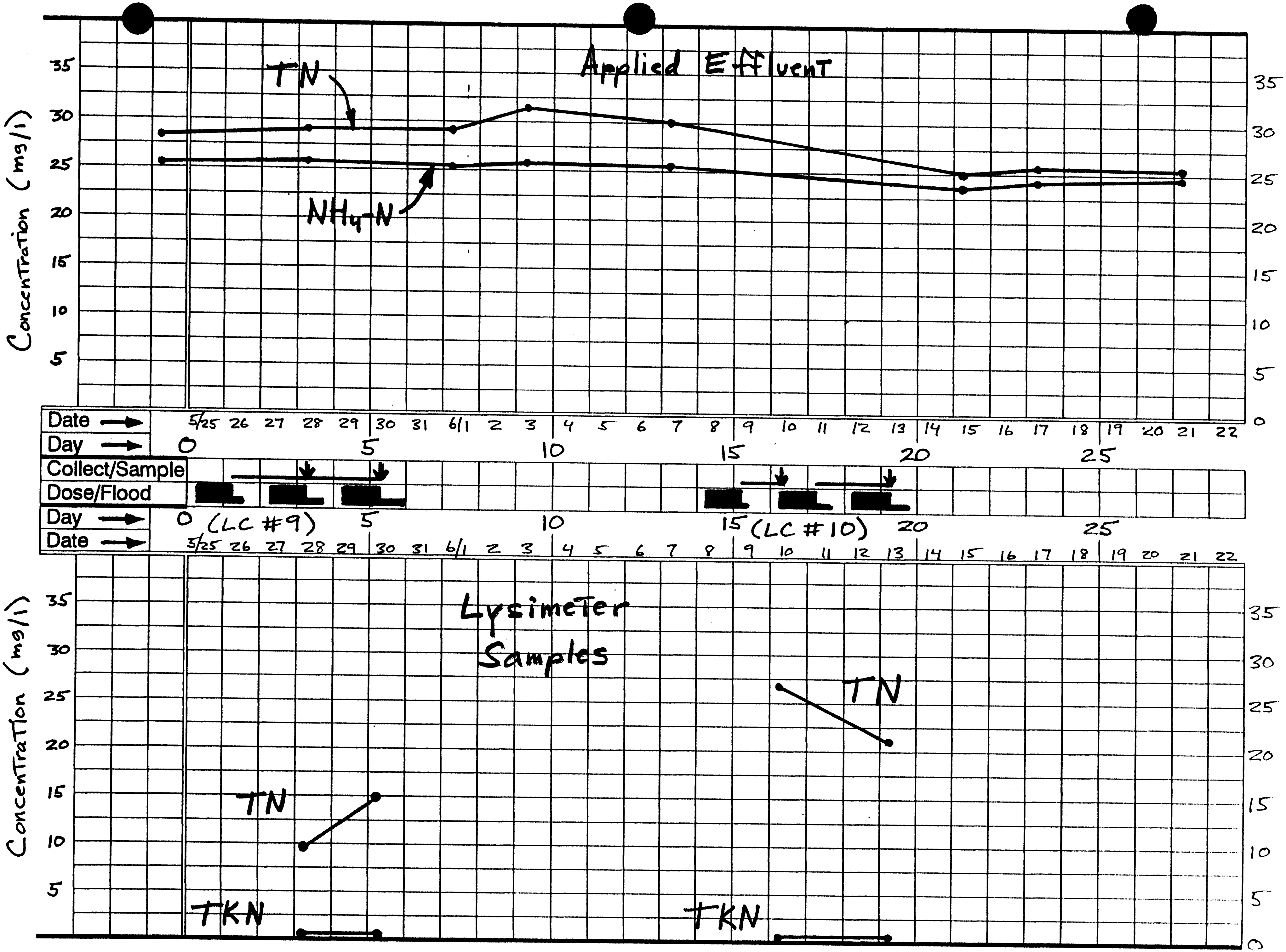
Cell 7 10/6 to 10/26/92



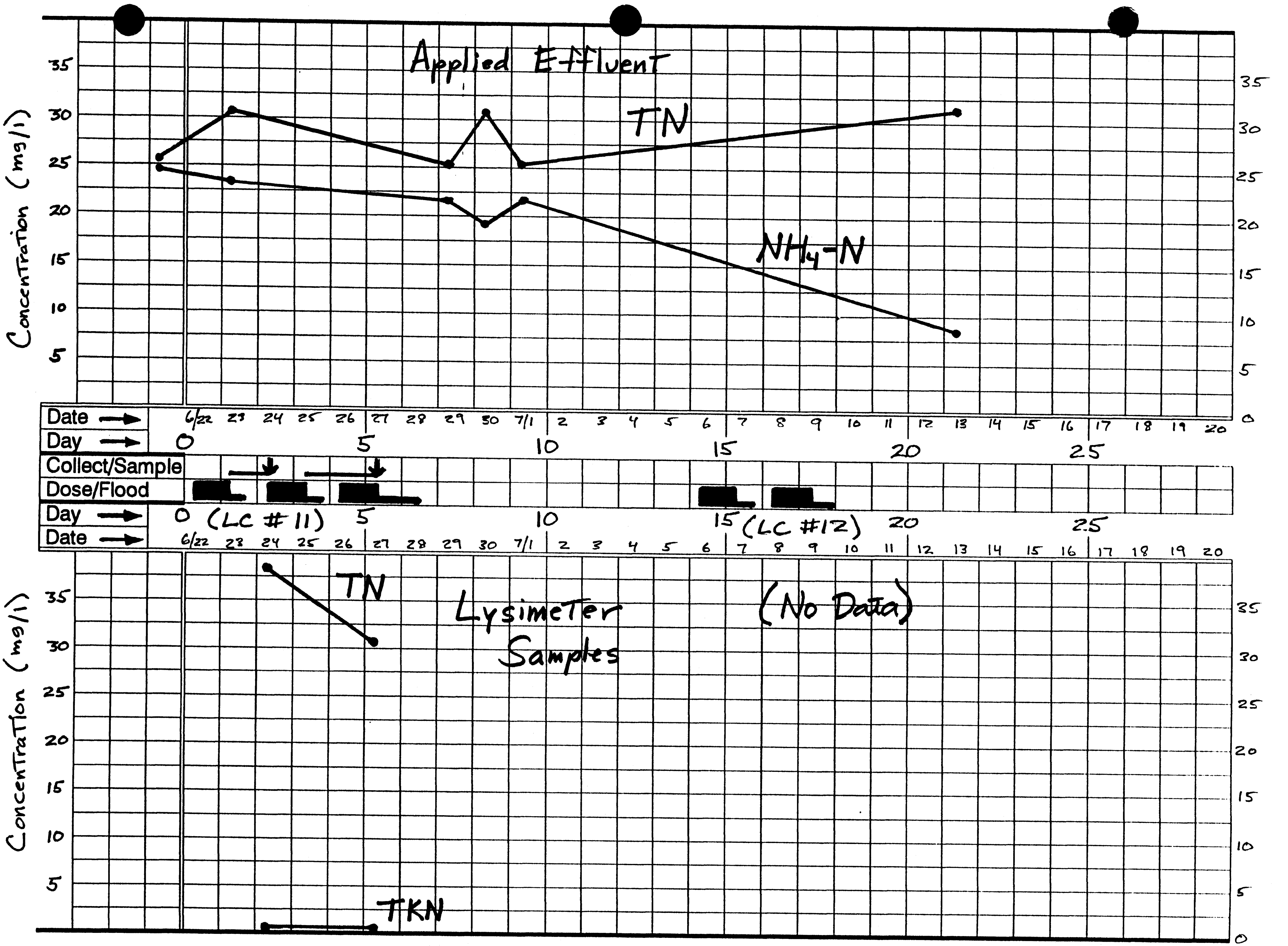
Cell 7 10/27 to END (1992)



