TRANSPORT OF SWINE EFFLUENT SALTS WHEN LAND-APPLIED IN A SEMI-ARID REGION THROUGH A SUBSURFACE DRIP IRRIGATION SYSTEM

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IRRIGATION SYSTEM

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CHAPTER I

INTRODUCTION

An 18th century Scottish proverb states, "We'll never know the worth of water till the well go dry." This statement is quickly becoming all too true because of the increased water consumption and the need for greater food production due to population growth around the world. In addition to water use efficiency, environmental protection will become incredibly important in the future to ensure the availability of clean water, particularly in arid and semi-arid regions.

Background

The panhandle of Oklahoma, here forth known as the panhandle, is a semi-arid agricultural region that relies primarily on the High Plains aquifer for municipal and domestic drinking water, livestock drinking water and crop irrigation. The High Plains aquifer underlies over 174,000 square miles (45 million ha) of land in parts of eight (8) states, including more than 7100 square miles (1.8 million ha) in northwestern Oklahoma (Andrews et al., 2000). In Oklahoma, this aquifer, known as the Ogallala, has a saturated thickness ranging from zero ft (0 m) to over 400 ft (121 m) (Luckey et al., 2000).

The panhandle is comprised of three counties: Cimarron, Texas and Beaver. The late 1960's brought more crop irrigation to the panhandle and the Ogallala became the source for the irrigation water. Figure I-1 shows a comparison of irrigated acres between each county in the panhandle, as well as, a total number of irrigated acres for that area. As is illustrated in figure I-1, the peak use occurred in the early 1970's and again in the early 1980's. Since then the total number of irrigated acres decreased, though in 1987 the number of irrigated acres was still nearly 300,000 (122,000 ha) for the entire panhandle.

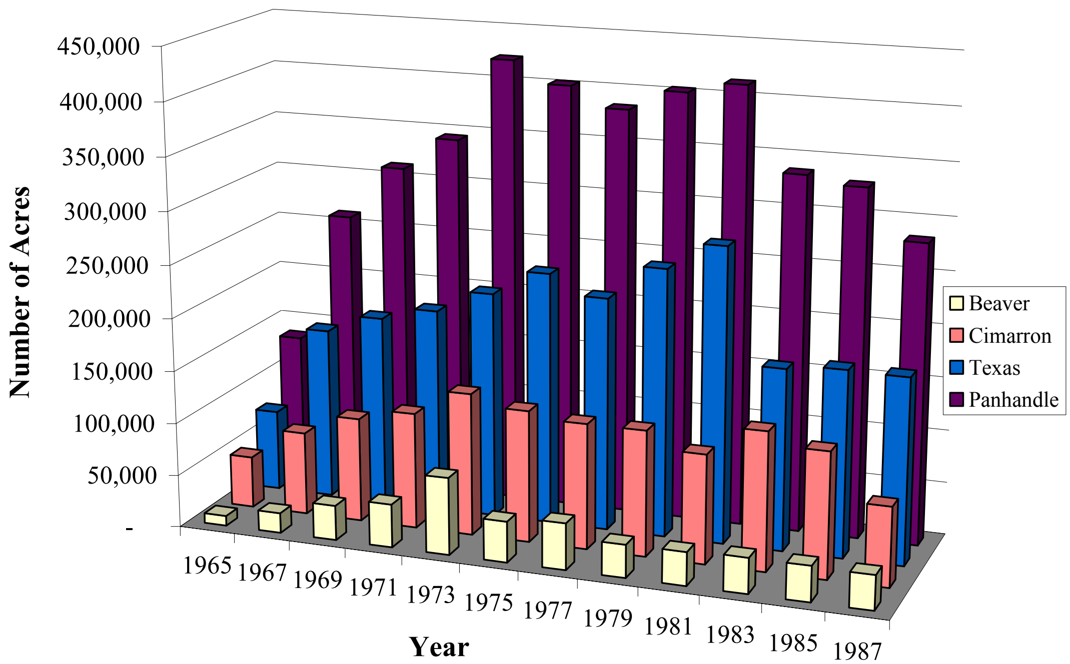


Figure I-1 Acres Irrigated with Groundwater in the panhandle of Oklahoma (OCES, 1965-1987).

Belden and Scurlock (2001) completed a comparison of the groundwater elevations in a well located in Texas County, Oklahoma. The graphic, shown in figure I-2, presents the water elevations for years 1965 to 2000. During that time, the groundwater levels decreased from approximately 3370 feet (1027 m) in 1965 to less than 3290 feet (1003 m) in 2000. The most distinct decrease between years is noted between 1972 and 1973, which corresponds with the maximum number of total hectares irrigated in the panhandle. Contrasting popular belief, the increase in irrigated hectares in 1981 did not seem to noticeably influence the groundwater level, at least not within this particular well. The reduction in hectares irrigated during the remainder of the 1980's data appears to have aided in a slight recharge of the aquifer until 1987.

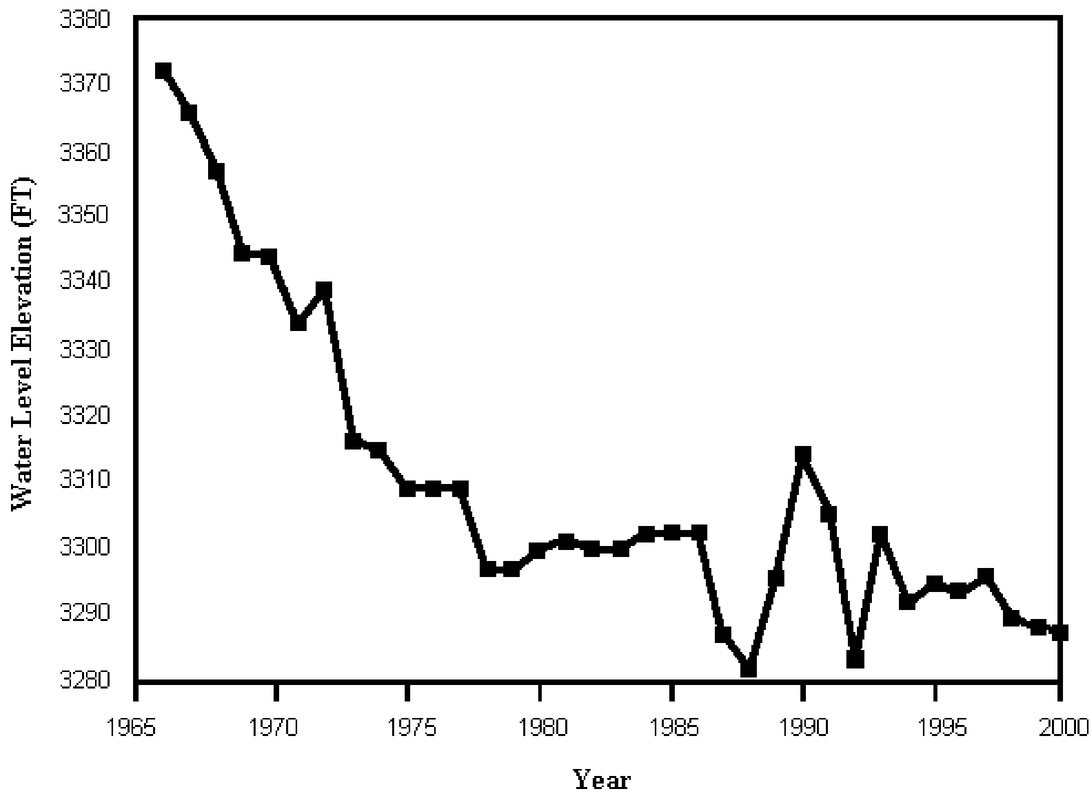


Figure I-2 Groundwater elevations in the Ogallala Aquifer in Texas County, Oklahoma (Belden and Scurlock, 2001).

Swine production in the Oklahoma panhandle has increased dramatically over the past 10 years. The number of swine located in that region (including Ellis and Harper Counties) has rapidly increased from 40,000 head in 1993 to almost 1.5 million head in 2001, as illustrated in figure I-3 (USDA-NASS, 2002).

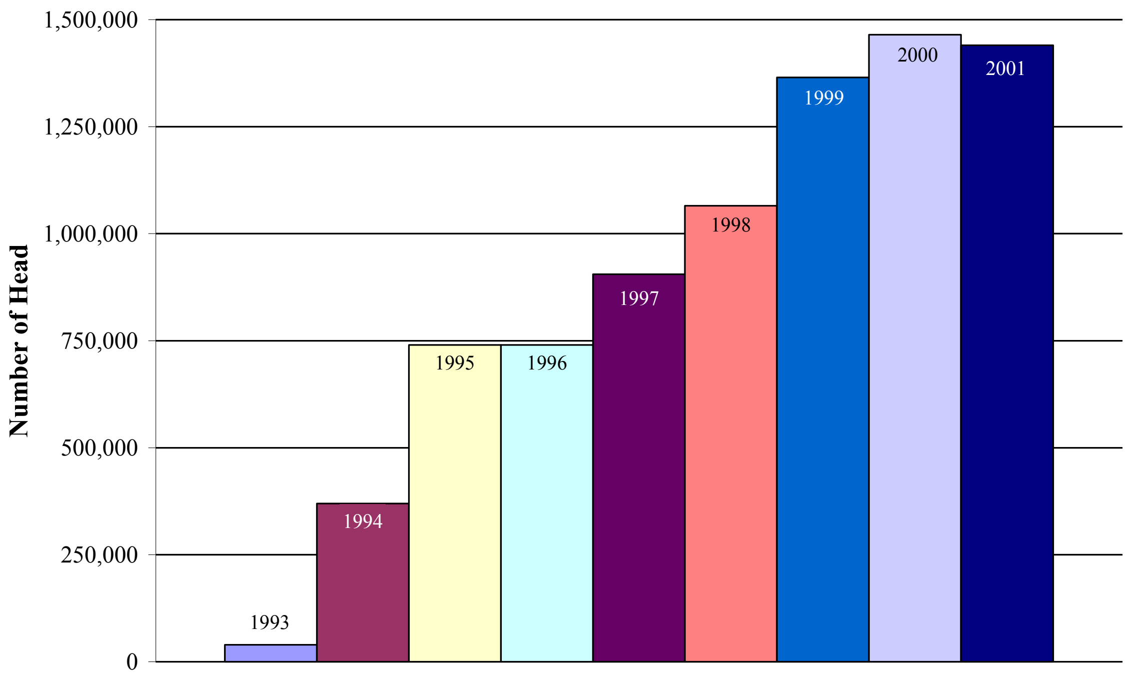


Figure I-3 Number of swine in the panhandle from 1993 through 2001 (USDA-NASS, 2002).

Most swine facilities in the area consist of barn(s), animal waste retention structure(s) (AWRS) and land application area(s). As a part of the operation of the facility, the volume within the AWRS is periodically pumped to remove effluent. The removed effluent is normally applied to land that is owned or leased by the facility owner. In general, land application is completed utilizing a volume gun sprinkler or a center pivot irrigation system. There are many advantages associated with the use of swine effluent for land application purposes, some of which include the use of nutrients from animal production rather than commercial fertilizers, along with reuse of water and the treatment of the liquid prior to discharge into a water of the state.

Due to the odorous nature of the effluent that is introduced through land application, swine facilities are subject to odor and improper land application complaints and run the risk of being fined for such problems. Figure I-4 provides an illustration of the number of complaints filed against swine facilities in the panhandle in the recent past. The types of complaints and the counties in which they are located are exemplified in the figure.

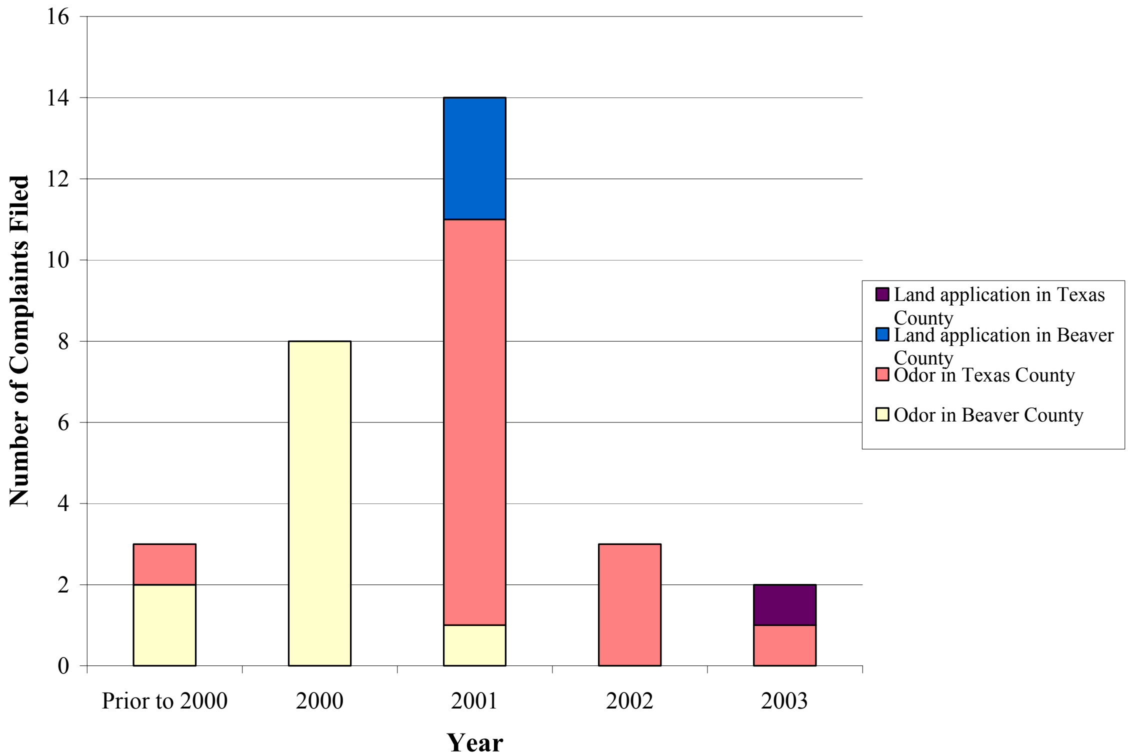


Figure I-4 Complaints filed against swine facilities in the panhandle (ODAFF-WQS, 2003).

Subsurface drip irrigation (SDI) is an alternative to surface land application of swine effluent. The idea of employing SDI will not only help to reduce the odors caused by the use of the swine effluent but will also aid in fresh water conservation. However, several problems could arise from the use of this type of technology with swine effluent. Emitter clogging due to solids content and precipitation of minerals within the effluent, and excess concentrations of salt in the root zone are two possible problems associated with applying swine effluent through an SDI system.

Lamm et al. (2002) determined the performance of five (5) different types of drip lines over a period of four years. Each drip line possessed a different emitter flow rate. The study was to establish the appropriate emitter size to prevent emitter clogging during the application of beef livestock wastewater. Thus far, the two smaller emitters have had a flow rate reduction of 30 and 40%, whereas the highest percentage of reduction in the three largest emitters was 13%.

Not only is it imperative to determine how the effluent will affect flow rate but also to determine the extent of salt transport in the soil when comparing different emitter sizes. This comparison is important because of time to saturation within the profile surrounding the emitter tape. The force of gravity will play a major role in determining the location of the salts. A higher flow rate will bring the profile to saturation faster, which should impede the capillary flow and enhance the gravitational flow. It is expected that the salinity and sodicity will be found in the lower portion of the profile within the plots with the higher flow rate emitters. Therefore, the plots with the lower flow rate emitters should show signs of salt buildup near the emitter tape.

Objective

The focus of this project is to make a recommendation for the appropriate size of emitter when land applying swine effluent. The recommendation will be based on the salt and sodium accumulation within the root zone. Field data will be utilized to determine the transport of salts by measuring electrical conductivity (EC), the sodium adsorption ratio (SAR) and several elemental components as they change over time in the saturated paste extracts. Three (3) different subsurface drip emitter sizes will be compared.

CHAPTER II

LITERATURE REVIEW

This literature review evaluates other contributions to the study of the use of SDI to land apply swine effluent. An examination of the constituents found in swine effluent and the effect of those constituents on soil structure and particle dispersion is included. Irrigation water quality is discussed along with remedies for adverse effects caused by the effluent and, finally, a review of SDI systems concludes this chapter.

Swine Effluent Constituents

The characteristics of a swine lagoon are variable and dependent on the treatment process and the season of the year. The use of anaerobic lagoons is common to aid in the reduction of nitrogen through the process of ammonia volatilization. When designed and operated properly they decrease BOD and COD by microbial and chemical degradation, and reduce odors to some extent (Tanji, 1997). Swine lagoon effluent contains additional components including nutrients, such as nitrogen and phosphorus, and salts like sodium, calcium, magnesium, potassium (which also has fertilizer benefits), chloride and sulfate.

The salt concentrations, typically measured by electrical conductivity (EC), in these semi-arid regions can range from 3 dS/m (3000 μmhos/cm) to 9 dS/m (9000 μmhos/cm) or higher (Hamilton, 2003). Sodium is one of the salts of concern found at high levels within swine effluent. High sodium concentrations lead to a high sodium adsorption ratio (SAR), which characteristically is found to be in the range of 3 to 9, in swine waste retention structures located in semi-arid regions. Additionally, nitrate is the nutrient that is of most concern with regards to groundwater pollution because it is highly mobile (Tanji, 1997).

Irrigation Water Quality

Johnson and Zhang (2003) provide two measures that are important in determining irrigation water quality: (i) the total amount of dissolved salts in the water and (ii) the amount of sodium (Na) in the water compared to calcium (Ca) plus magnesium (Mg). In addition to the two measures supplied by their research, Johnson and Zhang (2003) provide an illustration that indicates that a sodium adsorption ratio (SAR) above 4 and/or an EC above 3000 μmhos/cm (3 dS/m) is considered poor, very poor or unsuitable quality irrigation water.

The future may require the use of saline water for irrigation purposes if shortages of quality irrigation water becomes an problem. According to Oron et al. (1995), saline water can be used in arid and semi-arid regions if leaching and moisture content in the root zone are sustained. These practices will remove the salts from the root zone or maintain appropriate water balance for the crops, respectively.

Sodicity Effect on Soils

According to Donahue et al. (1977) and Johnson and Zhang (2003), it is detrimental for irrigation waters to contain high concentrations of sodium because the soil aggregates will disperse, seal the pores and cause the permeability to decrease due to the sodium ions adsorbing to the soil cation exchange sites. Whereas, if calcium and magnesium make up the majority of the cations in the soil, it is inclined to be more permeable (Eisenhauer et al., 2001). Suarez et al. (1984) claim that the subsurface regions of arid and semiarid soils are generally calcareous. Calcareous soils contain high levels of calcium carbonate and often high levels of magnesium carbonate.

Structural deterioration occurs when the clays in sodic soils disperse, the deterioration may cause a hard surface crust or a hardening in the subsurface layer when dry (Pratley and Robertson, 1998). The decrease in permeability caused by excess sodium can restrict the movement of water through the soil, which will reduce the movement of salts out of the root zone. Failing to remove salts from the plant root zone can cause water stress in plants due to increased osmotic potential in the soil water.

Salinity Effect on Soils

Salinity has become a significant element in the degradation of arid and semi-arid lands (Araüés et al., 1999; Assouline and Ben-Hur, 2003; Enciso et al., 2002; Feng et al., 2003; Nightingale et al., 1991; Royo et al., 2000). Eisenhauer et al. (2001) indicate that the weathering of primary minerals in rocks produce the soluble salts found in the soil and that the salts do not typically move from the original sites of weathering in arid regions, due to lack of rainfall. However, once these lands are placed into production the irrigation water becomes the source of salt, in addition to the salts already found in the soils. As water moves through the soil the soluble salts are carried to the extent of the wetting front (Nakayama and Bucks, 1986; Beltrao and Ben-Asher, 1997).

Plants must exert more energy to use the soil water if a solution with high salt concentration is present (Donahue et al., 1977). Campbell et al. (1986) confirmed that in semi-arid climates approximately one-third (1/3) of all irrigated areas were affected seriously by salinity, which often significantly decreases crop yield. Equation II-1 provides a means to calculate the relative yield in a salt affected soil.

$$Y_r = 100 - S\left(EC_e - T\right) \quad for\ EC_e > T$$ **Equation II-1**

where Y_r is the relative yield (%), T is salinity threshold expressed in EC_e (dS/m), S is slope expressed in % per dS/m, and EC_e is the mean salt concentration (dS/m) of saturated soil extracts taken from the crop root zone (Maas and Hoffman, 1977).

Management of Salinity and Sodicity

The reduction of the effects of salinity and sodicity in the crop root zone is discussed as follows by Kruse (1990): (i) select a crop that produces satisfactory yield under these conditions, (ii) utilize procedures during planting that reduce the accumulation of salts around the seeds, (iii) increase uniformity of irrigation water infiltration by using appropriate land preparation methods, (iv) provide adequate water content in the root zone by implementing proper irrigation procedures, (v) supply drainage systems, which provide for leaching, rooting and trafficability, (vi) maintain soil permeability and tilth through the use of chemical or organic treatments, (vii) take into consideration the soil properties when planning the use of saline irrigation water.

Leaching can be used to remove salts from the crop root zone. Eisenhauer et al. (2001) maintains that leaching must be increased as the salinity of the irrigation water increases or if the crops are more salt sensitive in order to preserve the appropriate yield. Equation II-2 describes this relationship.

$$L = \frac{d_d}{d_a} = \frac{C_a}{C_d} = \frac{EC_a}{EC_d}$$ **Equation II-2**

where L is the leaching fraction, d_d is the depth of water draining below the crop root zone, d_a is the depth of applied water (irrigation plus rainfall), C_a is the weighted-mean salt concentration of the applied water, and C_d is the salt concentration of the draining water (Eisenhauer et al., 2001). The weighted-mean salt concentration is given in equation II-3.

$$C_a = \frac{C_i d_g + C_r d_r}{d_g + d_r}$$ **Equation II-3**

where the subscript g denotes gross irrigation, r indicates rainfall, and a represents total applied water. The $C_r d_r$ term becomes zero (Eisenhauer et al., 2001) because C_r much less than C_i. To prevent any reduction in crop yield, the minimum leaching fraction must be calculated. This leaching requirement (L_r) is expressed in equation II-4.

$$L_r = \frac{d_d^*}{d_a} = \frac{C_a}{C_d^*} = \frac{EC_a}{EC_d^*}$$ **Equation II-4**

in which the superscript * distinguishes that the value must be taken from actual site specific data (Eisenhauer et al., 2001).

Subsurface Drip Irrigation

Subsurface drip irrigation (SDI) has been generally used only for the past 10 to 15 years to describe drip/trickle application equipment installed below the soil surface (Camp, 1998). Subsurface drip irrigation is defined by ASAE (1996) as "application of water below the soil surface through emitters, with discharge rates generally in the same range as drip irrigation". SDI systems provide many advantages for crop irrigation but at the same time there are disadvantages associated with this technology.