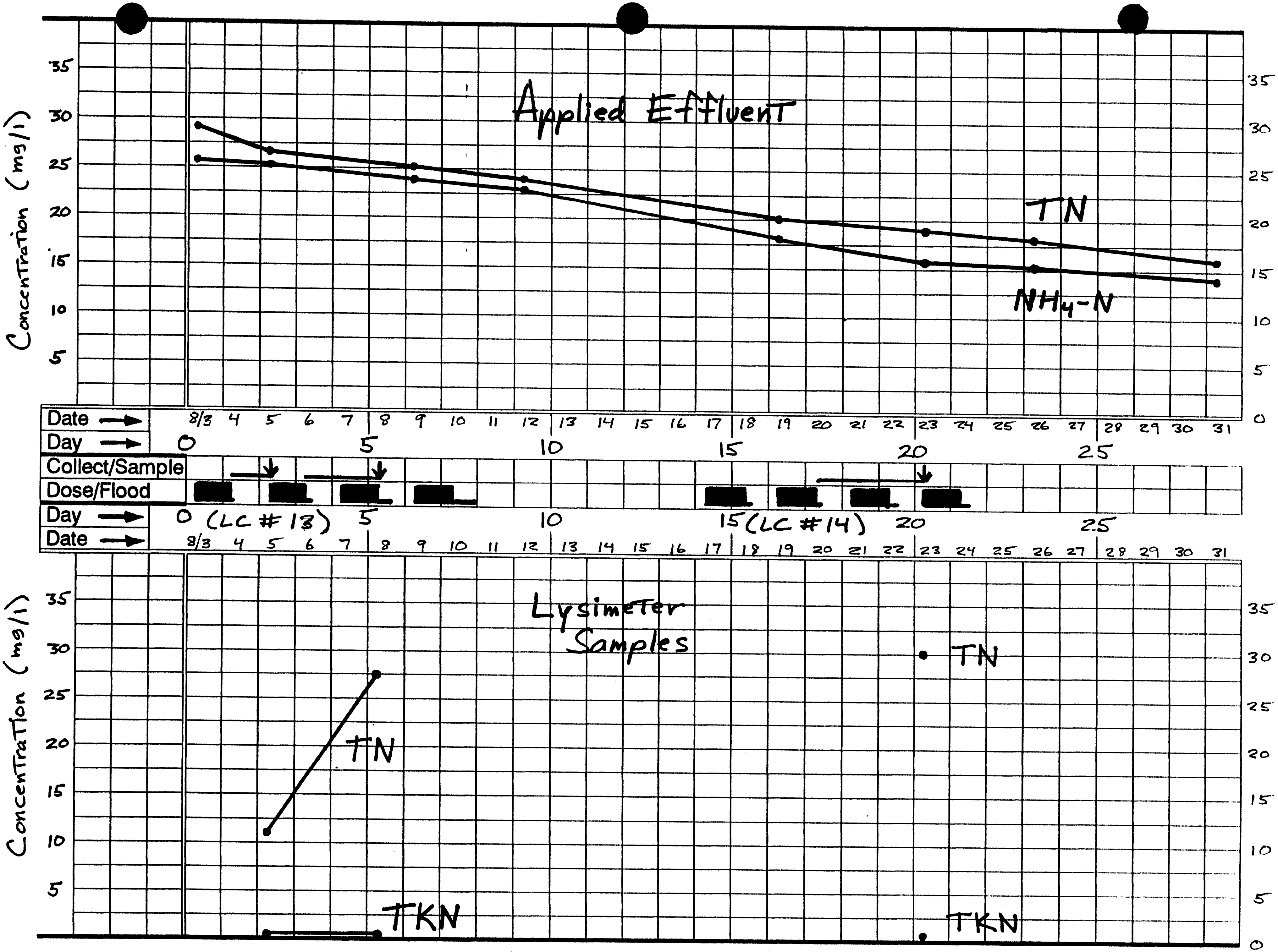
Cell 2 4/27 to 5/24/93



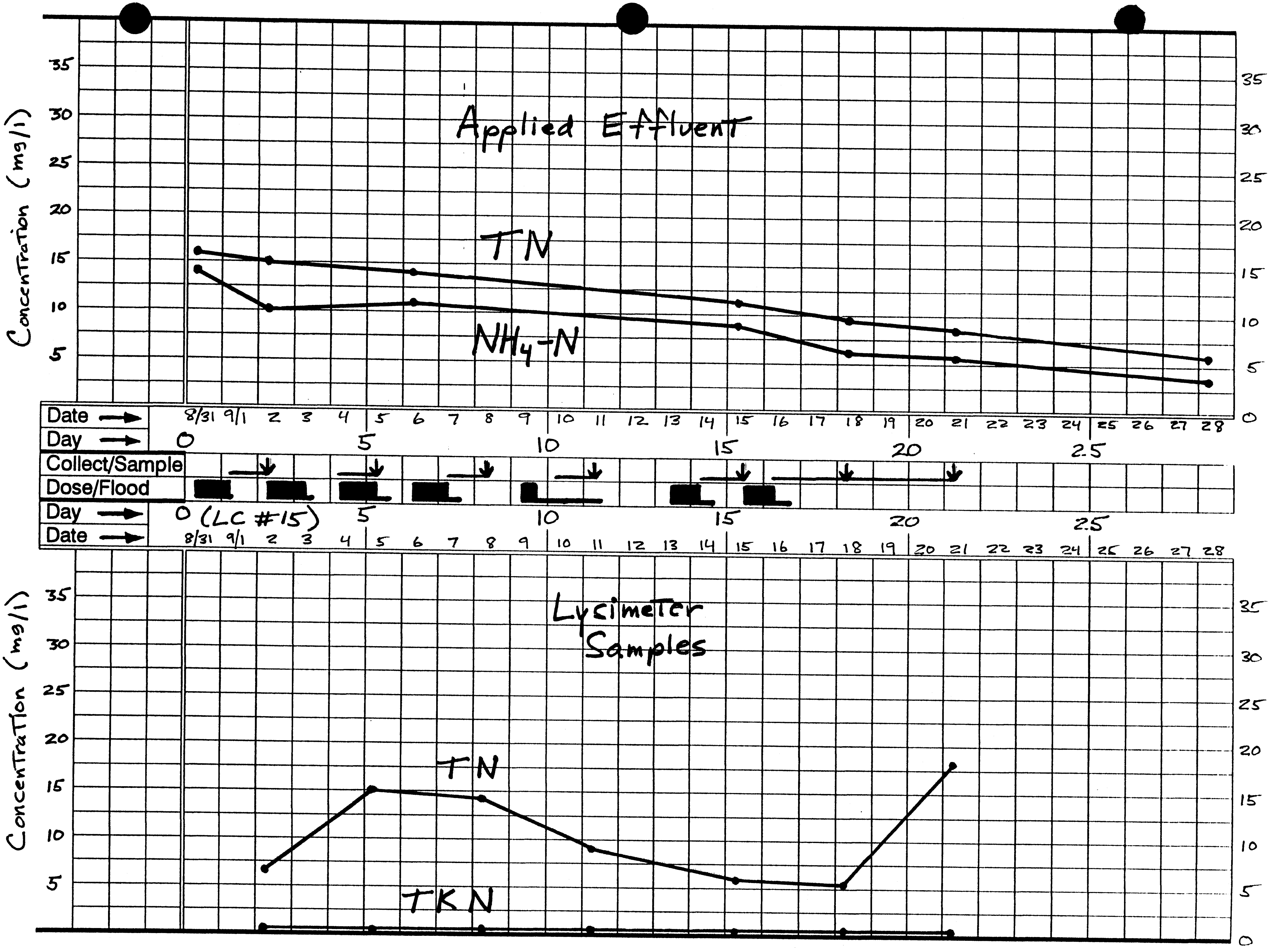
Cell 7 5/25 to 6/21/93



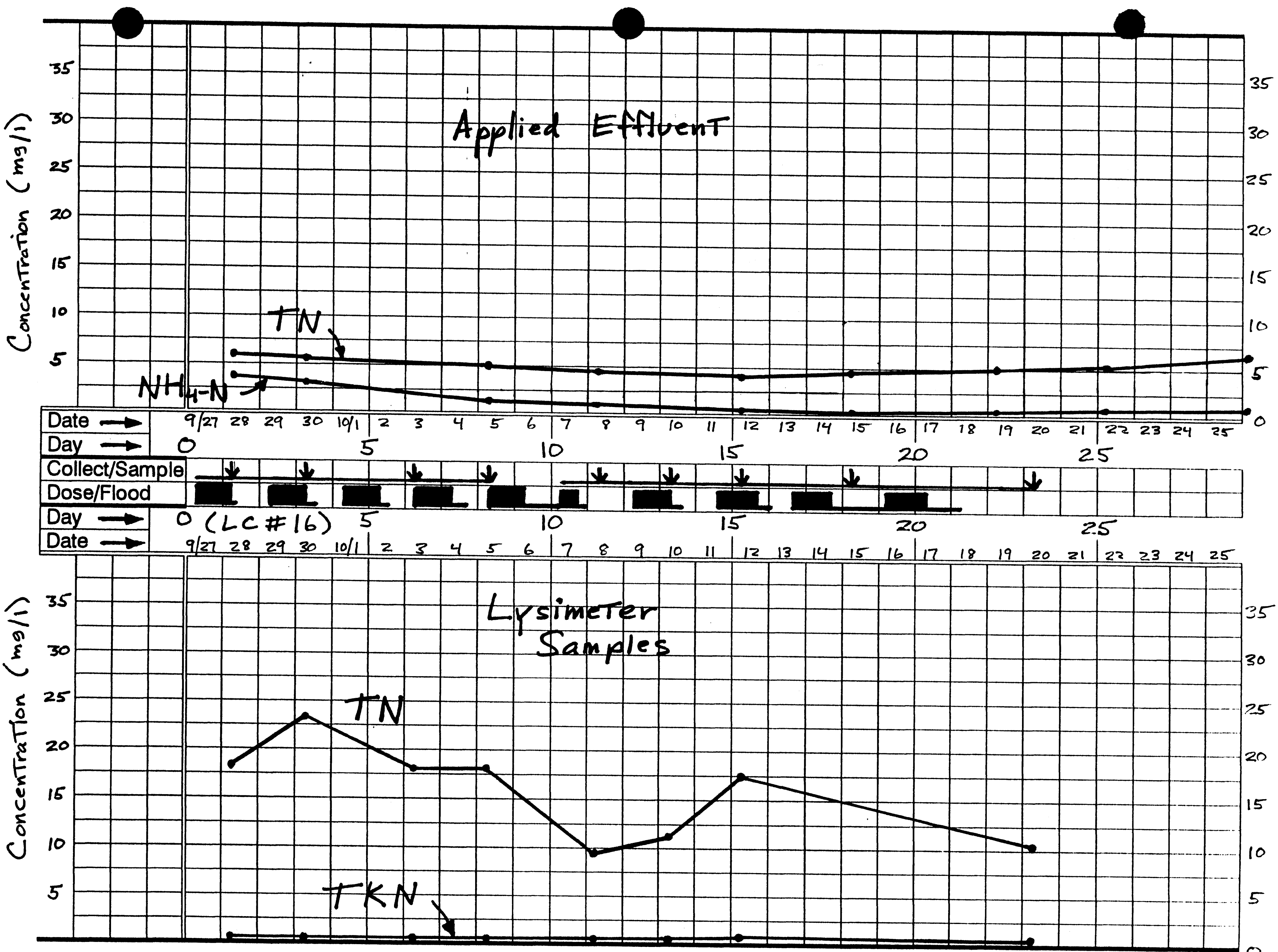
Cell 7 6/22 to 7/20/93



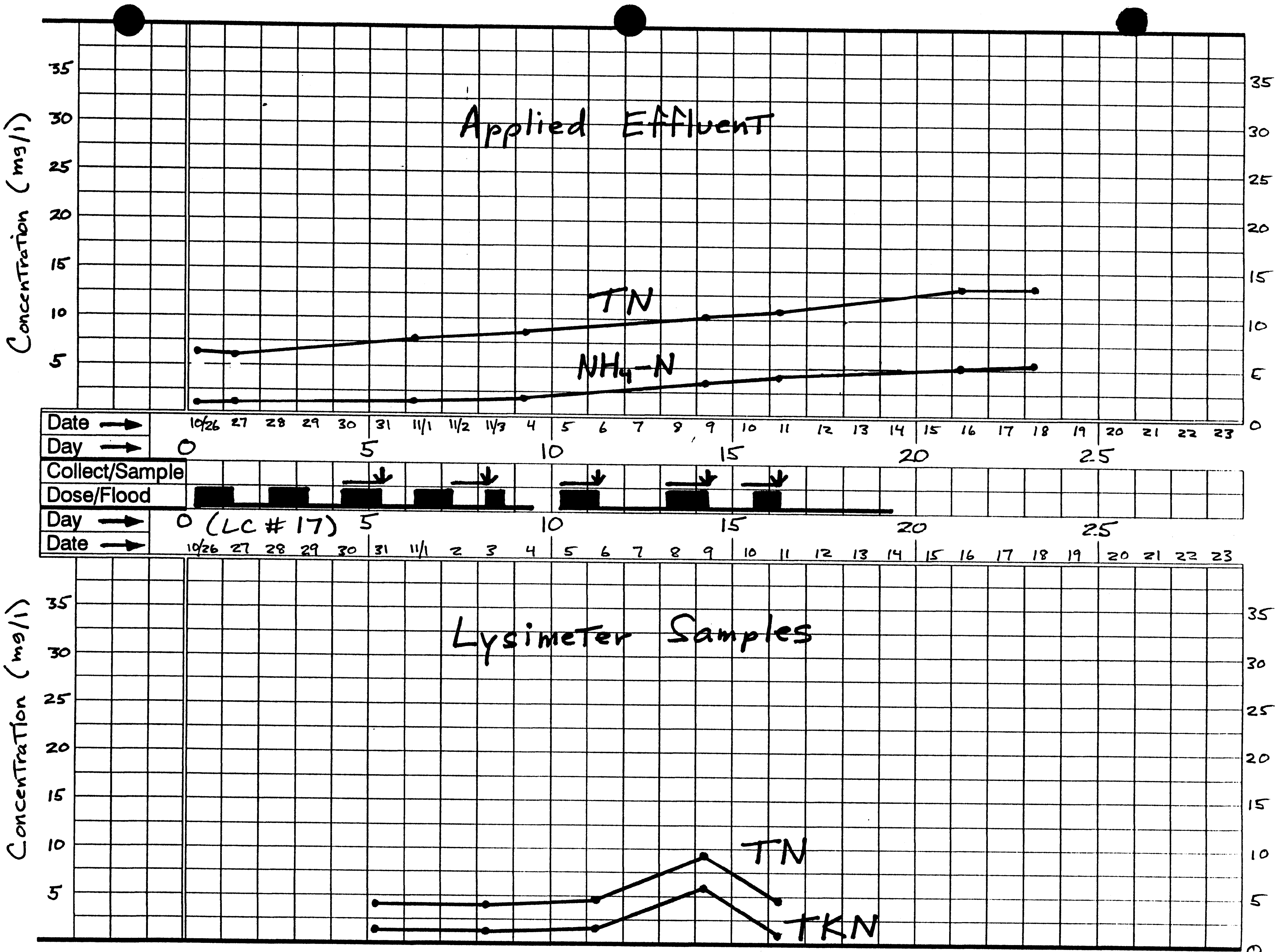
Cell 2 8/3 to 8/30/93



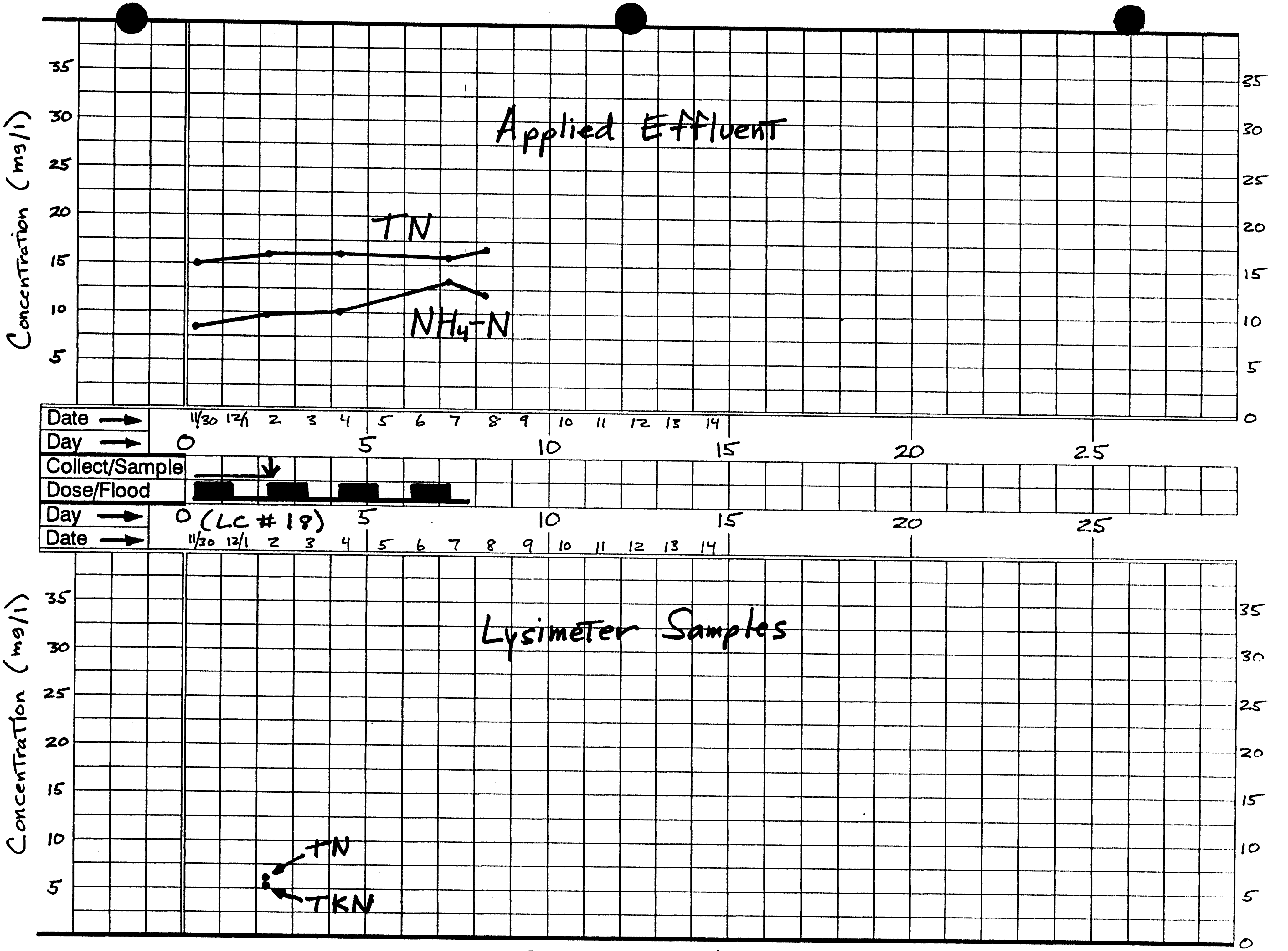
Cell 2 8/31 to 9/26/93



Cell 2 9/27 to 10/25/93



Cell 2 10/26 to 11/23/93



Cell 2 - 11/30 to END

CELL: 2

DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	TIME OF COLLECTION (DAYS)	TIME FROM DOSE START (DAYS)	SAMPLE SIZE (QT.)	SAMPLE TEMP. (°C)	EFFLUENT TEMP. (°C)	SAMPLE pH (S.U.)	EFFLUENT pH (S.U.)	AVERAGE INFILTRATION RATE (IN/D.)
	1992:									
1	8-4 TO 8-24	—	—	—	—	—	—	—	—	17.2
2	8-25 TO 9-7	8-31	1	6	0.5	15.3	15.3	7.0	7.6	22.5
3	9-8 TO 9-20	9-10	2	2	1.0	15.4	15.4	7.54	7.6	28.7
		9-11	1	3	0.03		13.5		7.6	↓
		9-14	1	6	0.25		16.8		7.6	
4	9-21 TO 10-5	9-28	3	7	0.05	12.4	13.5	7.45	7.5	23.0
5	10-6 TO 10-26	10-13	1	7	0.25	6.9	10.5	7.40	7.5	19.7
6	10-27 TO END	11-1	1	5	0.25	—	6.5	—	7.6	11.8
		11-3	2	7	0.50	—	5.7	—	7.7	↓
		11-7	1	11		—	6.3	—	7.6	
	1993:									
7	4-27 TO 5-10	—	—	—	—	—	—	—	—	25.0
8	5-11 TO 5-24	5-14	3	3		—	15.5	—	7.7	37.8 (?)
9	5-25 TO 6-7	5-28	2	3	12.0	—	13.7	—	7.4	27.2
		5-30	2	5	12.0	—	13.7	—	↓	↓
10	6-8 TO 6-21	6-10	1	2		—	16.8	—	7.5	29.6
		6-13	2	5		—	↓	—	↓	↓
11	6-22 TO 7-5	6-24	1	2	2.5	—	18.6	—	7.43	24.1
		6-27	2	5	2.0	—	↓	—	↓	↓
12	7-6 TO 8-2	—	—	—	—	—	—	—	—	26.1

CELL: 2

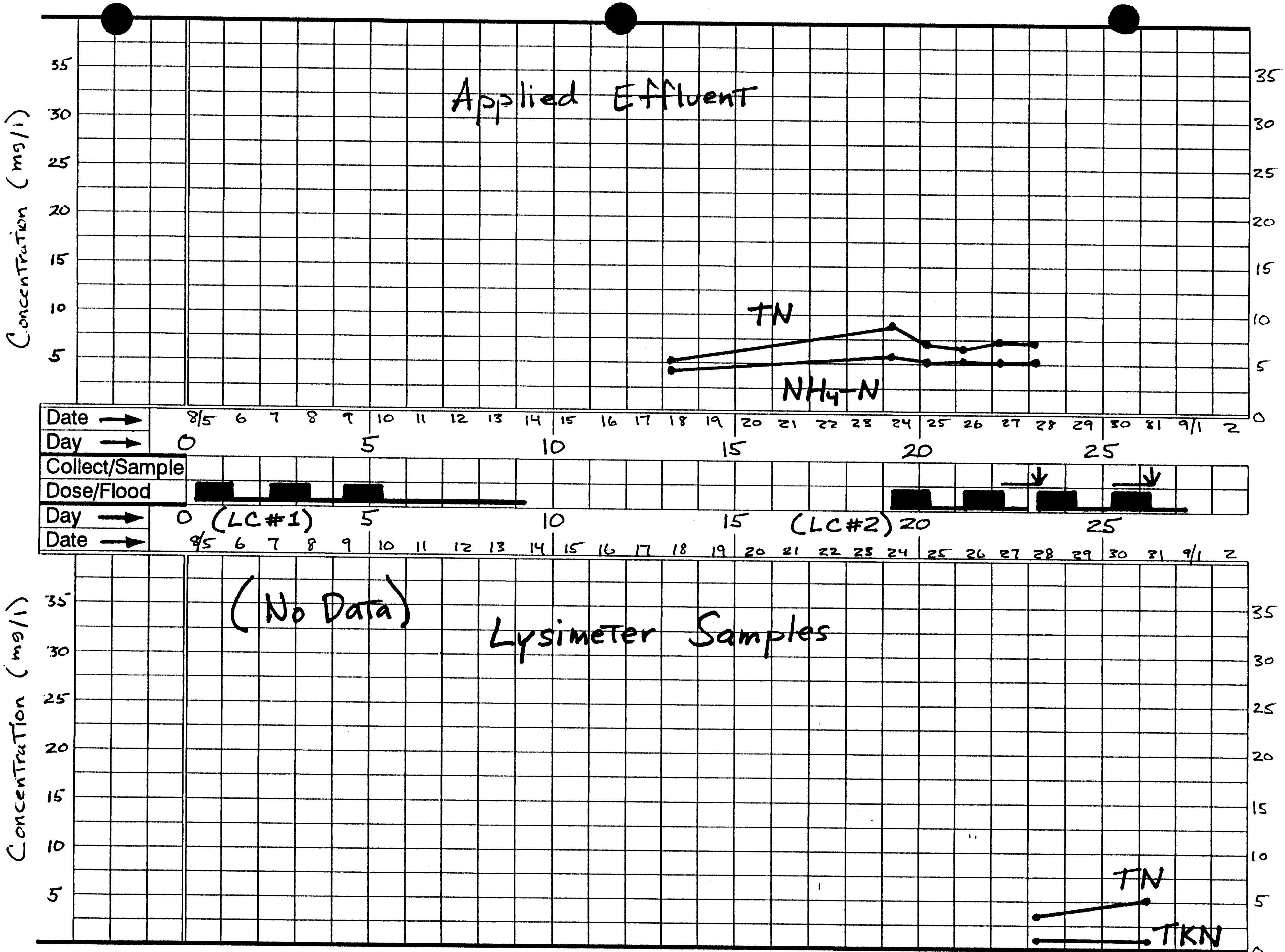
DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	TIME OF COLLECTION (DAYS)	TIME FROM DOSE START (DAYS)	SAMPLE SIZE (QT.)	SAMPLE TEMP. (°C)	EFFLUENT TEMP. (°C)	SAMPLE pH (S.U.)	EFFLUENT pH (S.U.)	AVERAGE INFILTRATION RATE (IN/D.)
13	8-3 TO 8-16	8-5	1	2	–	17.3	20.2	7.31	7.53	30.6
		8-8	2	5	2.5	17.4	↓	7.32	↓	↓
14	8-17 TO 8-30	8-23	3	6	2.0	20.2	20.4	7.20	7.4	31.9
15	8-31 TO 9-26	9-2	1	2	2.0	17.9	17.8	7.91	7.62	38.4