Advantages

The following discusses the advantages associated with the use of SDI. These advantages include, but are not limited to:

1. Reduction in evaporation can be achieved by converting a system from surface drip to SDI. Bonachela et al. (2001) noted that evaporation loss was reduced by 4-11% of the ET_c for mature orchard and 18-41% of the ET_c for a young orchard;
2. Placement of the irrigation water directly in the root zone;
3. Overall efficiency is increased, including conveyance efficiency, application efficiency and water use efficiency (Barth, 1999);
4. The top soil is predominantly dry which reduces humidity under the crop canopy. This minimizes the occurrence of soil-borne diseases, weeds, rot and impedes the growth of fungi and bacteria (Phene, 1999);
5. Fulton et al. (1991) offers that SDI reduces percolation below the root zone by applying only the amount of irrigation water that has been depleted;
6. Systems can be designed to fit fields of abnormal shape;
7. Oron et al. (1991) found that applying treated wastewater through SDI removes chances of crops becoming contaminated by fecal coliform;
8. Reduction of human contact with wastewater (Trooien et al., 1999);

9. Allows the field to be more trafficable because all pipes are buried and the surface remains relatively dry (Phene, 1999);
10. Crop yield increase (Camp, 1998); and
11. Eliminates the chances of surface runoff.

Disadvantages

There are also disadvantages associated with SDI systems, which include:

1. High initial cost;
2. Emitter clogging caused by small emitter sizes (Trooien, 1999), which includes particle clogging and root intrusion;
3. Damage of drip tape by burrowing animals; and
4. Salinity problems under poor management (Phene et al., 1995).

Soil Salinity Distribution under Subsurface Drip Irrigation

Hoffman et al. (1985) noted in their research that the soil salinity was higher near the soil surface and midway between the emitters. Yet, Camp et al. (2000) found that the concentration of salts on or near the surface were reduced utilizing properly designed and operated SDI in comparison with surface drip systems. At the same time, in arid and semi-arid regions where there is less rainfall, salinity may still be a problem above the drip tape (Camp et al., 2000). Salinity distribution in the soil as expressed by the EC_e, as determined by Oron et al. (1999), was extremely high in the upper few centimeters of the profile close to the soil surface, with the emitters installed at a 30 cm depth. They also found through this research that SDI continuously leaches salts in all directions radially from the emitters, which agrees with Hoffman et al. (1985) results. The research completed by Ayers et al. (1995) also corresponds with the others and indicates that drip laterals that are installed between crop rows, force the salts to move below the crop rows.

A study completed by the Irrigation Training and Research Center (ITRC) on systems three years old and older with a drip tape spacing of 80 in (203 cm) in the San Joaquin Valley of California produced results as follows (ITRC, 2003):

- No consistent pattern of salinity on the periphery of the wetted areas.
- Patterns of salinity with respect to depth were apparent.
- Soil samples from adjacent furrow irrigated fields did not show obvious differences in salinity when compared to the SDI fields.
- All SDI fields showed a gradient of increasing salt concentration above the hose depth due to evaporation from the soil surface and from plant uptake.

The ITRC (2003) concluded that it does not appear that special leaching practices are needed on fields irrigated with subsurface drip.

CHAPTER III

MATERIALS AND METHODS

Research Site

The research site is located at the Oklahoma Panhandle Research and Extension Center in Goodwell, Texas County, Oklahoma. Fifty-two research plots are positioned in the south half (S/2) of the southwest quarter (SW/4) of the southwest quarter (SW/4) of Section 36 Township 2 North (T2N), Range 13 East Cimarron Meridian (R13ECM). Forty-eight (48) small plots are utilized for agronomic research and four (4) larger plots, numbered 49-50, 51, 52, and 53, are used for this project. Each large plot is 183 m (600 ft) long and 18.3 m (60 ft) wide and is situated in a fashion that runs east and west. The land surface is fairly flat with an elevation change within the section of less than 3 m (10 ft) from northwest to southeast as shown on the Goodwell SE quad map found in Appendix A (TopoZone, 2003).

The soil at the site is Richfield Clay Loam. Richfield Clay Loam is one of the most productive and, therefore, is one of the most desirable soils in the county. The soil has a highly calcareous loess parent material with many outcrops of caliche within the Richfield series (USDA-SCS, 1961).

Subsurface Drip Irrigation System (SDI)

The subsurface drip irrigation system (SDI) that is being utilized for this research is very adaptable. There are many attributes to the system that are not being utilized for the research covered within this thesis, therefore, only the characteristics of the system that are being employed are described below.

1. A preexisting well is utilized by the system.
2. A 19 kW (25 hp) submersible pump is installed in the well with the ability to produce 662 L/min (175 gpm) at 207 kPa (30 psi) with 77% efficiency.
3. A 10.12 cm (4 in) pressure reducing valve follows the pump to reduce the water pressure from in excess of 690 kPa (120 psi) at low flow rates to approximately 310 kPa (45 psi).
4. A chemigation check valve is inline to prevent backflow of waste, acid and/or fertilizer into the well.
5. A pressure relief valve is mounted next and is set to release if the pressure exceeds 345 kPa (50 psi).
6. The pipeline is then reduced to 7.62 cm (3 in) diameter PVC pipe and buried until it reaches the controller building. A riser brings the line above ground outside the building.
7. A 7.62 cm (3 in) diameter flexible hose with a manual disconnect cam lever coupler connects the riser to the pipe entering the building. This is the location at which the tanker truck supply hose is connected when effluent application occurs.

8. Upon entering the control building, the flow passes through two, 140-mesh disk filters.
9. A pressure reducing/pressure sustaining valve follows the filters. This valve not only reduces the pressure going to the plots to 138 kPa (20 psi) but it also aids in flushing the filter system. When the pressure drop across the filters exceeds 34 kPa (5 psi) the valve provides the required 276 kPa (40 psi) of pressure to properly flush the filters.
10. The supply line then branches into to two separate lines to operate different plots simultaneously with differing conditions.
11. The system is equipped with two water meters, one installed in each supply line.
12. A fertilizer injection system follows each of the water meters. The fertilizer injection system consists of the following ports in order:
    a. An injection port introduces fertilizer, acid, etc. into the system. This port is also used to recycle the liquid that is removed from the system at the following ports.
    b. An electrical conductivity (EC) and pH sampling port constantly removes liquid and analyzes it for EC and pH.
    c. An intake port removes liquid from the flow stream to combine with fertilizer, acid, etc. that is added to the system.
13. The pipeline is next reduced to 2.54 cm (1 in) for the small plots and 5.08 cm (2 in) for the large plots.

14. There is a valve assembly for each plot next. The valve assemblies consist of the following items sequentially:
    a. A ball valve for each plot,
    b. A solenoid valve for each plot,
    c. A vacuum relief valve for each plot.
15. Five sub-mains for the large plots are then buried; two sub-mains for the first plot and one sub main for each of the remaining three plots.
16. The two sub-mains for plot 49-50 each lead to six (6) lateral lines. The high flow rate of the emitters on this plot required splitting the flow to minimize pressure loss in the valves and sub-main. When the remaining sub-mains reach each of the plots, 51, 52 and 53, 12 lateral lines branch onto the plots. The laterals are thin wall polyethylene drip tube with 13-mil thickness and are seamless. The drip tube is manufactured by Netafim.
17. Each plot is equipped with different emitters.
    a. Plot 49-50 consists of 2 L/h (0.53 gph) emitters on 61.0 cm (24 in) spacing.
    b. Plot 51 incorporates a 1.25 L/h (0.33 gph) emitter on 61.0 cm (24 in) spacing.
    c. Plot 52 integrates a 0.79 L/h (0.21 gph) emitter with a spacing of 45.7 cm (18 in).
    d. Plot 53 has a 45.7 cm (18 in) emitter spacing utilizing 0.61 L/h (0.16 gph) emitters.

e. The emitters incorporate a flap design to prevent shut off from causing a vacuum to draw soil particles back into the tubing and to reduce the chance of root intrusion.

18. The inlet and distal ends of the laterals are equipped with a riser bearing a pressure gauge, a ball valve and a vacuum relief valve.

The laterals are installed 1.52 m (5 ft) apart so that each drip tape will provide water and nutrients for two crop rows. They are buried at a depth of 30.5 cm (12 in) below the soil surface.

Swine Effluent

Swine effluent was applied to the plots through the SDI. The effluent was collected from a nearby nursery facility via a tanker truck that has a capacity of approximately 18.9 m^3 (5000 gal). The truck was parked near the controller building, where an 8.2 kW (11 hp), 10.2 cm (4 in) solids handling pump was utilized to convey the effluent from the truck into the system. The pump was connected to the system at the manual disconnection point.

Approximately 17 m^3 (4500 gal) of effluent was applied to each plot during an application, which was equivalent to about 5 mm (0.2 in) of liquid per application. In order to determine the volume of effluent required for application during a single growing season, several steps were taken. Figure III-1 provides the steps laid out in the OSU Extension Fact Sheet 2245 to determine the amount of effluent to apply during a single season.

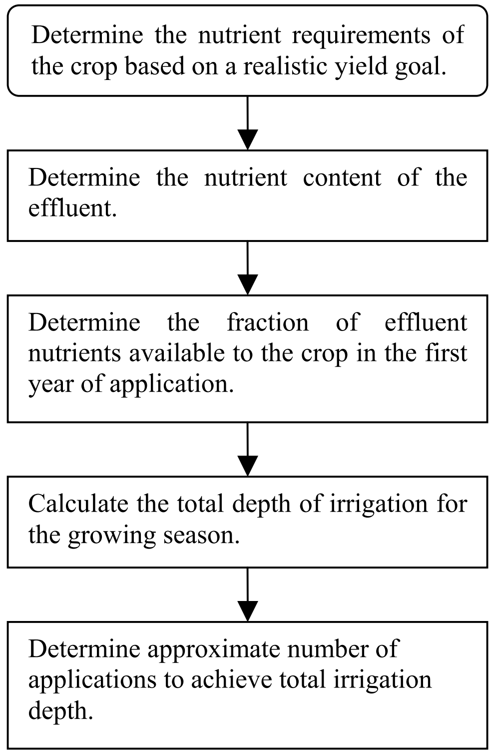


Figure III-1 Steps to determine depth of effluent application during a growing season (Zhang and Hamilton, 2002).

The plots had not been cultivated, therefore, a hypothetical wheat crop was chosen because it is one of the most common crops in the region. In addition, wheat removes the least amount of nutrients from the soil (USDA-SCS, 1996) and thus, presents a conservative estimate for the amount of nutrients to be applied. According to the Oklahoma Agricultural Statistical Survey, the maximum average yield for irrigated wheat in Texas County for the years 1998 through 2002 is 68.4 bu/A (USDA-NASS, 2000, 2003). This is equivalent to approximately 5 Mg/ha, assuming a dry weight of 27.2 kg/bu (60 lb/bu).

Following the steps provided in figure III-1, nutrient needs of the crop were determined first. Zhang et al. (2002) offer a table of primary nutrient soil test interpretations for selected small grains and row crops. This table includes wheat with yield goals ranging from 1 Mg/ha (15 bu/A) to 6.7 Mg/ha (100 bu/A) in increments of 0.7 Mg/ha (10 bu/A) between the values of 1.3 and 5.4 Mg/ha (20 and 80 bu/A). Therefore, a graph was generated utilizing the information included in the table. Figure III-2 shows the yield goal versus the nitrogen requirement for wheat. A trend line was added to the plot along with the equation for the trend line and an R^2 value.