		9-5	1	5	2.0	18.7	↓	7.83	↓	↓
		9-8	1	8	2.0	15.2		8.72		
		9-11	1	11	–	17.1		8.01		
		9-15	1	15	4.0	15.1		8.25		
		9-18	2	18	2.0	15.7		8.40		
		9-21	3	21	0.05	15.0		8.49		
16	9-27 TO 10-25	9-28	1	1	8.0	15.4	11.5	6.60	7.58	26.1
		9-30	2	3	1.0	12.4	↓	7.53	↓	↓
		10-3	3	6	0.05	12.7		7.66		
		10-5	2	8	0.05	8.2		8.21		
		10-8	1	11	–	13.4		–		
		10-10	2	13	–	–				
		10-12	2	15	0.02	10.1		8.35		
		10-15	3	18	0.05	–				
		10-19	?	22	–	–				
		10-20	5	23	0.50	8.1		8.20		
17	10-26 TO 11-29	10-31	1	5	9.0	7.6	6.31	7.83	7.88	16.4
		11-3	1	7	–	4.7	↓	7.86	↓	↓
		11-6	1	10	–	2.4		7.90		
		11-9	1	13	8.0	4.4		7.83		
		11-11	1	15	4.0	5.2		7.78		
18	11-30 TO END	12-2	2	2	0.1	0.0	2.75	8.12	7.75	22.2

CELL: 2										
DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	APPLIED NH4-N (DOSE AVG.) (mg/l)	APPLIED TN (DOSE AVG.) (mg/l)	DISCHARGED TN PER SAMPLE (mg/l)	DISCHARGED TN (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) %	DISCHARGED NO3-N PER SAMPLE (mg/l)	DISCHARGED NO3-N (DOSE AVG.) (mg/l)
	1992:									
1	8-4 to 8-24	—								
2	8-25 to 9-7	8-31	5.42	7.07	8.08	8.08	-1.01	-14.3	6.78	6.78
3	9-8 to 9-20	9-10	5.16	7.07	9.52	10.28	-3.21	-45.4	8.52	9.28
		9-11	↓	↓	11.40	↓			10.40	↓
		9-14			9.93				8.93	
4	9-21 to 10-5	9-28	4.97	7.72	12.3	12.3	-4.58	-59.3	10.3	10.3
5	10-6 to 10-26	10-13	4.69	7.12	13.5	13.5	-6.38	-89.6	12.1	12.1
6	10-27 to END	11-1	4.31	9.94	14.0	12.6	-2.66	-26.8	13.0	11.9
		11-3	↓	↓	10.5	↓			10.0	↓
		11-7			13.3				12.6	
	1993:									
7	4-27 to 5-10	—								
8	5-11 to 5-24	5-14	24.1	30.1	49.4	49.4	-19.3	-64.0	48.7	48.7
9	5-25 to 6-7	5-28	25.7	28.8	9.78	12.39	16.4	56.9	9.18	11.8
		5-30	↓	↓	15.0	↓			14.5	↓
10	6-8 to 6-21	6-10	24.9	27.6	27.1	24.3	3.3	12.1	26.5	23.8
		6-13	↓	↓	21.5	↓			21.0	↓
11	6-22 to 7-5	6-24	23.3	27.6	38.6	34.7	-7.1	-25.9	38.1	34.2
		6-27	↓	↓	30.8	↓			30.3	↓
12	7-6 to 8-2	—								

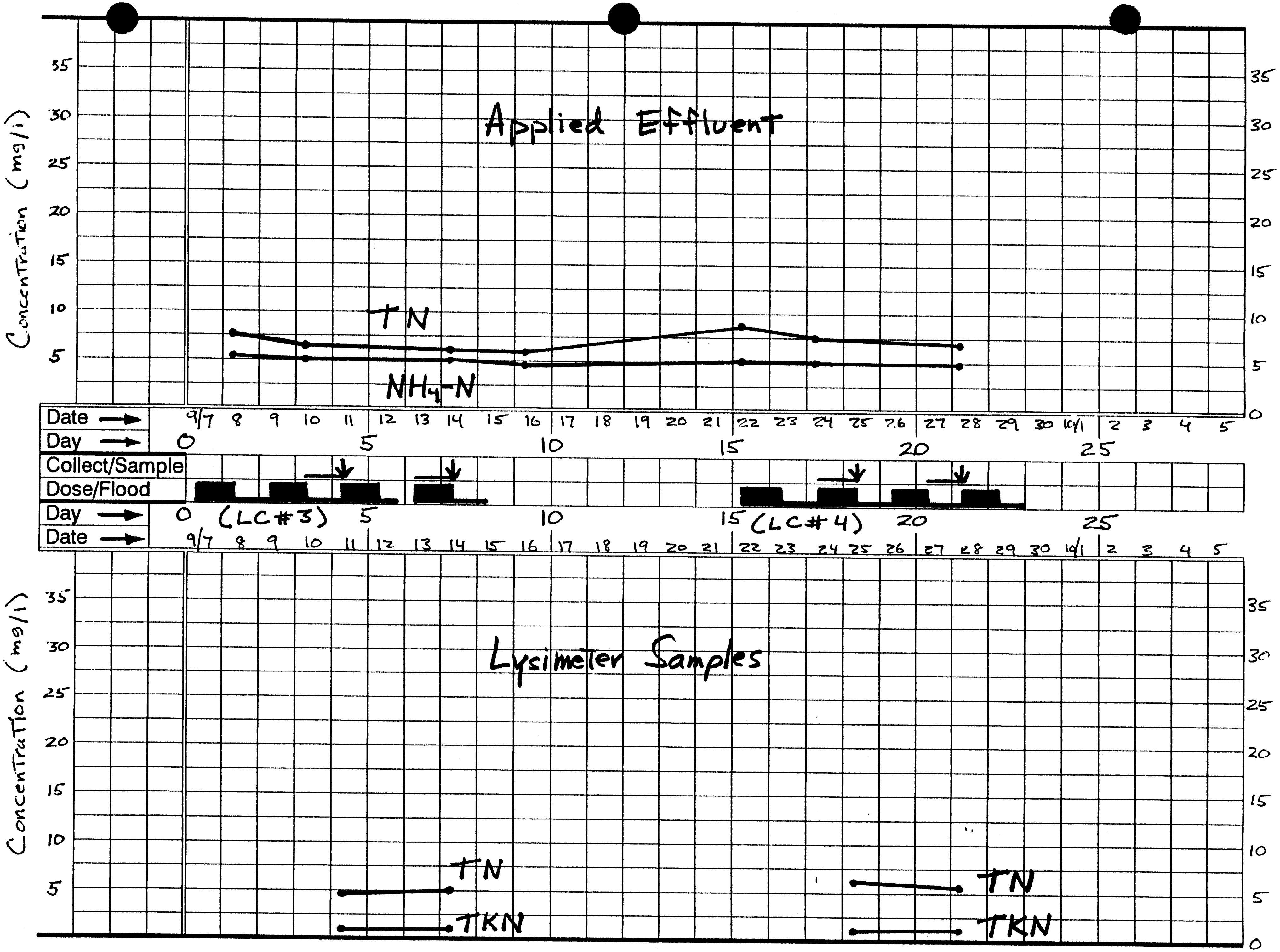
CELL: 2

DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	APPLIED NH4-N (DOSE AVG.) (mg/l)	APPLIED TN (DOSE AVG.) (mg/l)	DISCHARGED TN PER SAMPLE (mg/l)	DISCHARGED TN (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) %	DISCHARGED NO3-N PER SAMPLE (mg/l)	DISCHARGED NO3-N (DOSE AVG.) (mg/l)
13	8-3 TO 8-16	8-5	25.2	27.1	11.6	19.6	7.5	27.8	10.8	18.9
		8-8	↓	↓	27.5	↓			26.9	↓
14	8-17 TO 8-30	8-23	16.9	19.6	27.6	27.6	-8.0	-40.9	27.0	27.0
15	8-31 TO 9-26	9-2	10.3	13.3	6.98	10.8	2.5	18.5	6.38	10.2
		9-5	↓	↓	15.2	↓			14.6	↓
		9-8			14.4				13.8	
		9-11			9.23				8.63	
		9-15			6.42				5.82	
		9-18			5.62				5.22	
		9-21			17.9				17.1	
16	9-27 TO 10-25	9-28	1.85	4.99	18.5	15.9	-10.9	-217.5	18.0	15.2
		9-30	↓	↓	23.5	↓			23.0	↓
		10-3			17.9				17.1	
		10-5			17.8				16.9	
		10-8			9.49				9.09	
		10-10			11.7				11.2	
		10-12			17.5				16.5	
		10-15			—				—	
		10-19			—				—	
		10-20			10.4				9.81	
17	10-26 TO 11-29	10-31	2.32	8.34	4.11	5.32	3.0	36.2	2.71	3.06
		11-3	↓	↓	4.12	↓			2.82	↓
		11-6			4.70				3.00	
		11-9			9.17				3.27	
		11-11			4.48				3.48	
18	11-30 TO END	12-2	9.12	15.5	6.66	6.66	8.9	57.1	1.26	1.26

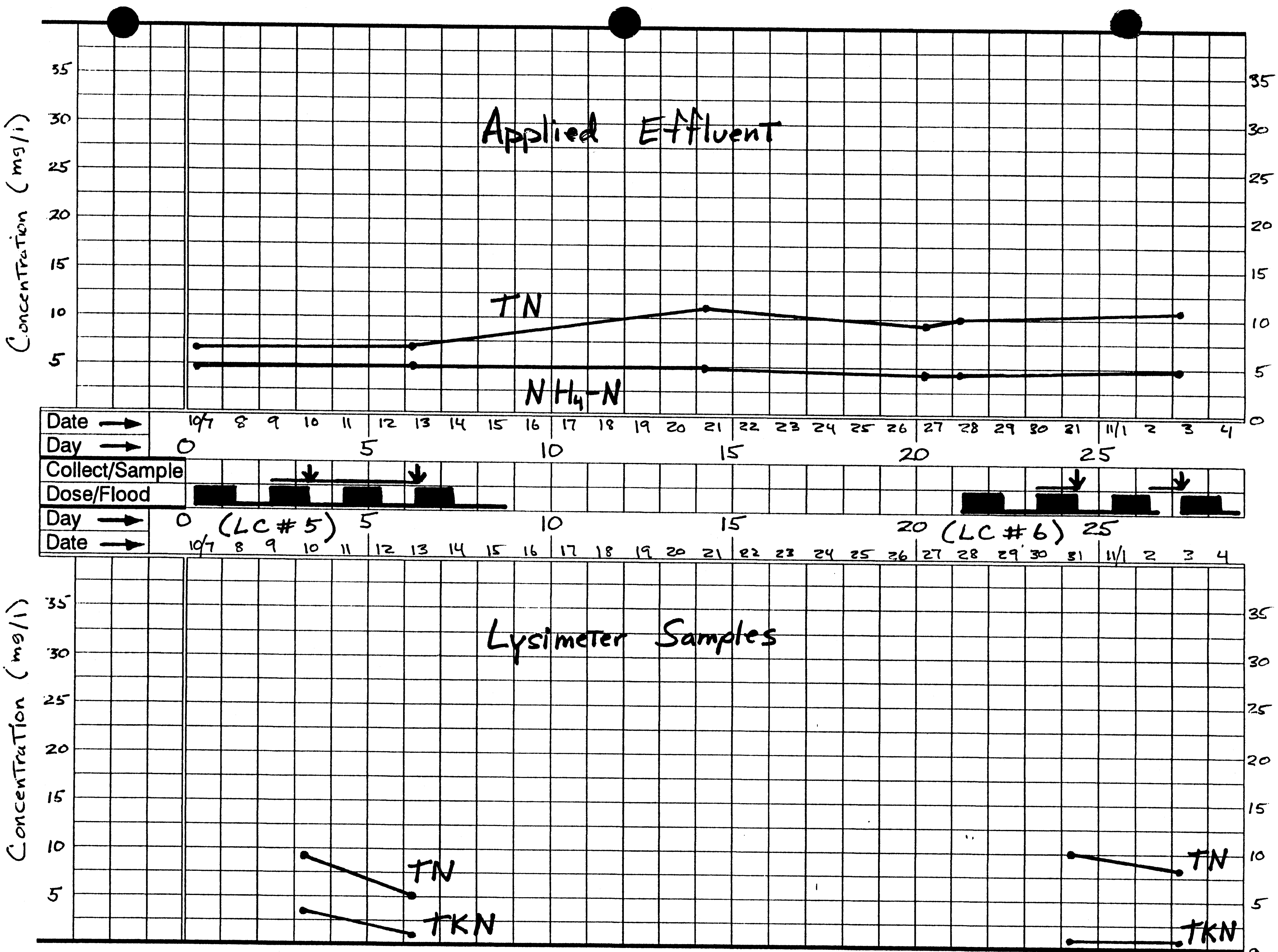
APPENDIX 6



Cell 5 8/5 to 9/2/92

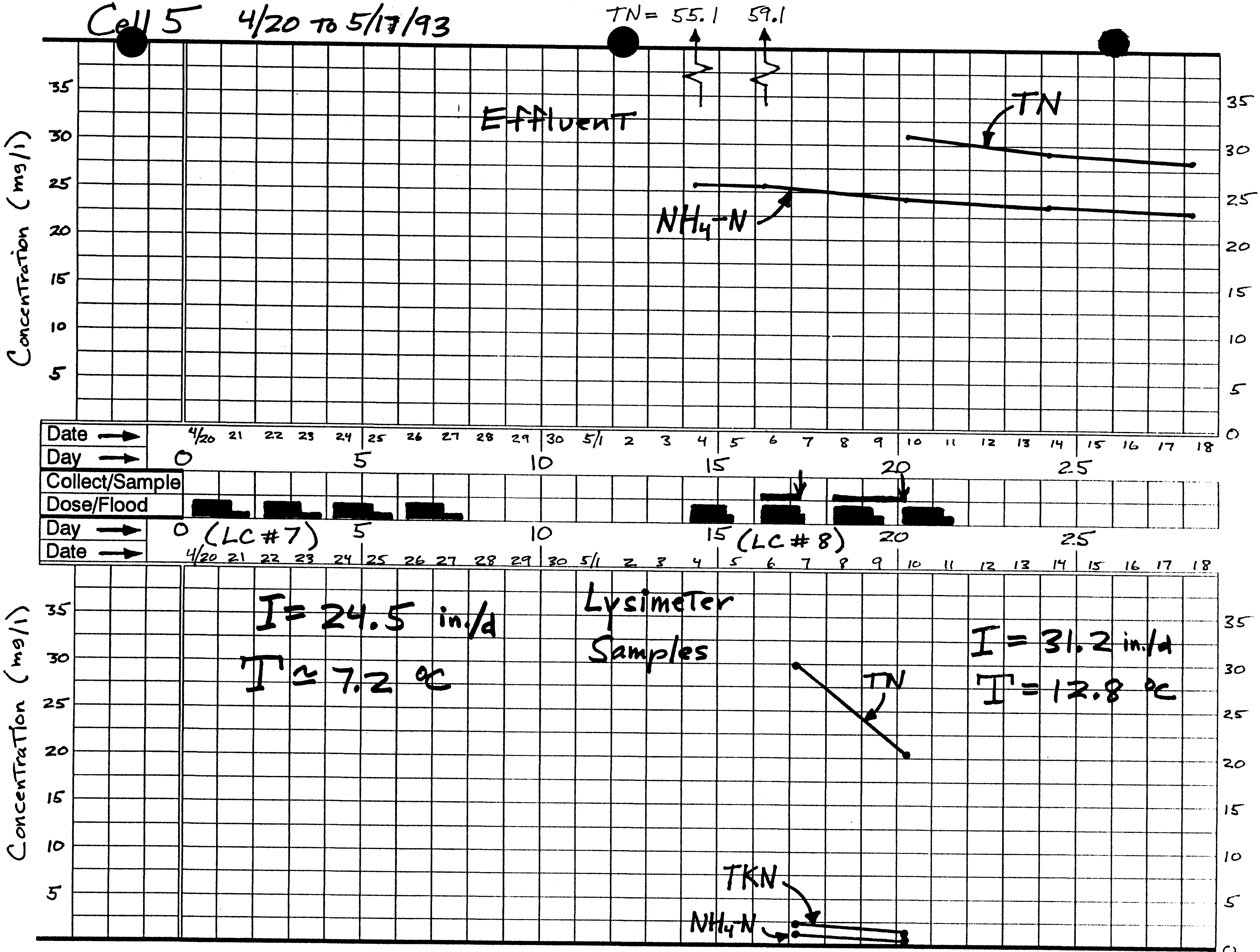


Cell 5 9/7 to 10/5/92



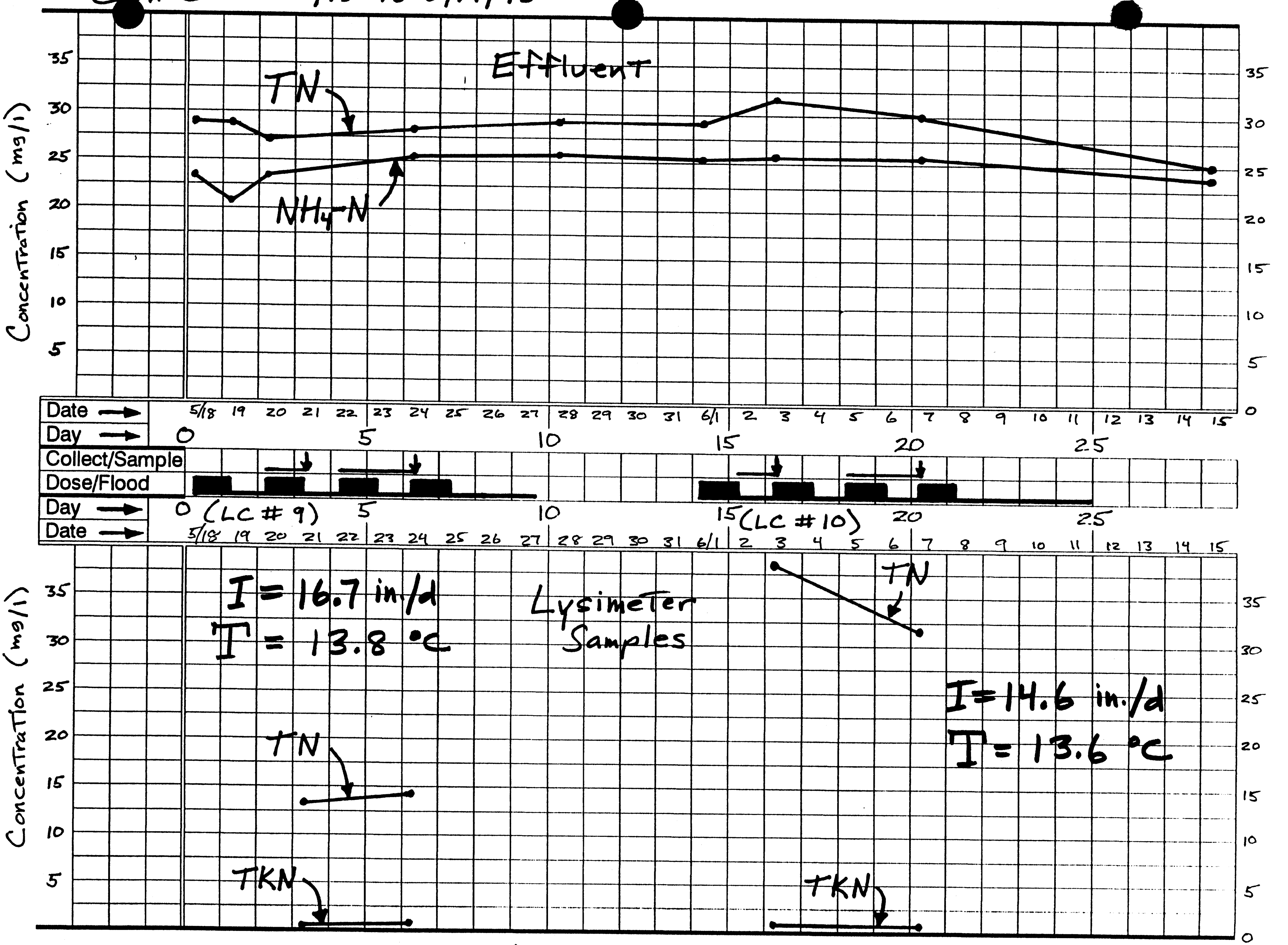
Cell 5 10/7 → END (1992)