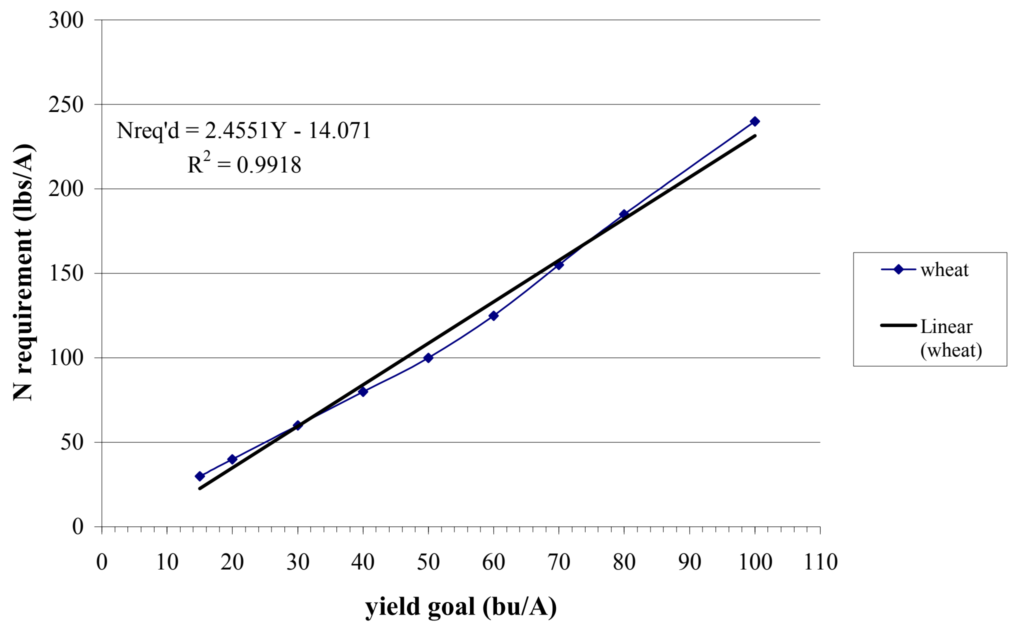


Figure III-2 Nitrogen requirement for wheat in lbs/A at given yield goal in bu/A.

The nitrogen requirement for a specified yield goal was calculated using equation III-1, which was taken from the graph in figure III-2.

$$N_{req'd} = 2.4551(Y) - 14.071$$ **Equation III-1**

where:

$N_{req'd}$ = nitrogen required for the crop (lbs/A)
Y = yield goal of the crop (bu/A)

The yield goal, as mentioned previously, was 5 Mg/ha (68.4 bu/A).

$$N_{req'd} = 2.4551(68.4) - 14.071$$

$$N_{req'd} = 153.9 \Rightarrow 154 lb/A \Rightarrow 173 kg/ha$$

Therefore, a wheat crop producing 5 Mg/ha (68.4 bu/A) requires 173 kilograms of nitrogen per hectare (154 lb N/A) during a growing season.

Background soil samples were taken and analyzed for NO_3-N, along with salinity analysis. These analyses, included in Appendix B, indicate that the average soil NO_3-N level for the research plots was 32.7 mg/l (ppm) or 73 kg/ha. The difference between the required nitrogen found with equation III-1 and the soil nitrogen was the amount of nitrogen that was required to be added to the crop during the growing season. So, the total amount of nitrogen that needed to be added to the crop was 100 kg/ha (88.6 lbs/A).

The next step was to determine the nutrient value of the effluent. The initial effluent sample, shown in Appendix C, was provided by the AWRS operator. It specifies a TKN value of 616 mg/l, this is equal to 5.2 lbs/1000 gal. In order to calculate the available nitrogen in the effluent it was necessary to remove the amount that may be volatilized during application. For a surface application, the typical quantity of ammonium (NH_4-N) that is volatilized is 50%. But because the application was subsurface, less ammonium volatilization occurs. In the calculations used in this research a 25% volatilization rate was assumed, this amount was specified because there are some volatilization losses within the tanker truck during transport, storage and some caused by agitation during pumping. Therefore, 75% of the nutrients applied were assumed to reach the plant roots and become available for uptake. The amount of nitrogen remaining after taking volatilization into account was approximately 462 mg/l (3.9 lbs/1000 gal).

An application rate was then calculated. To do so, the nutrient need of the crop was divided by the available nutrient, which provided an application rate of 208 m^3/ha (22,300 gal/A) with a total depth of 2.08 cm (0.82 in). This depth was achieved with 4 applications of approximately 0.5 cm (0.2 in) per application.

The average electrical conductivities (EC) for the effluent that was introduced into the soils for this project are provided in figure III-3. Figure III-3 shows the EC for a nursery swine facility located near the experiment plots from 1999 through 2002.

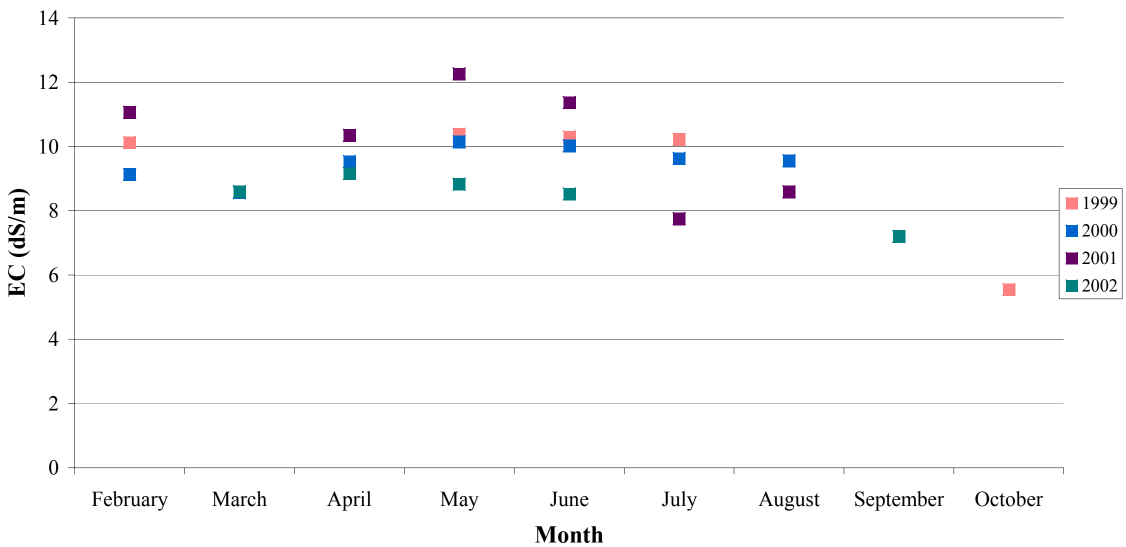


Figure III-3 Average electrical conductivity (EC) by month.

Soil Sampling and Analysis

Background samples were collected prior to any effluent application. Soil sampling was conducted approximately two (2) weeks after each effluent application, then again following a rainfall event. The samples were taken on plots 49-50, 51 and 53. These three (3) plots were chosen so that comparison between emitter sizes could be accomplished. Samples in each plot were collected between the sixth and seventh tape approximately 46 m (150 ft) from the inlet and distal ends of the plot. Three (3) soil cores were collected at each of these locations, one 25.4 cm (10 in), one 50.8 cm (20 in), and one 76.2 cm (30 in) from the sixth tape to a depth of approximately 61 cm (24 in).

The samples were collected in plastic tubes utilizing a Giddings hydraulic soil probe. The probe was attached to the PTO on a Massey Ferguson tractor. The tractor was parked just beyond the sampling point and a plastic tube was inserted into the probe. The probe was then introduced into the ground to a depth exceeding 61 cm (24 in) and removed. The plastic tube containing the soil core was removed from the probe and labeled according to the plot and location of the sample. This process was repeated for all eighteen (18) sampling locations. All samples were taken from a location within 61 cm (2 ft) of the baseline samples along the drip tape.

The samples were returned to the lab and cut into 15 cm (6 in) increments, so that each sampling site had four (4) samples. The cut samples were emptied into paper bags marked with the same label as the original tube along with a depth label and allowed to dry. Once the samples were dry, they were wetted and the liquid was extracted per Rhoades' (1996) method. The extract was analyzed for EC_e and pH_e by means of direct electrode readings. Titration with 0.02 N H_2SO_4 to a pH_e of 8.3 provided CO_3, and the same titration to a pH_e of 4.5 gave the HCO_3 values. An inductively coupled argon plasma spectrometer (ICAP) was then utilized to analyze the samples for Na, Ca, Mg, K, and SO_4.

The values obtained from the analyses were entered into a spreadsheet which calculated total soluble salts (TSS), sodium adsorption ratio (SAR), and exchangeable sodium percentage (ESP). These values were calculated per Zhang et al. (2003), the equations for each are provided in equations III-2 through III-4, respectively.

$$TSS = EC \times 0.66$$ **Equation III-2**

$$SAR = \frac{0.043498Na}{\sqrt{\left[\frac{(0.04990Ca + 0.08229Mg)}{2}\right]}}$$ **Equation III-3**

$$ESP = \frac{(1.47SAR - 1.26)}{(0.01475SAR + 0.99)}$$ **Equation III-4**

A total of 72 samples were analyzed for each application event along with 72 additional samples following the next rainfall event. The samples collected after the effluent applications were obtained within two (2) weeks of the application event. A total of 648 samples were collected and analyzed in conjunction with this project, including the baseline samples.

Comparison of Analyses

Each sample was compared with the following sample to denote any changes in salt concentration. This was completed by producing contour plots utilizing the EC and SAR values found through the analysis process. In addition to the contour plots, stacked bar graphs were completed for Na, Ca and Mg in comparison to depth within the profile.

The contour plots were completed using SigmaPlot 8.0, where the origin was set at the location of the emitter tape. Each 15 cm (6 in) core was assumed to be homogeneous; therefore, the values found for each increment were entered at the average depth of the sample (i.e. the EC value of the top 15 cm (6 in) were entered at a depth of

7.6 cm (3 in) below the soil surface, and so on). Once the entries into SigmaPlot 8.0 were complete, an EC versus distance and an SAR versus distance contour graph was produce by the program for each sampling location. The scale along the y-axis is measured in positive and negative distance from the emitter tape. Each graph was visually compared to the graph depicting the previous sampling event and the sampling event following.

The stacked bar graphs were also developed utilizing SigmaPlot 8.0. The concentration of each element was converted from parts per million (ppm) to grams per cubic meter (g/m^3) by summing the concentrations at each distance from the drip tape within a depth increment. After the concentrations were summed for each depth increment, the average mass water content (θ_m) added prior to extraction and the average bulk density (ρ_b) were used to calculate the concentration on a gram per cubic meter (g/m^3) basis. The sampling date is along the x-axis with the concentration found on the left-hand y-axis. In addition to the total elemental concentrations found within the soil profile, these graphs include a predicted elemental concentration based on the baseline sample and a predicted elemental concentration based on the previous sample for each sample following an effluent application. The precipitation amount is provided along the right-hand y-axis. Once again, the graphs were used to visually compare the depth based concentrations of each sampling event.

Modeling of Results

Two computer models were tested to determine whether they are capable of accurately modeling the transport of salts through the subsurface region near the laterals of a subsurface drip irrigation system. HYDRUS-1D and VS2DTI were the two models chosen for comparison with field data.

HYDRUS-1D is a one-dimensional model for simulating flow and transport of water, heat and solutes within variably saturated media. The model numerically solves the convection-dispersion equation (CDE) to determine the extent of solute transport and the Richards' equation is solved for flow. HYDRUS-1D is available for free download through the United States Salinity Laboratory website. The steps taken to set up the model for the purposes of this type of simulation along with the options chosen are provided in Appendix D.