Cell 5 4/20 to 5/17/93



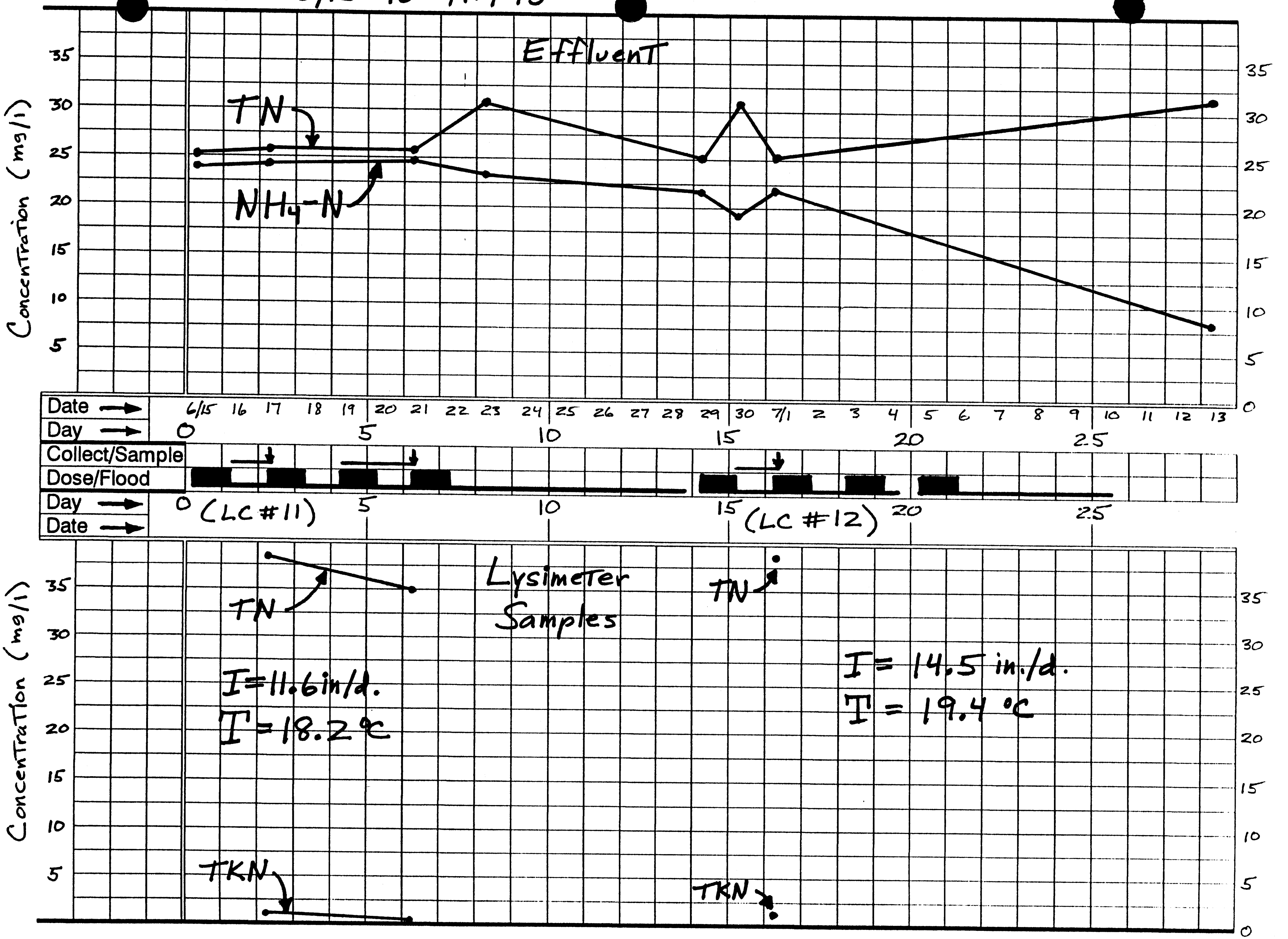
Cell 5 - 4/20 to 5/17/93

Cell 5 - 5/18 to 6/14/93



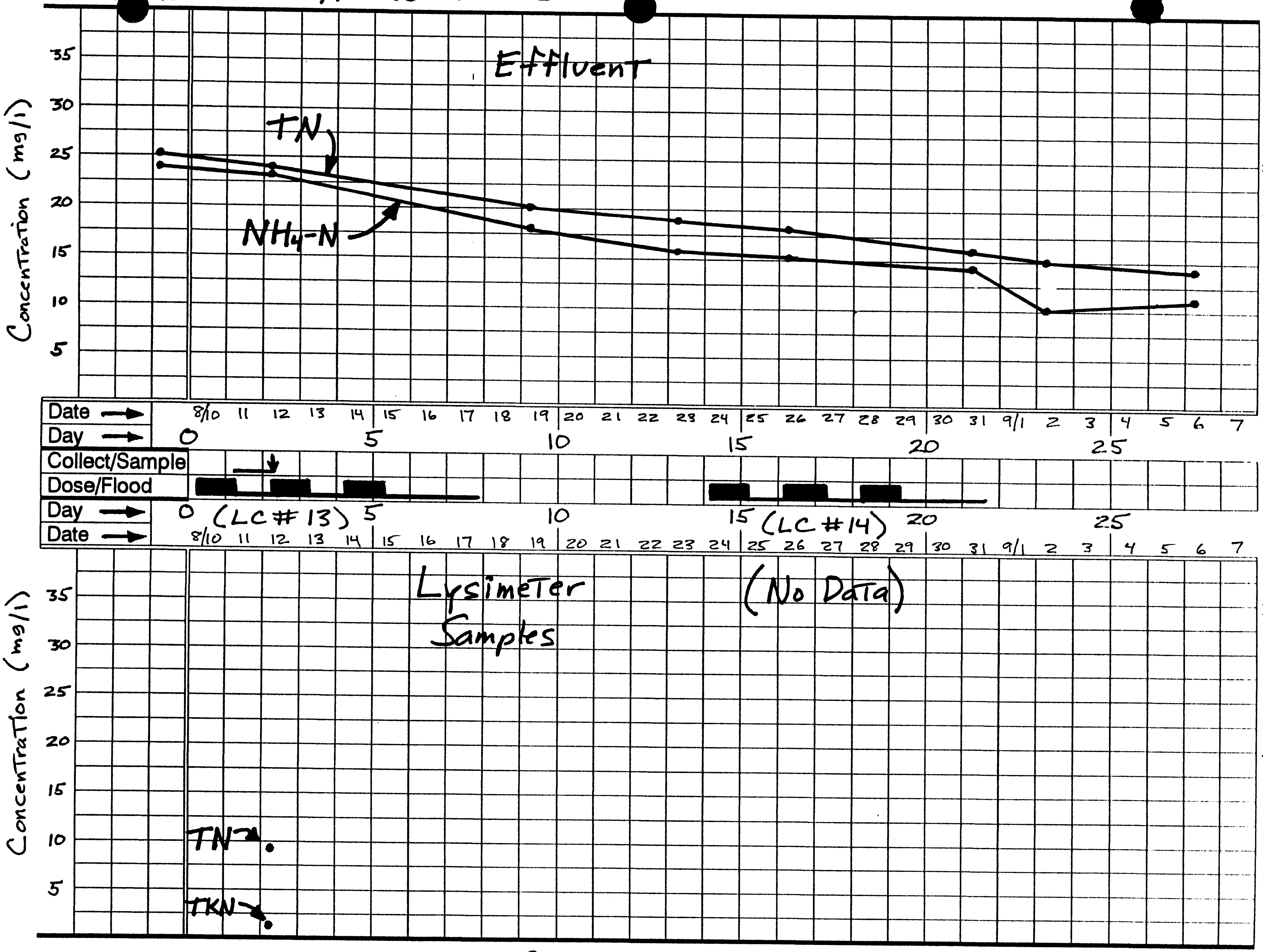
Cell 5 - 5/18 to 6/14/93

Cell 5 - 6/15 to 7/13/93



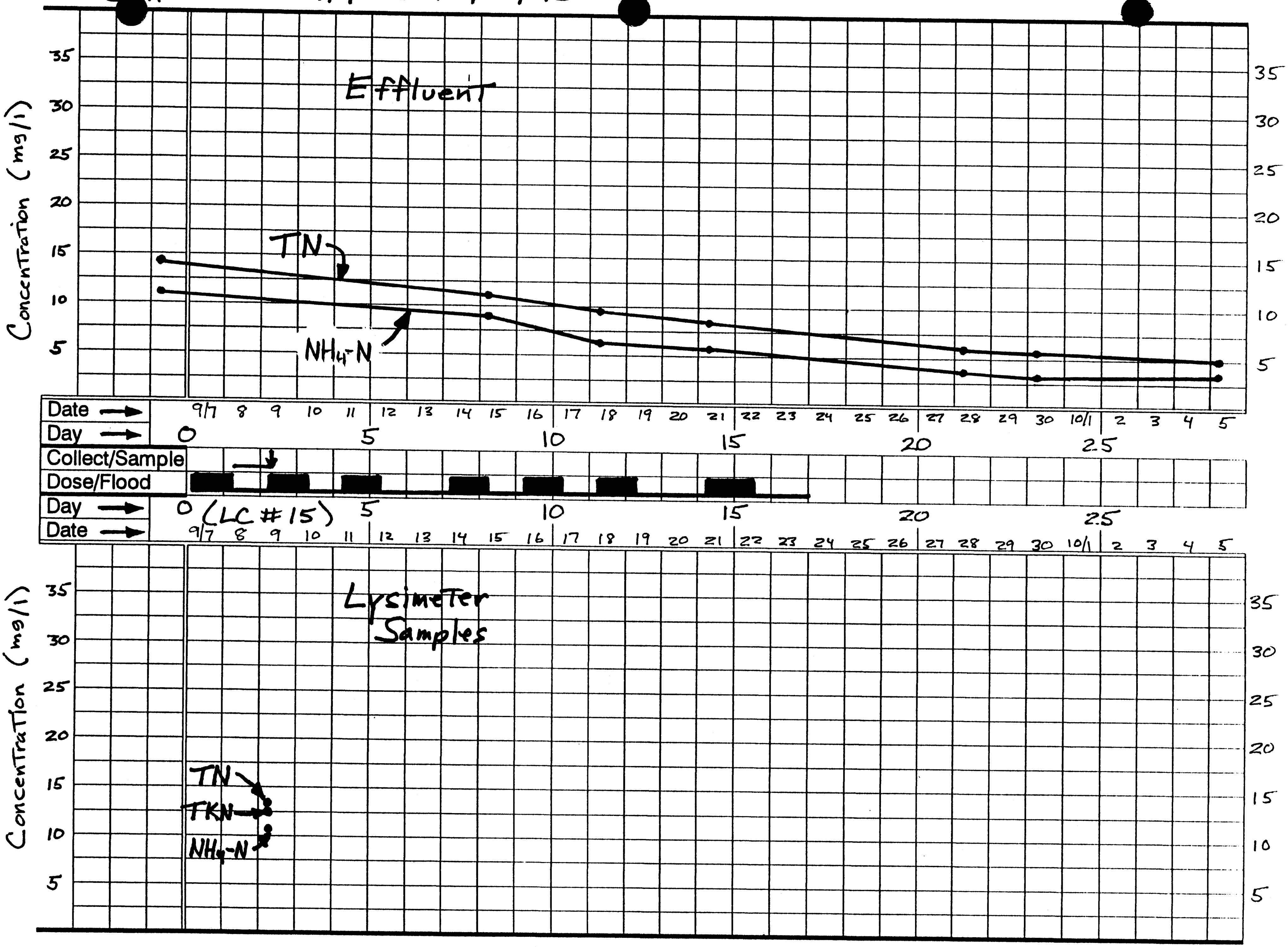
Cell 5 - 6/15 to 7/13/93

Cell 5 - 8/10 to 9/6/93



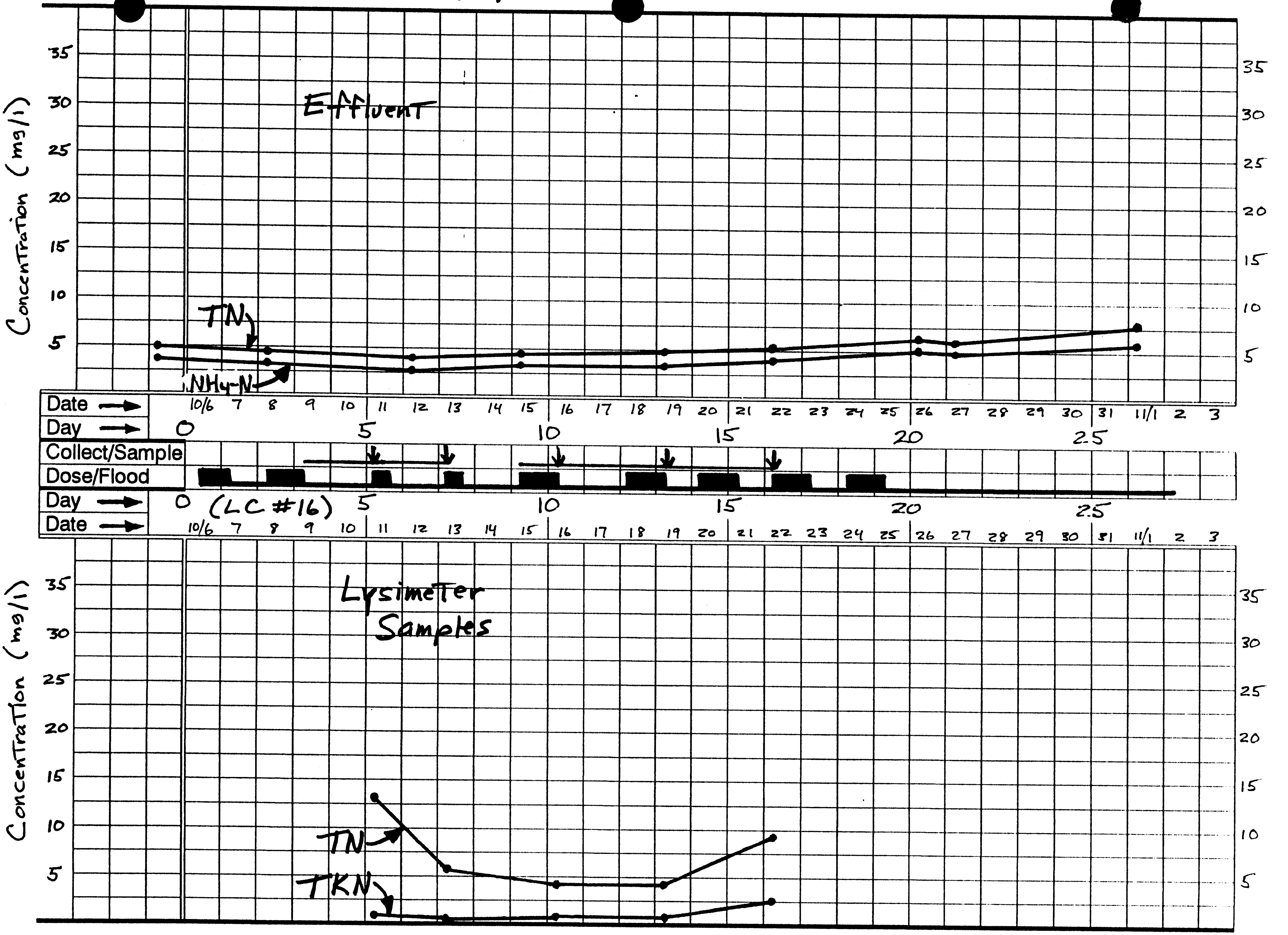
Cell 5 - 8/10 to 9/6/93

Cell 5 - 9/7 to 10/5/93



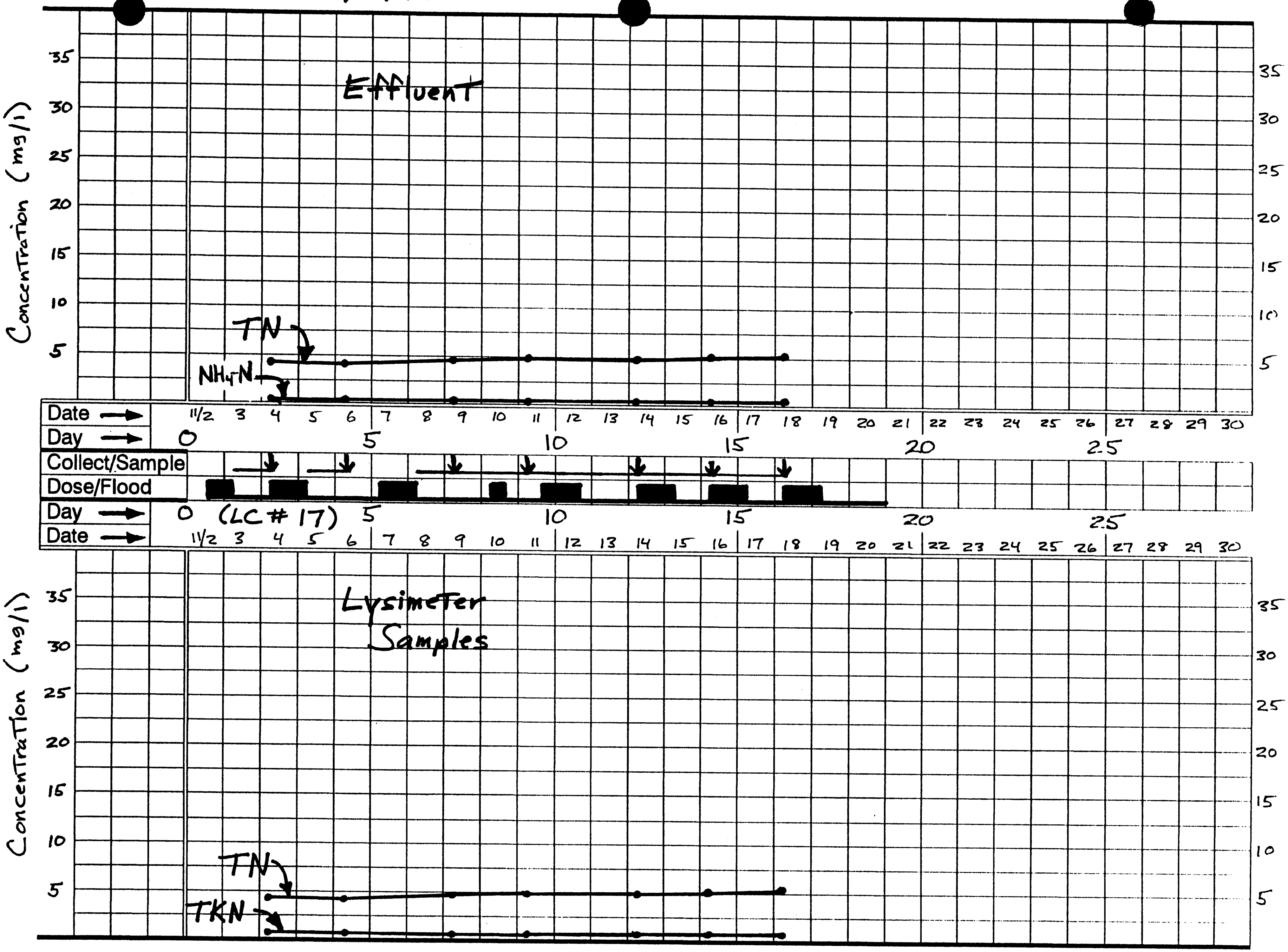
Cell 5 - 9/7 to 10/5/92

Cell 5 - 10/6 to 11/2/93



Cell 5 - 10/6 to 11/2/93

Cell 5 - 11/2/93 to End



Cell 5 - 11/2 to END (1993)

CELL: 5

DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	TIME OF COLLECTION (DAYS)	TIME FROM DOSE START (DAYS)	SAMPLE SIZE (QT.)	SAMPLE TEMP. (°C)	EFFLUENT TEMP. (°C)	SAMPLE pH (S.U.)	EFFLUENT pH (S.U.)	AVERAGE INFILTRATION RATE (IN/D.)
	1992:									
1	8-5 TO 8-23	—								12.7
2	8-24 TO 9-6	8-28	1	4	3.0	17.4	19.0	7.60	7.55	20.8
		8-31	1	7	5.5	15.3	↓	7.56	↓	↓
3	9-7 TO 9-21	9-11	1	4	2.0	13.5	16.1	7.53	7.54	19.5
		9-14	1	7	12	16.8	↓	—	↓	↓
4	9-22 TO 10-6	9-25	1	3	4.0	14.0	14.0	7.4	7.51	19.3
		9-28	1	6	12	12.3	↓	7.5	↓	↓
5	10-7 TO 10-27	10-10	1	3	?	13.7	12.1	7.44	7.53	18.5
		10-13	3	6	12	8.1	↓	7.45	↓	↓
6	10-28 TO END	10-31	1	3	3.0	—	6.95	—	7.59	23.4
		11-3	1	6	2.0	—	↓	—	↓	↓
	1993:									
7	4-20 TO 5-3	—								24.5
8	5-4 TO 5-17	5-7	1	3	5.0		12.8		7.53	31.2
		5-10	2	6	6.0		↓		↓	↓
9	5-18 TO 5-31	5-21	1	3	2.0		13.8		7.37	16.7
		5-24	2	6	0.5		↓		↓	↓
10	6-1 TO 6-14	6-3	1	2	0.85		13.6		7.53	14.6
		6-7	2	6	1.0		↓		↓	↓
11	6-15 TO 6-28	6-17	1	2	0.75		18.2		7.43	11.6
		6-21	2	6	0.25		↓		↓	↓

CELL: 5

DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	TIME OF COLLECTION (DAYS)	TIME FROM DOSE START (DAYS)	SAMPLE SIZE (QT.)	SAMPLE TEMP. (°C)	EFFLUENT TEMP. (°C)	SAMPLE pH (S.U.)	EFFLUENT pH (S.U.)	AVERAGE INFILTRATION RATE (IN/D.)
12	6-29 TO 8-9	7-1	1	2	0.50		19.4		7.50	14.5
13	8-10 TO 8-23	8-12	1	2	8.0	19.5	20.4	7.31	7.50	15.3
14	8-24 TO 9-6	—								16.0
15	9-7 TO 10-5	9-9	1	2	?		17.0		7.55	19.4
16	10-6 TO 11-1	10-11	2	5	0.50	9.4	10.5	8.23	7.66	12.3
		10-13	2	7	1.0	8.3	↓	8.41	↓	↓
		10-16	1	10	?	8.5	↓	8.10	↓	↓
		10-19	3	13	5.0	10.5	↓	8.34	↓	↓
		10-22	3	16	1.0	9.4	↓	8.44	↓	↓
17	11-2 TO END	11-4	1	2	?	6.6	4.18	7.96	7.93	16.2
		11-6	1	4	?	3.1	↓	7.57	↓	↓
		11-9	1	7	4.0	4.6	↓	8.15	↓	↓
		11-11	2 (?)	9	1.0	6.2	↓	7.99	↓	↓
		11-14	3	12	2.0	5.0	↓	8.21	↓	↓
		11-16	2	14	0.1	3.8	↓	7.93	↓	↓
		11-18	2	16	0.1	4.7	↓	7.88	↓	↓

CELL: 5

DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	APPLIED NH4-N (DOSE AVG.) (mg/l)	APPLIED TN (DOSE AVG.) (mg/l)	DISCHARGED TN PER SAMPLE (mg/l)	DISCHARGED TN (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) %	DISCHARGED NO3-N PER SAMPLE (mg/l)	DISCHARGED NO3-N (DOSE AVG.) (mg/l)
	1992:									
1	8-5 TO 8-23	—								
2	8-24 TO 9-6	8-28	5.53	7.40	3.47	4.33	3.13	42.3	2.37	3.28
		8-31	↓	↓	5.18	↓			4.18	↓
3	9-7 TO 9-21	9-11	5.16	7.07	4.74	4.87	2.20	31.1	3.74	3.77
		9-14	↓	↓	5.00	↓			3.80	↓
4	9-22 TO 10-6	9-25	4.97	7.72	6.34	5.90	1.82	23.6	5.24	4.75
		9-28	↓	↓	5.46	↓			4.26	↓
5	10-7 TO 10-27	10-10	4.69	7.12	9.08	7.12	0	0	5.48	4.82
		10-13	↓	↓	5.15	↓			4.15	↓
6	10-28 to END	10-31	4.41	10.36	9.95	8.93	1.43	13.8	9.05	8.02
		11-3	↓	↓	7.90	↓			7.00	↓
	1993:									
7	4-20 TO 5-3	—								
8	5-4 TO 5-17	5-7	25.1	48.4	29.9	25.2	23.2	48.0	27.7	23.3
		5-10	↓	↓	20.4	↓			18.8	↓
9	5-18 TO 5-31	5-21	23.3	28.0	13.0	13.6	14.4	51.4	12.1	12.7
		5-24	↓	↓	14.2	↓			13.2	↓
10	6-1 TO 6-14	6-3	25.8	30.5	38.6	35.4	-4.9	-15.9	37.7	34.5
		6-7	↓	↓	32.1	↓			31.3	↓
11	6-15 TO 6-28	6-17	24.5	25.8	38.3	36.6	-10.8	-41.9	37.0	35.6
		6-21	↓	↓	34.8	↓			34.1	↓