VS2DTI is a two-dimensional graphical software package for simulating fluid flow and solute transport in variably saturated media. As with HYDRUS-1D, the fluid flow model solves Richards' equation to predict flow. Yet, the solute transport portion of the software utilizes the advection-dispersion equation. VS2DTI is a public-domain software provided by the United State Geological Survey (USGS). The modeling parameters are input into VS2DTI differently than those in HYDRUS-1D. The domain is drawn to the dimensions of the profile to be modeled. A textural profile is added within the domain; in this case it is assumed to be homogeneous and is set as a clay loam. Initial concentration contours are provided along with observation points. An initial equilibrium profile is entered providing the depth to groundwater and boundary conditions are set. For this scenario, a second domain is included within the first domain which represents the emitter tape. Within the emitter tape domain the concentration of the effluent is presented as the initial concentration with the boundary conditions being set to allow a volumetric flow out of the domain from the top boundary. Then the simulation is processed.

CHAPTER IV

RESULTS AND DISCUSSION

Graphical Comparisons of Plot 51

The results for the analyses of samples from Plot 51 are presented in this section. Recall that the mid-sized emitters are installed within this plot. These emitters have a flow rate of 1.25 L/h (0.33 gph) and are spaced 61.0 cm (24 in) apart.

<u>Comparison of EC Concentration</u>

Figure IV-1 offers a contour graph indicating the background EC distribution throughout the sampling profile for the distal end of Plot 51. As mentioned in the previous chapter, the origin is at the expected location of the drip tape, approximately 30 cm (12 in) below the soil surface. It should be observed that at least one sampling event contained an EC concentration of 400 μS/cm (0.4 dS/m) and at least one contained an EC value of 1200 μS/cm (1.2 dS/m). Thus, the EC concentration scale for Plot 51 ranges from 400 to 1200 μS/cm (0.4 to 1.2 dS/m) for all sampling events, for comparison purposes.

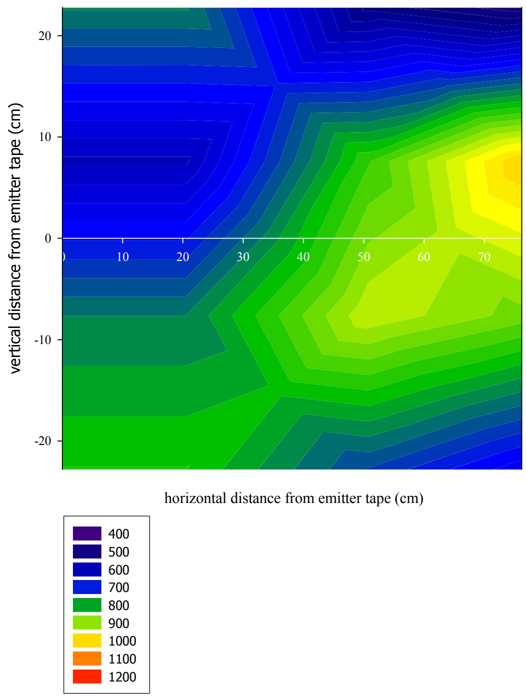


Figure IV-1 Background EC (μS/cm) profile for the distal end of Plot 51.

Prior to any effluent application there was an insignificant amount of salt present near the emitter tape in the sampling profile as evidenced by the EC contours provided in figure IV-1. However, there was a point of higher salinity approximately halfway between the laterals at about 25.4 cm (10 in) below the surface. This may be due to natural weathering of minerals in the soil.

The initial effluent application, illustrated by figure IV-2(a), flushed the salts between the laterals farther out of the sampling profile. While at the same time, the application increased the salt content at the surface of the soil above the lateral. The graph gives the impression that the tape along this lateral at the distal end of Plot 51 was buried to a depth of about 35.6 cm (14 in). This conclusion was drawn because the location of the highest salt concentration in this particular sampling profile was below the assumed origin. Figure IV-2(b) presents the image of the same sampling profile following a 4.01 cm (1.58 in) rainfall event. The infiltration leached the salts provided by the effluent application below the emitter tape.

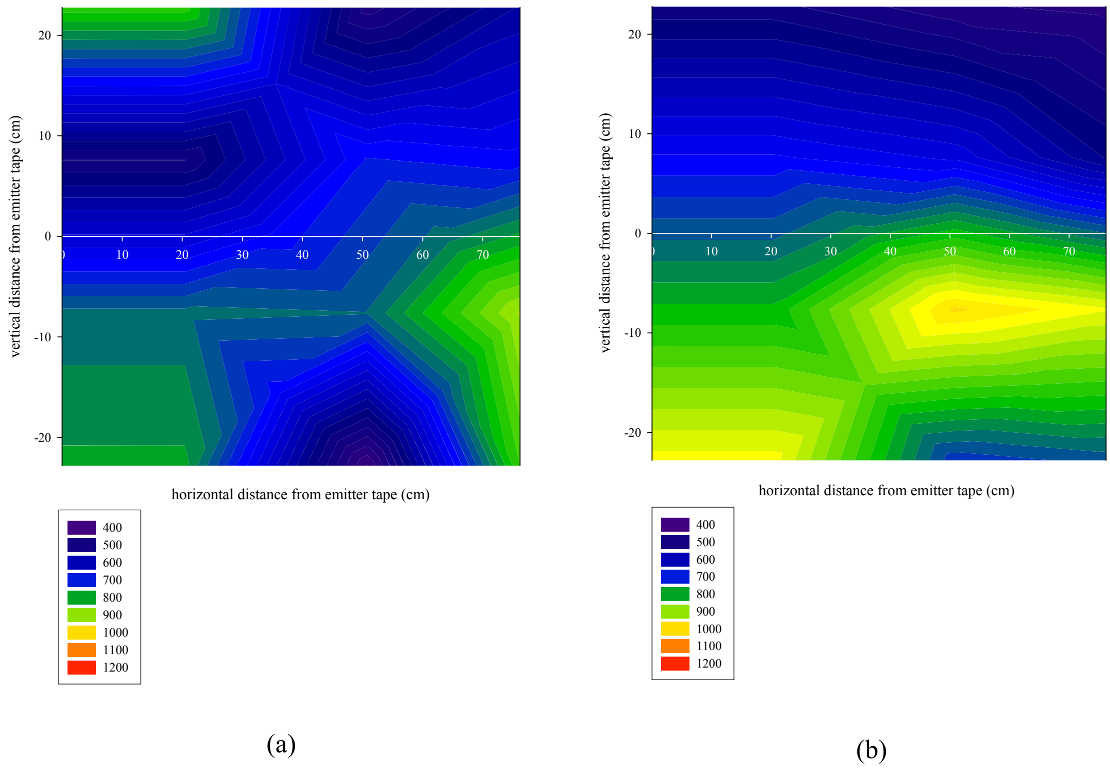
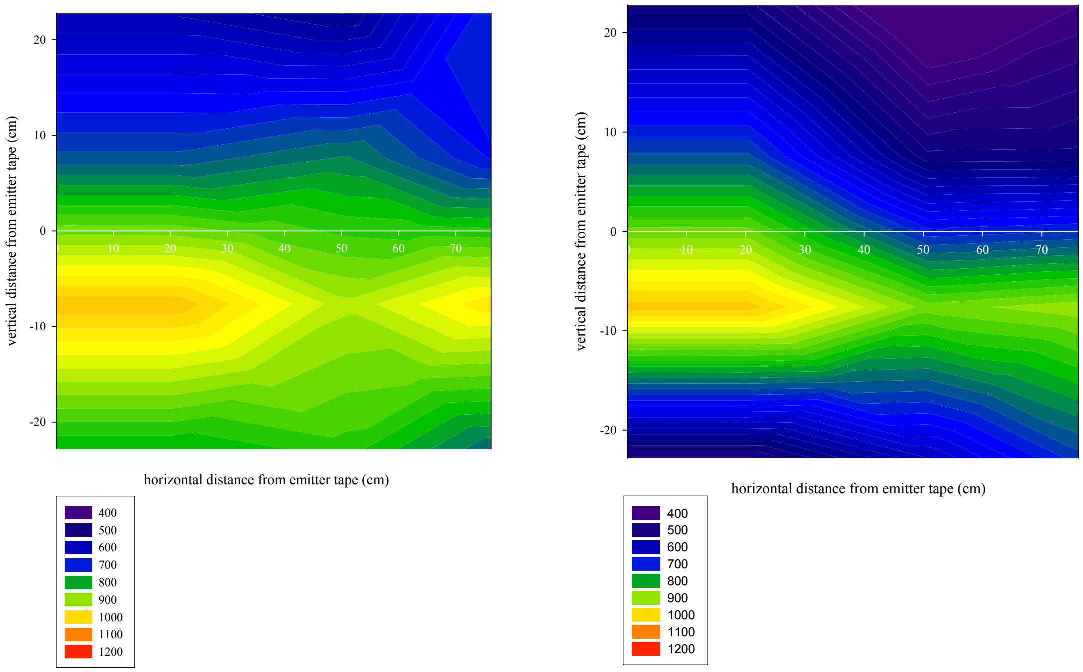


Figure IV-2 Comparison of salt content, EC (μS/cm) after initial effluent application (a) and after 4.01 cm (1.58 in) rainfall (b) for the distal end of Plot 51.

Three more applications were completed and figure IV-3(a) shows the results for the analysis following the fourth and final land application event, once more at the distal end of the lateral. The remaining graphical figures for the distal end of Plot 51 are inserted in Appendix E. The highest concentration again appears approximately 5.08 cm (2 in) below the assumed origin. The pattern was more symmetrical in this sampling and the concentration from the adjacent lateral was beginning to infringe on this profile. In addition, figure IV-3(b) provides the outcome of the investigation following the final recorded rainfall event. The top portion of the salt profile has been forced down;

however, the movement was not equivalent to that of figure IV-2(b). This phenomenon was almost certainly due to significantly less rainfall, 1.7 cm (0.67 in), between the samples shown in figures IV-3(a) and (b).



(a) (b)

Figure IV-3 Comparison of salt concentration, EC (µS/cm), after final effluent application (a) and after 1.70 cm (0.67 in) rainfall (b) for the distal end of Plot 51.

The analysis results for the inlet end of Plot 51 are found in Appendix F. The results of the examination of the inlet end of the laterals were similar to that of the distal end. However, the lateral depth appears to be at the location of the origin. The initial salinity at this location was relatively high but a rainfall event of 7.77 cm (3.06 in) drove the salts found in the initial inspection out of the profile. The first two effluent applications did not affect the salt concentration of the soil at this particular site within the plot. Yet, the following application events did have an effect on the salinity of the profile.

The application rate associated with the emitters installed in Plot 51 tended to provide the profile with the most consistent application of the three emitters researched. However, the salts were concentrated in the root zone directly below the location of any future planting row.

Comparison of SAR Distribution

Figure IV-4 presents the background distribution of sodium adsorption ratio (SAR) for the distal end of Plot 51. The SAR values for all samples ranged from 0.1 to approximately 3 with very few exceeding 2, therefore, the scale employed for all graphs depicting SAR is from 0.1 to 2. As is shown in figure IV-4, the SAR found in the lower portion of the sampling profile was approaching 2 prior to any effluent application. With an effluent SAR of 7.14 (Appendix C), this could prove to be a problem in the future.