CELL: 5

DOSE CYCLE NO.	DATES	LYSIMETER SAMPLE DATE	APPLIED NH4-N (DOSE AVG.) (mg/l)	APPLIED TN (DOSE AVG.) (mg/l)	DISCHARGED TN PER SAMPLE (mg/l)	DISCHARGED TN (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) (mg/l)	TN REDUCTION (DOSE AVG.) %	DISCHARGED NO3-N PER SAMPLE (mg/l)	DISCHARGED NO3-N (DOSE AVG.) (mg/l)
12	6-29 to 8-9	7-1	22.1	25.5	38.7	38.7	-13.2	-51.7	37.4	37.4
13	8-10 To 8-23	8-12	23.7	24.7	9.24	9.24	15.4	62.5	8.04	8.04
14	8-24 To 9-6	—								
15	9-7 To 10-5	9-9	10.1	12.8	13.4	13.4	-0.6	-4.3	0.37	0.37
16	10-6 To 11-1	10-11	0.99	4.69	13.0	7.35	-2.7	-56.6	12.0	6.17
		10-13	↓	↓	6.06	↓			5.46	↓
		10-16			4.24				3.34	
		10-19			4.23				3.33	
		10-22			9.20				6.70	
17	11-2 To END	11-4	3.71	10.7	4.20	4.68	6.0	56.1	3.40	3.95
		11-6	↓	↓	3.92	↓			3.22	↓
		11-9			4.49				3.89	
		11-11			4.79				4.19	
		11-14			4.80				3.90	
		11-16			5.16				4.36	
		11-18			5.39				4.69	

APPENDIX 7

FLORENCE ABSORPTION POND RESEARCH
EFFLUENT DATA

Date	NH4-N	NO3-N	TKN	Org. N	TN	T °C		pH	BOD	TSS	DAY
18-Aug-92	4.30	0.05	5.50	1.20	5.55	18.5		7.50	10.0	1.0	18
24-Aug-92	6.00	0.05	8.70	2.70	8.75	20.3		7.60	3.0	1.0	24
25-Aug-92	5.24	0.10	7.00	1.76	7.10	21.1		7.54			25
26-Aug-92	5.58	0.01	6.70	1.12	6.71	18.3		7.52			26
27-Aug-92	5.43	0.08	7.20	1.77	7.28	17.9		7.55			27
28-Aug-92	5.42	0.08	7.10	1.68	7.18	17.4		7.54			28
08-Sep-92	5.40	0.19	7.40	2.00	7.59	16.10		7.48			39
10-Sep-92	5.04	0.26	6.60	1.56	6.86	15.4		7.54			41
14-Sep-92	5.04	0.35	6.40	1.36	6.75	16.8		7.60			45
16-Sep-92	4.40	0.34	6.30	1.90	6.64	16.7		7.60	4.0	1.0	47
22-Sep-92	5.11	0.37	8.20	3.09	8.57	15.1		7.56	10.0	3.0	53
24-Sep-92	4.98	0.46	7.00	2.02	7.46	13.5		7.51			55
28-Sep-92	4.82	0.62	6.50	1.68	7.12	13.5		7.45			59
07-Oct-92	4.56	0.97	6.10	1.54	7.07	13.1		7.60			68
13-Oct-92	4.82	0.86	6.30	1.48	7.16	11.0		7.45			74
21-Oct-92	4.70	1.70	9.70	5.00	11.40	7.7		7.70	11.0	4.0	82
27-Oct-92	4.10	2.80	6.30	2.20	9.10	7.8		7.60	19.0	16.0	88
28-Oct-92	4.22	2.55	7.30	3.08	9.85	7.6		7.58			89
03-Nov-92	4.60	2.76	8.10	3.50	10.86	6.3		7.60			95
06-Nov-92	4.75	2.86	8.80	4.05	11.66	4.8		7.60			98
10-Nov-92	5.00	2.60	8.10	3.10	10.70	4.9		7.70	15.0	29.0	102
17-Nov-92	7.20	1.90	9.10	1.90	11.00	4.5		7.80	17.0	29.0	109
06-Apr-93	27.00	0.12	34.00	7.00	34.12	2.8		7.30	23.0	19.0	249
13-Apr-93	21.00	0.14	26.00	5.00	26.14	3.0		7.90	18.0	11.0	256
04-May-93	25.50	0.10	55.00	29.50	55.10	11.5		7.50	20.0	4.0	277
06-May-93	25.30	0.07	59.00	33.70	59.07	12.3		7.50			279
10-May-93	24.40	0.02	31.00	6.60	31.02	14.7		7.60			283
14-May-93	23.70	0.23	29.00	5.30	29.23	16.3		7.80			287
18-May-93	23.00	0.47	28.00	5.00	28.47	13.5		7.50			291
19-May-93	21.00	0.23	28.00	7.00	28.23	13.8		7.40	25.0	28.0	292
20-May-93	23.70	0.29	27.00	3.30	27.29	13.5		7.30			293
24-May-93	25.40	0.01	28.00	2.60	28.01	14.5		7.30			297
28-May-93	26.00	0.03	29.00	3.00	29.03	14.0		7.40			301
01-Jun-93	25.60	0.21	29.00	3.40	29.21	12.6		7.50			305
03-Jun-93	26.00	0.08	32.00	6.00	32.08	13.7		7.60			307
07-Jun-93	25.80	0.18	30.00	4.20	30.18	14.6		7.50			311
15-Jun-93	24.00	0.20	24.90	0.90	25.10	19.1		7.50			319
17-Jun-93	24.70	0.11	26.00	1.30	26.11	18.2		7.40			321
21-Jun-93	24.80	0.07	26.00	1.20	26.07	17.4		7.40			325
23-Jun-93	23.00	0.10	31.00	8.00	31.10	19.0		7.40	17.0	20.0	327
29-Jun-93	22.10	0.51	25.00	2.90	25.51	19.4	*	7.50			333
30-Jun-93	19.00	0.39	31.00	12.00	31.39	19.3	*	7.50	24.0	28.0	334
01-Jul-93	22.30	0.42	25.00	2.70	25.42	19.2		7.50			335
13-Jul-93	7.90	0.02	32.00	24.10	32.02	20.7		7.50	6.0	20.0	347
03-Aug-93	26.10	0.05	29.00	2.90	29.05	20.4		7.60			368
05-Aug-93	25.60	0.08	27.00	1.40	27.08	20.1		7.50			370

EFFLUENT DATA

Date	NH4−N	NO3−N	TKN	Org. N	TN	T °C		pH	BOD	TSS	DAY
09−Aug−93	23.90	0.15	25.00	1.10	25.15	20.3		7.50			374
12−Aug−93	23.40	0.16	24.00	0.60	24.16	20.5		7.50			377
19−Aug−93	17.80	0.15	20.00	2.20	20.15	20.0		7.50			384
23−Aug−93	16.00	0.04	19.00	3.00	19.04	20.8		7.30			388
26−Aug−93	15.20	0.01	18.00	2.80	18.01	22.4		7.60			391
31−Aug−93	14.40	0.04	16.00	1.60	16.04	19.8		7.70			396
02−Sep−93	10.00	0.15	15.00	5.00	15.15	18.6		7.70			398
06−Sep−93	11.60	0.13	14.00	2.40	14.13	18.3		7.60			402
15−Sep−93	8.67	0.50	11.00	2.33	11.50	15.8		7.50	12.0	5.0	411
18−Sep−93	6.87	1.20	8.40	1.53	9.60	16.8		7.60			414
21−Sep−93	5.90	0.69	7.80	1.90	8.49	15.0		7.50			417
28−Sep−93	3.77	0.76	5.40	1.63	6.16	14.1		7.40			424
30−Sep−93	3.10	0.90	4.80	1.70	5.70	12.4		7.50			426
05−Oct−93	1.63	1.38	3.60	1.97	4.98	10.4		7.50			431
08−Oct−93	1.14	1.25	3.30	2.16	4.55	12.4		7.60			434
12−Oct−93	0.82	1.24	2.80	1.98	4.04	9.9		7.70	12.0	10.0	438
15−Oct−93	0.62	1.32	3.20	2.58	4.52	9.9		7.80			441
19−Oct−93	0.78	1.30	3.50	2.72	4.80	10.3		7.70			445
22−Oct−93	0.97	1.25	4.00	3.03	5.25	10.2		7.70			448
26−Oct−93	1.03	1.26	5.20	4.17	6.46	9.4		7.80			452
27−Oct−93	1.40	1.20	4.80	3.40	6.00	10.3		7.60	12.0	24.0	453
01−Nov−93	1.72	1.30	6.40	4.68	7.70	5.4		7.90			458
04−Nov−93	2.16	1.22	7.20	5.04	8.42	5.3		7.90			461
09−Nov−93	3.57	1.20	9.10	5.53	10.30	3.7		8.10			466
11−Nov−93	4.01	1.14	10.00	5.99	11.14	3.8		8.00			468
16−Nov−93	5.18	1.16	12.00	6.82	13.16	3.5	*	8.10			473
18−Nov−93	5.61	1.20	12.00	6.39	13.20	3.4	*	7.60			475
30−Nov−93	8.51	1.02	14.00	5.49	15.02	2.8	*	7.80			487
02−Dec−93	9.72	1.00	15.00	5.28	16.00	2.7		7.70			489
04−Dec−93	9.98	0.93	15.00	5.02	15.93	2.1		7.90			491
07−Dec−93	13.00	0.70	15.00	2.00	15.70	4.1		7.80			494
08−Dec−93	12.20	0.80	16.00	3.80	16.80	4.3		7.70			495

* INTERPOLATED T DATA

DELETED DATA FROM ABOVE

Date		NH4−N	NO3−N	TKN	Org. N	TN	T °C	pH	BOD	TSS	DAY
17−Aug−93		19.90	0.16		−19.90	0.16	19.9	7.50			382
24−Jun−93		0.00	38.10	0.50	0.50	38.60	20.0	7.40			328
22−Jul−93	*	34.00	0.05	26.00	−8.00	26.05	19.3	7.60	7.0	9.0	356
25−Aug−93		17.00	0.12	14.00	−3.00	14.12	20.7	7.40			390

BOD AND TSS DATA

Date	NH4−N	NO3−N	TKN	Org. N	TN	T °C		pH	BOD	TSS	DAY
18−Aug−92 *	4.30	0.05	5.50	1.20	5.55	18.5		7.50	10.0	1.0	18
24−Aug−92 *	6.00	0.05	8.70	2.70	8.75	20.3		7.60	3.0	1.0	24
16−Sep−92 *	4.40	0.34	6.30	1.90	6.64	16.7		7.60	4.0	1.0	47
22−Sep−92 *	5.11	0.37	8.20	3.09	8.57	15.1		7.56	10.0	3.0	53
21−Oct−92 *	4.70	1.70	9.70	5.00	11.40	7.7		7.70	11.0	4.0	82
27−Oct−92 *	4.10	2.80	6.30	2.20	9.10	7.8		7.60	19.0	16.0	88
10−Nov−92 *	5.00	2.60	8.10	3.10	10.70	4.9		7.70	15.0	29.0	102
17−Nov−92 *	7.20	1.90	9.10	1.90	11.00	4.5		7.80	17.0	29.0	109
06−Apr−93 *	27.00	0.12	34.00	7.00	34.12	2.8		7.30	23.0	19.0	249
13−Apr−93 *	21.00	0.14	26.00	5.00	26.14	3.0		7.90	18.0	11.0	256
04−May−93 *	25.50	0.10	55.00	29.50	55.10	11.5		7.50	20.0	4.0	277
19−May−93 *	21.00	0.23	28.00	7.00	28.23	13.8		7.40	25.0	28.0	292
23−Jun−93									17.0	20.0	327
30−Jun−93 *	19.00	0.39	31.00	12.00	31.39			7.50	24.0	28.0	334
13−Jul−93									6.0	20.0	347
22−Jul−93									7.0	9.0	356
02−Aug−93				0.00	0.00				15.0	8.0	367
24−Aug−93				0.00	0.00				7.0	13.0	389
09−Sep−93				0.00	0.00	16.7		7.50	10.0	8.0	405
15−Sep−93	8.67	0.50	11.00	2.33	11.50	15.8		7.50	12.0	5.0	411
12−Oct−93	0.82	1.24	2.80	1.98	4.04	9.9		7.70	12.0	10.0	438
27−Oct−93	1.40	1.20	4.80	3.40	6.00	10.3		7.60	12.0	24.0	453
10−Nov−93				0.00	0.00				13.0	35.0	467
17−Nov−93				0.00	0.00				16.0	40.0	474