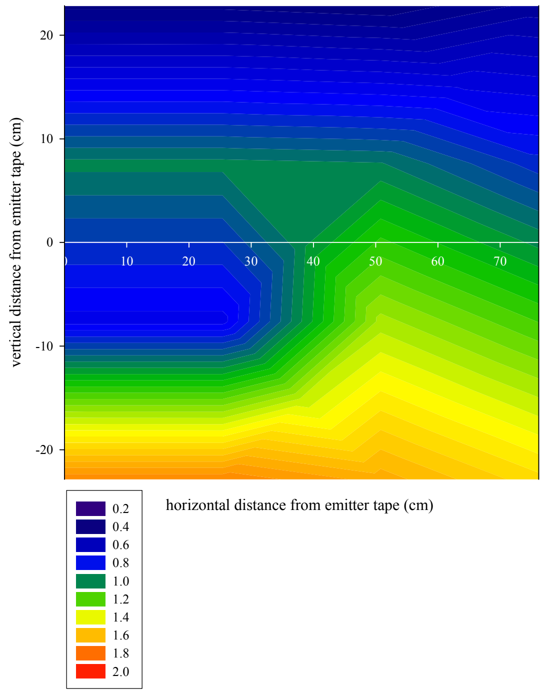
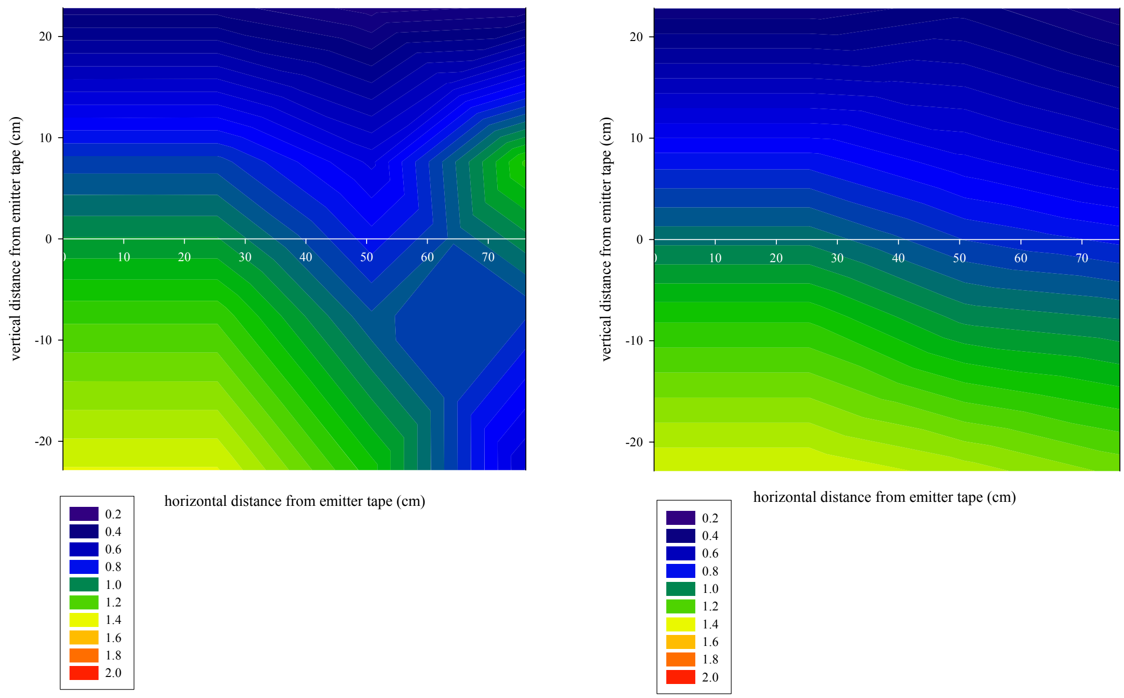


Figure IV-4 Background SAR for distal end of Plot 51.

Following the initial effluent application, figure IV-5(a), the SAR decreased somewhat for the distal end of Plot 51. The decrease occurred because of the rainfall event that took place between the background sampling event and the initial application. The contours produced following the land application possessed an outline similar to that found in figure IV-1 with a higher concentration being found midway between the tapes about 25.4 cm (10 in) below the soil surface. This indicates that the high EC in that area was mainly comprised of Na because the Na had moved to a deeper location within the profile. Na is a monovalent element and, therefore, has a higher mobility than that of Ca and Mg which are divalent elements because these elements follow the lyotropic series.

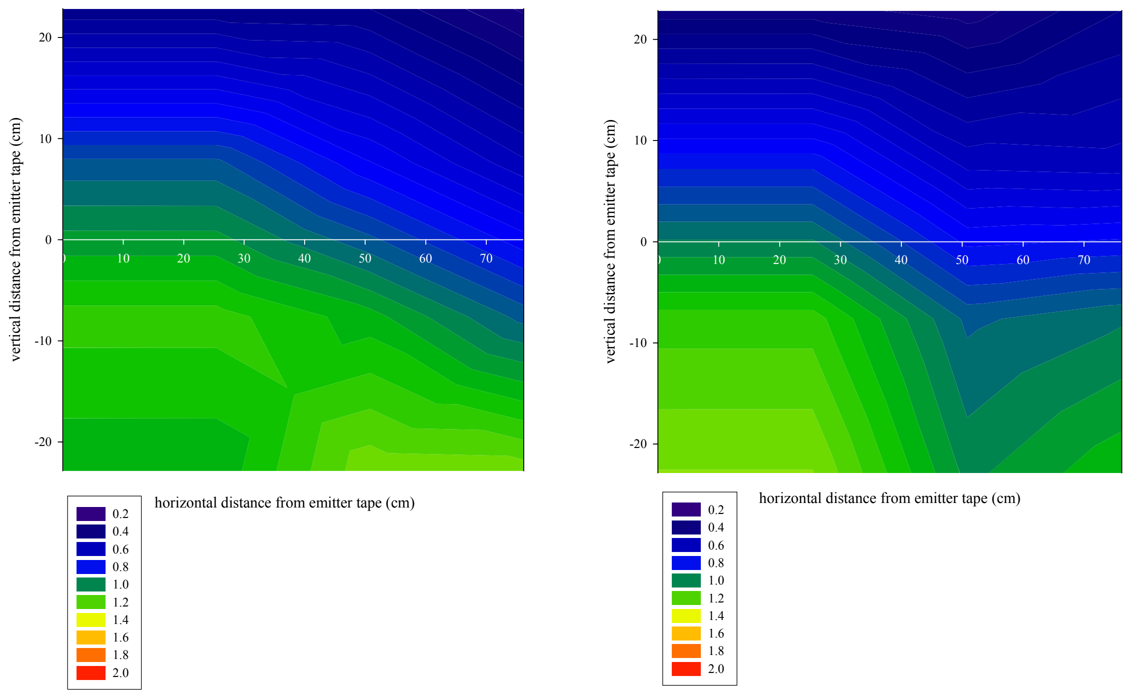


(a) (b)

Figure IV-5 Comparison of SAR after initial effluent application (a) and after 4.01 cm (1.58 in) rainfall (b) for the distal end of Plot 51.

Figure IV-5 (b) illustrates the results following a 4.01 cm (1.58 in) rainfall event. As is evident, the infiltration of fresh water forced the sodium farther below the surface, resulting in the higher SAR towards the lower portion of the profile.

As stated in the EC distribution section, three more applications of swine effluent were performed. The SAR values at the distal end of Plot 51 throughout the application process did increase after the application of effluent, but the rainfall events appeared to reduce it to levels near but slightly higher than the levels prior to the effluent application. Figure IV-6 offers the graphical results for the distal end of Plot 51 following the final application (a) and the final recorded rainfall event (b). The SAR graphs not appearing within the thesis body for the distal end of Plot 51 are located in Appendix G.



(a) (b)

Figure IV-6 Comparison of SAR after final effluent application (a) and after 1.70 cm (0.67 in) rainfall (b) for the distal end of Plot 51.

The inlet end of Plot 51, results in Appendix H, displays a higher initial SAR value. Throughout the research time the values fluctuated just as they did at the distal end, however, the final SAR values near the inlet were higher than those at the distal end. The second application and beyond appear to be distributing a higher concentration of the monovalent cation, so the SAR values were higher.

Comparison of Na Concentration

Figure IV-7 provides the Na stacked bar graphs for the distal end of Plot 51. The y-axis for the graphs characterizing the amount of Na found in the samples is based on a scale ranging from zero grams per cubic meter (0 g/m^3) to 650 g/m^3. It appears that the highest levels of initial Na were located in the two lower portions of the profile, 30-45 cm

(12-18 in) and 45-60 cm (18-24 in), which corresponds with the findings of the EC and SAR analysis. This remains so throughout the season until the last two samples. With the exception of the sample following the initial effluent application, the total concentration of Na decreased following rainfall events. It was apparent that the predicted Na values do not consistently correspond with the actual values and ultimately the concentration of Na did not increase over the season. This would indicate that the amount of rainfall was adequate to remove any accumulation of Na from the profile.

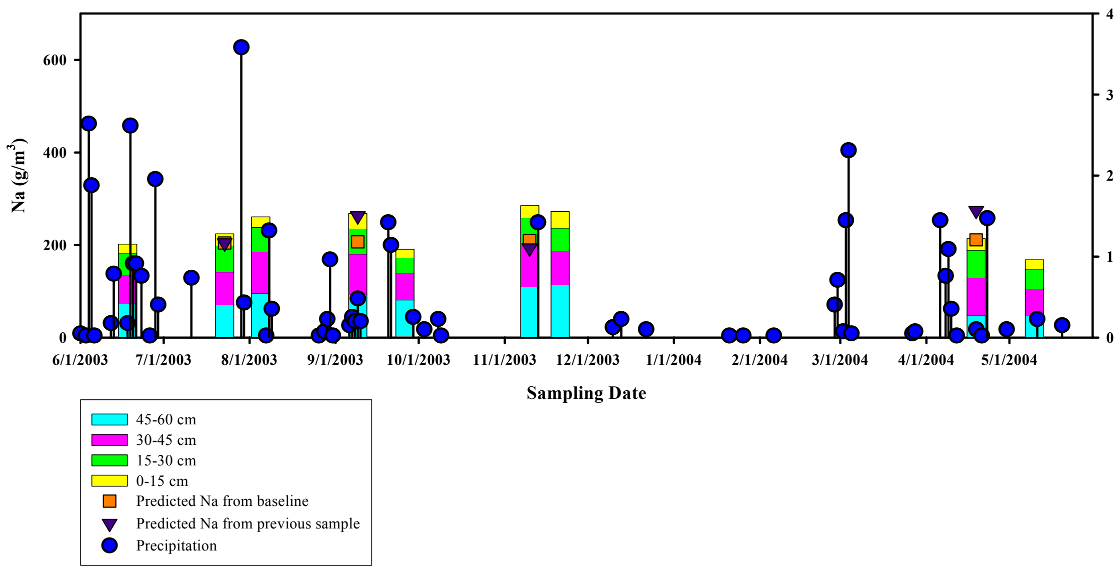


Figure IV-7 Comparison of depth-based Na concentrations for distal end of Plot 51.

The Na concentration graph representing the inlet end of Plot 51 is in Appendix I. As is true with the distal end of Plot 51, the two deepest layers of the soil profile contained the higher concentrations of Na and the overall concentrations decreased after a rainfall event for all applications except the initial application. However, the predicted Na concentration based on the baseline sample had a tendency to more accurately predict the actual amount of Na present than that of the distal end. When comparing the background sample with the final sample of the season, there was very little change in the Na concentration.

Comparison of Ca Concentration

The Ca concentrations for the distal end of Plot 51 are represented in figure IV-8. The Ca amounts found within the plots range from zero grams per cubic meter (0 g/m^3) to approximately 1600 g/m^3.