FLORENCE ABSORPTION POND RESEARCH
CELL 2 – UNDERDRAIN DATA

Date	NH4–N	NO3–N	TKN	Org. N	TN	T °C		pH			DAY
31–Aug–92	0.04	6.78	1.30	1.26	8.08	15.30		7.56			31
10–Sep–92	0.01	8.52	1.00	0.99	9.52	15.40		7.54			41
11–Sep–92	0.00	10.40	1.00	1.00	11.40	13.50		7.53			42
14–Sep–92	0.02	8.93	1.00	0.99	9.93	16.80					45
28–Sep–92	0.02	10.30	2.00	1.98	12.30	12.40		7.45			59
13–Oct–92	0.03	12.10	1.40	1.37	13.50	6.90		7.40			74
01–Nov–92	0.04	13.00	1.00	0.96	14.00						93
03–Nov–92	0.02	10.00	0.50	0.48	10.50						95
07–Nov–92	0.01	12.60	0.70	0.69	13.30						99
14–May–93	0.13	48.70	0.70	0.57	49.40						287
28–May–93	0.04	9.18	0.60	0.56	9.78						301
30–May–93	0.04	14.50	0.50	0.46	15.00						303
10–Jun–93	0.32	26.50	0.60	0.28	27.10						314
13–Jun–93	0.04	21.00	0.50	0.46	21.50						317
24–Jun–93	0.00	38.10	0.50	0.50	38.60						328
27–Jun–93	0.04	30.30	0.50	0.46	30.80						331
05–Aug–93	0.02	10.80	0.80	0.78	11.60	17.30		7.31			370
08–Aug–93	0.05	26.90	0.60	0.55	27.50	17.40		7.32			373
16–Aug–93				0.00	0.00	21.70		7.10			381
18–Aug–93				0.00	0.00	20.70		7.00			383
23–Aug–93	0.06	27.00	0.60	0.54	27.60	20.20		7.20			388
02–Sep–93	0.02	6.38	0.60	0.58	6.98	17.90		7.91			398
05–Sep–93	0.04	14.60	0.60	0.56	15.20	18.70		7.83			401
08–Sep–93	0.03	13.80	0.60	0.57	14.40	15.20		8.72			404
11–Sep–93	0.04	8.63	0.60	0.57	9.23	17.10		8.01			407
15–Sep–93	0.02	5.82	0.60	0.58	6.42	15.10		8.35			411
18–Sep–93	0.01	5.22	0.40	0.39	5.62	15.70		8.40			414
21–Sep–93	0.01	17.10	0.80	0.80	17.90	15.00		8.49			417
28–Sep–93	0.01	18.00	0.50	0.50	18.50	15.40		6.60			424
30–Sep–93	0.01	23.00	0.50	0.49	23.50	12.40		7.53			426
03–Oct–93	0.03	17.10	0.80	0.77	17.90	12.70		7.66			429
05–Oct–93	0.05	16.90	0.90	0.85	17.80	8.20		8.21			431
08–Oct–93	0.04	9.09	0.40	0.36	9.49	13.40					434
10–Oct–93	0.02	11.20	0.50	0.48	11.70						436
12–Oct–93	0.01	16.50	1.00	1.00	17.50	10.10		8.35			438
15–Oct–93				0.00	0.00	9.90		8.51			441
19–Oct–93				0.00	0.00	10.30		7.70			445
20–Oct–93	0.04	9.81	0.60	0.56	10.41	8.10		8.20			446
31–Oct–93	0.02	2.71	1.40	1.38	4.11	7.60		7.83			457
03–Nov–93	0.01	2.82	1.30	1.29	4.12	4.70		7.86			460
06–Nov–93	0.01	3.00	1.70	1.69	4.70	2.40		7.90			463
09–Nov–93	0.02	3.27	5.90	5.88	9.17	4.40		7.83			466
11–Nov–93	0.01	3.48	1.00	0.99	4.48	5.20		7.78			468
02–Dec–93	0.18	1.26	5.40	5.22	6.66	0.00		8.12			489

FLORENCE ABSORPTION POND RESEARCH
CELL 5 – UNDERDRAIN DATA

Date	NH4–N	NO3–N	TKN	Org. N	TN	T °C		pH			DAY
28–Aug–92	0.09	2.37	1.10	1.01	3.47	17.40		7.60			28
31–Aug–92	0.08	4.18	1.00	0.92	5.18	15.30		7.56			31
11–Sep–92	0.03	3.74	1.00	0.97	4.74	13.50		7.53			42
14–Sep–92	0.04	3.80	1.20	1.16	5.00	16.80					45
25–Sep–92	0.25	5.24	1.10	0.85	6.34	14.00		7.40			56
28–Sep–92	0.14	4.26	1.20	1.06	5.46	12.30		7.50			59
10–Oct–92	2.73	5.48	3.60	0.87	9.08	13.70		7.44			71
13–Oct–92	0.08	4.15	1.00	0.92	5.15	8.10		7.45			74
31–Oct–92	0.09	9.05	0.90	0.81	9.95						92
03–Nov–92	0.13	7.00	0.90	0.78	7.90						95
17–Nov–92	0.07	5.97	0.80	0.73	6.77	4.00		7.75			109
07–May–93	1.08	27.70	2.20	1.12	29.90						280
10–May–93	0.47	18.80	1.60	1.13	20.40						283
21–May–93	0.06	12.10	0.90	0.84	13.00						294
24–May–93	0.15	13.20	1.00	0.85	14.20						297
03–Jun–93	0.71	37.70	0.90	0.19	38.60						307
07–Jun–93	0.06	31.30	0.80	0.74	32.10						311
17–Jun–93	0.10	37.00	1.30	1.20	38.30						321
21–Jun–93	0.04	34.10	0.70	0.66	34.80						325
01–Jul–93	0.18	37.40	1.30	1.12	38.70						335
12–Aug–93	0.05	8.04	1.20	1.15	9.24	19.50		7.31			377
14–Aug–93				0.00	0.00	19.50		7.38			379
09–Sep–93	11.00	0.37	13.00	2.00	13.37						405
11–Oct–93	0.04	12.00	1.00	0.96	13.00	9.40		8.23			437
13–Oct–93	0.02	5.46	0.60	0.58	6.06	8.30		8.41			439
16–Oct–93	0.01	3.34	0.90	0.89	4.24	8.50		8.10			442
19–Oct–93	0.01	3.33	0.90	0.89	4.23	10.50		8.34			445
22–Oct–93	0.04	6.70	2.50	2.46	9.20	9.40		8.44			448
04–Nov–93	0.03	3.40	0.80	0.78	4.20	6.60		7.96			461
06–Nov–93	0.02	3.22	0.70	0.68	3.92	3.10		7.57			463
09–Nov–93	0.03	3.89	0.60	0.57	4.49	4.60		8.15			466
11–Nov–93	0.01	4.19	0.60	0.60	4.79	6.20		7.99			468
14–Nov–93	0.04	3.90	0.90	0.86	4.80	5.00		8.21			471
16–Nov–93	0.06	4.36	0.80	0.74	5.16	3.80		7.93			473
18–Nov–93	0.08	4.69	0.70	0.62	5.39	4.70		7.88			475

FLORENCE ABSORPTION POND RESEARCH
CELL 3 – UNDERDRAIN DATA

Date	NH4–N	NO3–N	TKN	Org. N	TN	T °C		pH			DAY
28–Aug–92	4.57	0.84	6.00	1.43	6.84	17.40		7.60			28
10–Sep–92	3.95	1.40	5.40	1.45	6.80	13.50		7.53			41
25–Sep–92	3.14	2.49	4.40	1.26	6.89	14.00		7.40			56
10–Oct–92	2.68	3.12	4.10	1.42	7.22	13.70		7.44			71
31–Oct–92	2.17	4.68	4.10	1.93	8.78						92
07–May–93	22.10	3.03	26.00	3.90	29.03						280
21–May–93	22.20	3.54	25.00	2.80	28.54						294
03–Jun–93	24.30	0.82	26.00	1.70	26.82			7.68			307
17–Jun–93	0.11	182.00	1.90	1.79	183.90						321
01–Jul–93	21.20	0.76	21.00	−0.20	21.76						335
03–Aug–93	25.20	0.68	26.00	0.80	26.68						368
05–Aug–93	0.07	162.00	0.20	0.13	162.20	18.10					370
19–Aug–93	2.93	7.89	5.20	2.27	13.09	22.20		7.33			384
31–Aug–93	0.02	21.70	1.20	1.18	22.90	18.50		7.75			396
02–Sep–93	12.50	1.05	14.00	1.50	15.05	19.10		7.66			398
21–Sep–93	1.74	4.90	2.90	1.16	7.80	15.60		7.51			417
28–Sep–93	0.02	19.30	1.00	0.98	20.30	12.60		7.61			424
30–Sep–93	1.44	2.67	3.00	1.56	5.67						426
20–Oct–93	0.01	2.04	1.50	1.49	3.54	9.60		7.64			446
22–Oct–93	0.02	2.17	1.40	1.38	3.57	9.30		7.73			448
25–Oct–93				0.00	0.00	9.10		7.53			451
26–Oct–93	0.10	2.07	1.60	1.50	3.67						452
28–Oct–93	0.07	2.34	1.70	1.63	4.04	8.10		7.58			454
16–Nov–93	4.16	1.73	15.00	10.84	16.73	4.30		7.70			473
18–Nov–93	4.58	15.00	15.00	10.42	30.00	5.00		7.66			475
30–Nov–93	0.88	16.60	2.70	1.82	19.30	2.10		7.25			487
02–Dec–93	0.08	12.10	1.80	1.72	13.90	4.90		7.55			489

FLORENCE ABSORPTION POND RESEARCH
CELL 1 – UNDERDRAIN DATA

Date	NH4–N	NO3–N	TKN	Org. N	TN	T °C		pH			DAY
07–Nov–92	0.02	4.68	1.20	1.18	5.88						99
09–Nov–92	0.01	9.53	0.30	0.29	9.83						101
17–Nov–92	0.01	5.59	0.40	0.39	5.99	4.00		7.75			109
07–May–93	12.50	13.80	13.00	0.50	26.80						280
10–May–93	11.80	2.44	13.00	1.20	15.44						283
21–May–93	1.63	3.63	2.80	1.17	6.43						294
24–May–93	15.60	0.06	16.00	0.40	16.06						297
03–Jun–93	10.00	1.74	11.00	1.00	12.74						307
07–Jun–93	14.60	0.72	16.00	1.40	16.72						311
17–Jun–93	15.30	0.15	17.00	1.70	17.15						321
21–Jun–93	14.60	1.08	15.00	0.40	16.08						325
01–Jul–93	10.20	6.48	12.00	1.80	18.48						335
05–Aug–93	0.85	4.15	1.80	0.95	5.95	19.70		6.33			370
09–Aug–93	13.30	0.57	13.00	–0.30	13.57	20.30		–			374
19–Aug–93	1.27	2.14	2.30	1.03	4.44	22.50		6.75			384
23–Aug–93	4.26	1.08	5.40	1.14	6.48	21.50		7.18			388
31–Aug–93	3.67	0.37	5.00	1.33	5.37	20.50		6.80			396
02–Sep–93	5.47	0.93	6.60	1.13	7.53	19.50		7.03			398
05–Sep–93	2.40	5.05	3.40	1.00	8.45	19.50		7.75			401
08–Sep–93	1.77	10.50	2.50	0.73	13.00	16.00		7.15			404
11–Sep–93	1.24	18.40	1.90	0.66	20.30	17.60		7.85			407
15–Sep–93	0.02	14.00	0.80	0.78	14.80	15.60		7.86			411
18–Sep–93	0.23	7.34	1.10	0.87	8.44	15.90		7.17			414
21–Sep–93	0.01	22.90	0.06	0.05	22.96	15.40		7.81			417
03–Oct–93	0.03	41.20	0.80	0.77	42.00	13.10		7.85			429
04–Oct–93	0.01	5.74	0.80	0.80	6.54	11.60		6.86			430
05–Oct–93	0.04	3.04	1.00	0.97	4.04	11.70		6.88			431
06–Oct–93	0.01	2.83	0.90	0.89	3.73	10.60		7.24			432
07–Oct–93	0.01	2.39	0.90	0.89	3.29	12.30		7.15			433
08–Oct–93	0.02	2.14	0.80	0.78	2.94	12.90		7.66			434
09–Oct–93	0.02	2.38	0.60	0.58	2.98	10.50		7.44			435
10–Oct–93	0.02	2.38	0.70	0.68	3.08						436
11–Oct–93	0.02	2.80	0.60	0.58	3.40	9.70		7.05			437
12–Oct–93	0.02	2.26	0.60	0.58	2.86	9.00		7.26			438
13–Oct–93	0.02	1.76	0.60	0.58	2.36	9.60		7.17			439
14–Oct–93	0.03	1.82	0.80	0.77	2.62	8.60		7.25			440
15–Oct–93				0.00	0.00	9.30		7.30			441
16–Oct–93	0.01	1.83	0.90	0.89	2.73	8.60		7.61			442
17–Oct–93	0.01	1.65	0.80	0.79	2.45	8.70		7.63			443
18–Oct–93	0.01	1.45	0.90	0.89	2.35	9.30		7.30			444
19–Oct–93	0.01	1.41	0.70	0.69	2.11	10.60		7.26			445
20–Oct–93	0.01	1.34	0.70	0.69	2.04	8.10		7.40			446
21–Oct–93	0.01	1.36	0.60	0.59	1.96	11.60		7.84			447
22–Oct–93	0.01	1.47	0.60	0.59	2.07	9.10		7.64			448

CELL 1

Date	NH4-N	NO3-N	TKN	Org. N	TN	T °C		pH			DAY
28-Oct-93				0.00	0.00	9.00		7.21			454
31-Oct-93	0.02	2.23	1.10	1.08	3.33	7.70		7.58			457
03-Nov-93	0.01	2.56	1.70	1.69	4.26	4.50		7.80			460
06-Nov-93	0.01	2.64	1.00	0.99	3.64	3.60		7.83			463
09-Nov-93	0.01	3.43	1.50	1.49	4.93	4.50		7.05			466
11-Nov-93	0.01	3.20	1.90	1.89	5.10	5.70		7.09			468
02-Dec-93	0.05	5.71	0.60	0.55	6.31	5.00		8.25			489
04-Dec-93	0.04	5.79	0.60	0.56	6.39	1.50		7.87			491
06-Dec-93	0.05	6.01	0.60	0.55	6.61	3.60		8.13			493
08-Dec-93	0.06	6.64	0.60	0.54	7.24	4.80		7.77			495