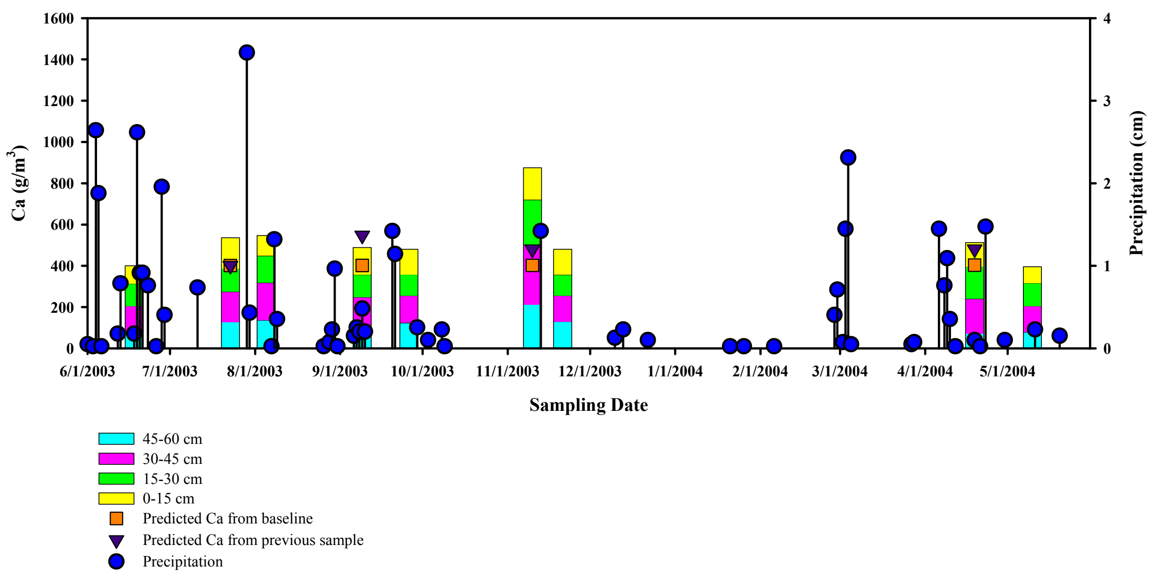


Figure IV-8 Comparison of depth-based Ca concentrations for distal end of Plot 51.

The Ca found at this location in the plot appeared to be fairly evenly distributed among the layers established within the profile for all of the sampling events. Once more, a decrease in the concentration following a rainfall event occurs for all applications with the exception of the first. The predicted Ca concentrations do not match well with the actual data but the background sample was comparable with the final sample.

Appendix J includes the Ca concentration graph for the inlet end of Plot 51 along with the predicted Ca concentrations and the precipitation values. As discerned at the distal end, the distribution of Ca was comparatively invariable among the different layers. The overall amount of Ca found in the profile at the last sampling event exceeded that of the initial sample.

Comparison of Mg Concentration

The concentrations of Mg within the three plots were found to fall between zero grams per cubic meter (0 g/m^3) and 400 g/m^3. The predicted Mg concentration based on the background sample shown in figure IV-9 consistently underestimated the measured value. The distributions of Mg within the four layers were not constant, which was different than that perceived for Ca, nor did it follow the same pattern as the Na, where the greater concentration were found in the two deeper layers of the profile. The middle layers, 15-45 cm (6-18 in) appeared to contain the heavier concentrations of Mg for most of the samples. The initial and final samples had comparable amounts of Mg.

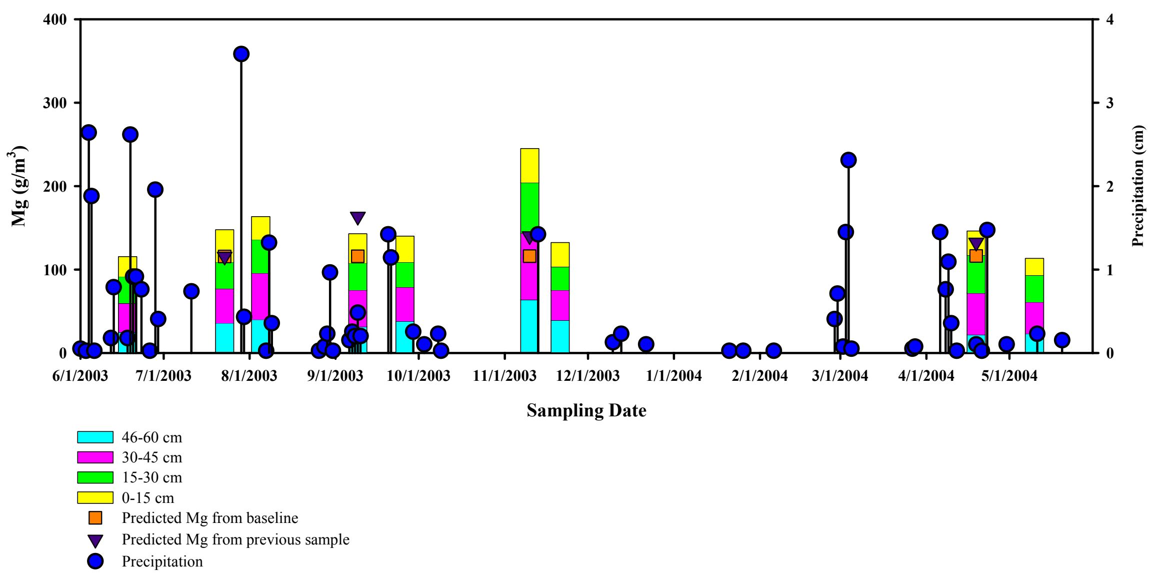


Figure IV-9 Comparison of depth-based Mg concentrations for distal end of Plot 51.

The graphical analysis for Mg at the inlet of Plot 51 is inserted into Appendix K. The results for this end of the plot were similar to those observed at the distal end, except that the layer-based distribution of the Mg was reasonably even.

The distributions of the elemental components in Plot 51 appear to follow closely the lyotropic series. The Ca and Mg attach first remaining closer to the emitter tape, this in turn drove the Na farther from the tape to a deeper point in the profile by way of gravitational force.

Graphical Comparisons of Plot 49-50

Bear in mind that the emitter application rate associated with Plot 49-50 is the highest rate of the three being compared, possessing a rate of 2 L/h.

Comparison of EC Concentration

The salts found in Plot 49-50, as shown in Appendices L and M, were of the lowest concentration of the three plots, with the exception of, what appears to be, a surface contamination source near the inlet end of the lateral approximately six months into the project. Both inlet and distal ends of the tape exhibited the trend linked to lower salinity. The reasonable explanation for this occurrence is that the rate was high enough to force the salts out of the sampling profile because the higher application rate caused saturation during application. The saturation caused the salts to move radially out of the sampling area due to the movement of the wetting front. This may have also lead to greater gravitational influence and leaching of salts lower in the profile.

Comparison of SAR distribution

The sodium adsorption ratio (SAR) of inlet end of Plot 49-50 was the highest of all three emitters. Appendix N provides the graphical results from the sampling located at this end of the plot. The background SAR at this particular point was above 2.0 in the lower region of the profile. The 7.77 cm (3.06 in) rainfall between the background sample time and the initial application aided in decreasing the SAR to an extent, however, it remained high throughout all of the applications and rainfall events. When approached from the EC vantage this seems illogical because this plot possesses the lowest EC concentration. Yet, if the sodium concentration far exceeds the concentration of calcium and magnesium then the occurrence of an elevated SAR is reasonable.

The SAR at the distal end of Plot 49-50 acted in a different manner than the inlet, as shown in Appendix O. The sample prior to any activity had a much lower concentration of cations than the inlet end. The contours behaved similar to those in Plot 51 until the period following the third application. The graph associated with this application has a point of higher SAR. It appears that the Na from the adjacent tape was encroaching on the profile for this tape. This could be due to a higher concentration of the divalent cations closer to the adjacent tape. This development had increased the SAR within the sampling profile significantly. Still, the graphs depicting the final application and coupled rainfall behave normally.

Comparison of Na distribution

Appendix P provides the layer-based distribution of Na for the inlet end of Plot 49-50. The baseline concentration of Na at this location was greater than those concentrations recorded for the rest of the research area. For the most part, the Na concentration within the top layer had increased to a higher degree than the other three layers. This corresponds well with the SAR results discussed for this location. The predicted values do not aid in determining an expected value at any of the sampling dates. However, when comparing the initial sample with the final sample, the overall concentration decreased somewhat.

The graphical analysis for the Na distribution in the distal end of Plot 49-50 is found in Appendix Q. Unlike the inlet end, the background concentration of Na at this end of the plot was the lowest when compared to all other sampling sites and the Na was primarily found at a depth of 30 cm (12 in) or greater, which corresponds with the SAR. Once again, the amount of this particular element within the profile decreased following a rainfall event for all sampling events excluding the sample subsequent to the initial effluent application. The predicted values for Na consistently underestimated the measured value but the baseline sample and the final sample were equivalent.

Comparison of Ca distribution

The inlet end of Plot 49-50 had the lowest baseline Ca concentration and the highest final Ca concentration of all three research plots, which is shown graphically in Appendix R. Like the Na at this end of this plot, the majority of the Ca was located in the uppermost layer of the profile. The deepest layer, the layer from 45-60 cm (18-24 in), remained reasonably constant throughout the year.

Appendix S illustrates the graphical data for the distal end of Plot 49-50. The Ca concentration was distributed rather evenly throughout the profile for all of the sampling dates and the total Ca remained comparative during the year. Each sampling date subsequent to a rainfall event showed a decrease in Ca from the samples prior to the rainfall event and the measured values met the predicted values more closely than the other sampling sites.

Comparison of Mg distribution

As evidenced in Appendix T, the majority of the Mg found at the inlet end of Plot 49-50 was located in the uppermost layer. At the beginning of the research the Mg concentration at this point was one of the lowest of all of the sampling sites. However, the final analysis indicates that has increased the most over time and now holds the highest concentration of Mg. The calculated Mg was generally much less than the measured amount.

The graphical analysis for the distal end of Plot 49-50 is in Appendix U. The results throughout the year were reasonably similar to each other with respect to total Mg. The distribution of Mg among the layers was also reasonably similar and the calculated values for Mg were the best prediction of the actual data for this sampling location. When comparing the total amount of Mg discovered in the initial sample with that of the final sample, there was very little difference.

Graphical Comparisons of Plot 53

The emitters utilized for application in Plot 53 are the smallest of the three at 0.61 L/h (0.16 gph) and also possess the smallest spacing at 45.7 cm (18 in) apart.

Comparison of EC Concentration

Even with such a low rate of application these emitters show no signs of salt accumulation around the tape. It is possible that the decrease in emitter spacing has aided the movement of salts away from the lateral. The background samples taken at both inlet and distal ends of the tape have a salinity value greater than that acceptable for most crops.

As was true with Plot 51, the rainfall event following the background sampling and prior to the first effluent application moved the salts through the soil profile to a location below the tape at the inlet end of the lateral (See Appendix V). The first application did not increase the salinity at the inlet. In fact, the concentrations within the profile near the inlet only increased at a considerable distance below the emitter tape. The increases and decreases throughout the research period followed no rational pattern. Possible explanation are that a hard pan was located below the sampling profile which was preventing the salts from leaching in a consistent manner and that the emitters near this sampling site were clogged.

The lateral placement at the distal end of Plot 53 appeared to be shallower than 30.5 cm (12 in) because the logical movement of the salt front was located approximately 5 cm (2 in) above the origin of the contour plot, as evidenced in the graphs in Appendix W. The initial effluent application suggested that the highest salt concentration will remain near the emitter tape. However, all subsequent applications indicate that the wetting front moved to a location equal to or greater than 40 cm (15.7 in) from the lateral. Once again, just as with the emitters in Plot 53, this will be in the root zone of the future crops.

Comparison of SAR distribution

The background SAR at the inlet end of Plot 53 was greater than 2 at points within the profile. Appendix X, indicates that the rainfall following the initial sample forced the cations downward. The subsequent samples behaved in a manner consistent with the lyotropic series, in that the Na was found at the bottom of the profile. On the other hand, the results after the rainfall event following the second application showed a spike in Na, evidenced by a significant increase in SAR. This sample appeared to have been extracted from a portion of the plot adjacent to an emitter, which explains the significant difference between the SAR values. The remaining results had a higher value of SAR in the bottom portion of the profile. This could continue to increase during future application procedures.

Appendix Y offers the graphical results for the distal end of Plot 53. The graphs indicate that there was no noteworthy increase in Na at this point along the lateral.

Comparison of Na distribution

As discussed in the previous section the Na appeared to be following the lyotropic series and was concentrated in the lower 30 cm (12 in) of the profile at the inlet end of Plot 53, as is evidenced in Appendix Z. The total amount of Na decreased from the concentration measured at the initial sample to amount found in the last sample. Neither of the predicted values consistently estimated the measured value on any of the sampling dates.

According to Appendix AA, once again, the greatest concentration of Na was located in the lower two layers of the profile for all of the sampling dates recorded for the distal end of Plot 53. The predicted Na values that were calculated for this sampling site matched the actual values better than those considered for any other location within the research site. And as was true with all other locations, the initial and the final Na values are analogous.

Comparison of Ca distribution

At the inlet end of Plot 53 the Ca in each of the samples following a rainfall event decreased in comparison to the samples following the previous land application (Appendix BB). The predicted concentrations were without fail lower than the measured values. Yet, there was no significant increase in Ca when comparing the background sample to the last sample of the year.

As was true with the inlet end, there was not a significant change in the concentration of Ca from the beginning to the end of the trial period for the distal end of Plot 53, as confirmed by Appendix CC. The amount of Ca was evenly distributed from top to bottom throughout the profile.

Comparison of Mg distribution

A higher concentration of Mg was represented in the deepest layer at the inlet end of Plot 53, as shown in Appendix DD. Each sample following a rainfall decreased in Mg from the analysis conducted prior to the rainfall event. The change in concentration throughout the year was insignificant, in that the initial and final samples are practically equivalent.

Appendix EE offers the final graphical analysis and represents the distal end of Plot 53. The graph shows an even distribution of Mg throughout the profile for each sample collected. The total Mg concentration was typically underestimated by the calculated predictions. Like the inlet end of Plot 53, the change in concentration was inconsequential.

Computer Simulations

HYDRUS-1D

The HYDRUS-1D model failed to converge when utilizing the inputs that describe this scenario. The conditions within this project required a software package that enables the user to provide an applied volume, whereas, HYDRUS-1D does not allow for a volume input. It is possible to add a concentration to a point at the top or bottom of the profile but not at a position somewhere within the profile.

Difficulty arose when trying to exemplify the actual application of a volume of effluent at a point in mid-profile. It was possible to separate the profile into two layers in which a concentration could be input at the bottom of the first layer and the top of the second layer. This allowed the model to simulate the movement within each layer. Yet, without demonstrating the contribution of a volume of effluent the model over simplified the simulation and produced inaccurate results for this scenario.

VS2DTI

The USGS model, VS2DTI, allowed for all of the input parameters required to run a model consistent with this scenario, including the concentration and volume added by the application of effluent at a point within the domain. It was also possible to change the boundary conditions at all edges of the domain or profile area to suit different scenarios. This simulation converged for the given scenario. Still, the accuracy within the simulation of solute transport never exceeded 68%, allowing for an error of 32%. This was determined by running a simulation with the data used to calibrate the model and comparing the model output to the initial data. This was not an acceptable error for this purpose. With this inaccuracy within the simulation, the ambiguity when using the field data made the model output of no value for predictive purposes.

CHAPTER V

SUMMARY AND CONCLUSION

Each of the three (3) plots utilized in this project were equipped with a subsurface drip irrigation system. With respect to the three (3) research plots discussed in this thesis, the field portion of the system consisted of drip tape with three (3) different emitter sizes with one of the three (3) having a closer emitter spacing. A comparison based on salinity and sodicity transport was made to determine which emitter size is appropriate to utilize when applying swine effluent to row crops. In addition, these salts were broken down into the elemental components, Na, Ca and Mg. Each of these elements were utilized to compare the three (3) emitters. Four (4) effluent applications were made on each plot to achieve a total of 2 cm (0.8 in) of effluent applied. Sampling was conducted throughout the project to determine the distribution and transport of salts within the soil profile near the laterals.

Emitter Recommendation Based on Salinity

The graphical analysis of salinity within the three (3) plots indicated that the 0.61 L/h (0.16 gph) emitters with a spacing of 45.7 cm (18 in) and the 1.25 L/h (0.33 gph) emitter on 61.0 cm (24 in) spacing distributed the salts into the root zone of any future crop. Whereas, the 2 L/h (0.53 gph) emitters on 61.0 cm (24 in) spacing located in Plot 49-50 appeared to force the high concentration of salts out of the root zone. In order to maintain a suitable crop yield it is desirable to move the salts away from the root zone, therefore, the 2 L/h (0.53 gph) emitters on 61.0 cm (24 in) spacing were the most desirable of the three (3) reviewed within this study. At the same time, it is likely that this emitter size will also drive valuable nutrients found in swine effluent away from the root zone as well.

Maintaining a suitable balance between salt content and nutrient content becomes a key factor in the design of this type of system. Since water conservation and nutrient utilization were the two main objectives for using this system, it was not feasible to surface apply fresh water to leach salts out of the root zone of the two (2) smaller emitter plots. In addition, high sodicity will eventually cause the soils to become less permeable, which will restrict water movement and root growth.

Emitter Recommendation Based on Sodicity

It was difficult to base an emitter size recommendation on the sodium analysis within the plots used in this research. The most appropriate emitter based on SAR was the 1.25 L/h (0.33 gph) emitter. The SAR values associated with the mid-sized emitter at both locations had an accumulation in the lower portion of the profile but the extent of the buildup was much less than that of the remaining two emitter sizes.

The largest emitters were the most suitable based on the salinity results. However, the inlet end of Plot 49-50 possessed the highest sodium adsorption ratio (SAR) throughout the profile of all plots for all sites sampled. Therefore, the 2 L/h (0.53 gph) emitters were not suitable because the Na accumulation may become such that the soil permeability was decreased to a point of harm for the crops.

Finally, the 0.61 L/h (0.16 gph) emitters with a spacing of 45.7 cm (18 in) appeared to leave an excessive amount of Na in the profile around the lateral. Since the flow rate was not high enough to force the monovalent cation away from the emitter it is likely that the SAR will continue to increase with additional applications and will begin to build up in the lower layers due to gravitational pull.

Emitter Recommendations based on Elemental Components

Providing a complete emitter recommendation based on Na, Ca and Mg was unfeasible at this point in the research. However, when observing the overall changes in the elemental components it was obvious that after one year of data collection there was typically no significant increase or decrease in the amount of Na, Ca or Mg within any of the three plots.

The 2 L/h (0.53 gph) emitters installed in Plot 49-50 appeared to exaggerate the concentrations of the elements probably because the higher flow rates cause nearly immediate saturation. This amplification was primarily noted at the inlet end of the plot where the pressure was higher than that of the distal end. Contrary to the idea stated in the objectives, the wetting front was forcing the elements to the shallow layer of the profile, where there was greater possibility for evaporation of liquid which will leave a higher concentration of Na. Assuming that this continues to be the case in future analysis, this emitter size will not be suitable for use with swine effluent because cultivation depth will place the seed in the layer of highest concentration.

The midsized emitter (1.25 L/h (0.33 gph)) in Plot 51 provided the most even distribution of the elemental components. This is a more ideal division of the elements than that noted in Plot 49-50. Yet, the rooting zone will encompass nearly all of the profile area and, therefore, if the elemental components increase such that the salts elevate throughout the zone then the salt tolerance for the crops may be exceeded.

Plot 53 containing the 0.61 L/h (0.16 gph) emitters appeared to be more greatly affected by gravitational flow and/or leaching because the greatest increase of the elemental components were found in the deepest layer of the profile. However, since the flow rate is so low, gravity should not have the opportunity to move the elements to the deeper layer because saturation was not reached. In a location with a greater amount of rainfall or a situation in which freshwater irrigation was practiced, leaching would normally aid in moving the components out of the root zone. Yet, at this particular site the precipitation amount was not high enough to do so nor was freshwater irrigation practiced. A shallow caliche layer was positioned at approximately 60 cm (24 in) below the soil surface. The caliche appears to be acting as a confining layer, immobilizing deep downward movement of the effluent within this experimental plot. The caliche layer was positioned such that the elements in the effluent will remain in the root zone.

Contributions to Error

Several issues have arisen that could contribute to error within this study. Because the system was newly installed employing a plow, the soils around the emitter tape were disturbed. The disturbance may have caused preferential flow along the emitter tape providing a source for error. Additional preferential flow may have been caused by cracks in the soil and in the caliche layer. There is also a likelihood of rodent holes and holes created by sampling events causing preferential flow. These alleys of preferential flow, if near a sampling site, would bias the data.

Spatial variation was another source of error. Due to the sampling method utilized, multiple samples cannot be taken in exactly the same location; therefore, any given sample may be closer to or farther away from an emitter than the previous sample. This would, once again, distort the numbers.

The caliche layer appeared to be rolling rather than continually sloping and effluent may have pooled in any low spot. Thus, if a sample was extracted from a low lying subsurface location then the concentration values may have been skewed. Knowing that these issues have the potential to exist, one cannot be confident that any recommendation based on a single year of data is appropriate.

General Recommendations based on Salinity and Sodicity Hazards

The EC and SAR conclusions contradict one another, in that the largest emitter size appeared to be more appropriate for EC, whereas the midsized emitter was more suitable based on SAR, and the elemental component results acted similar for all three emitter sizes. Thus, it was not fitting to make an emitter size recommendation at this stage in the research.

Enough swine effluent was land applied to fulfill the annual nitrogen requirements for a wheat crop. Despite no freshwater irrigation, with only 38.5 cm (15.14 in) of rainfall, the baseline TSS data and the final TSS data at all sites showed only an increase of 0.25% for the entire 60 cm (2 ft) profile. The layer-wise percent difference for TSS ranged from -0.06% at the deepest layer to 0.86% at the shallowest layer. The instrumentation utilized to determine the EC, which was the basis for the TSS calculations, was accurate to within 1 μS/cm. This is important because the average overall increase was approximately 2 μS/cm. Therefore, half of the difference could have been due to instrumentation error. Nonetheless, it does not appear from this single year of data that the application of swine effluent by SDI will significantly alter the build-up of salts in the crop root zone for the soil conditions at this experimental site.

Modeling Recommendations

Neither of the models tested for the scenario presented in this research were adequate. There were other models available that might provide results that are appropriate for the given situation. However, after reviewing the accessibility of options other than the ones chosen within this research, it was concluded that financial limitation may inhibit many individuals from using other software packages. Due to this fact, it is recommended that an affordable model be developed.

Recommendations for Future Research

This research should be continued to record results from year two of the project and beyond. Crops should be incorporated into the research to determine any adverse effects that may exist. Furthermore, nutrient tracking would be useful to establish if the nutrients are moved in the same manner as the salts. Consideration should be made concerning sampling method; the destructive manner in which the samples are taken for this project should be avoided. Acid injections into the system to eliminate emitter clogging will also add an interesting aspect to the research. In addition to supplementary field research, an affordable model depicting the salt movement from an SDI system applying effluent should be contemplated following the gathering of several years of field data.

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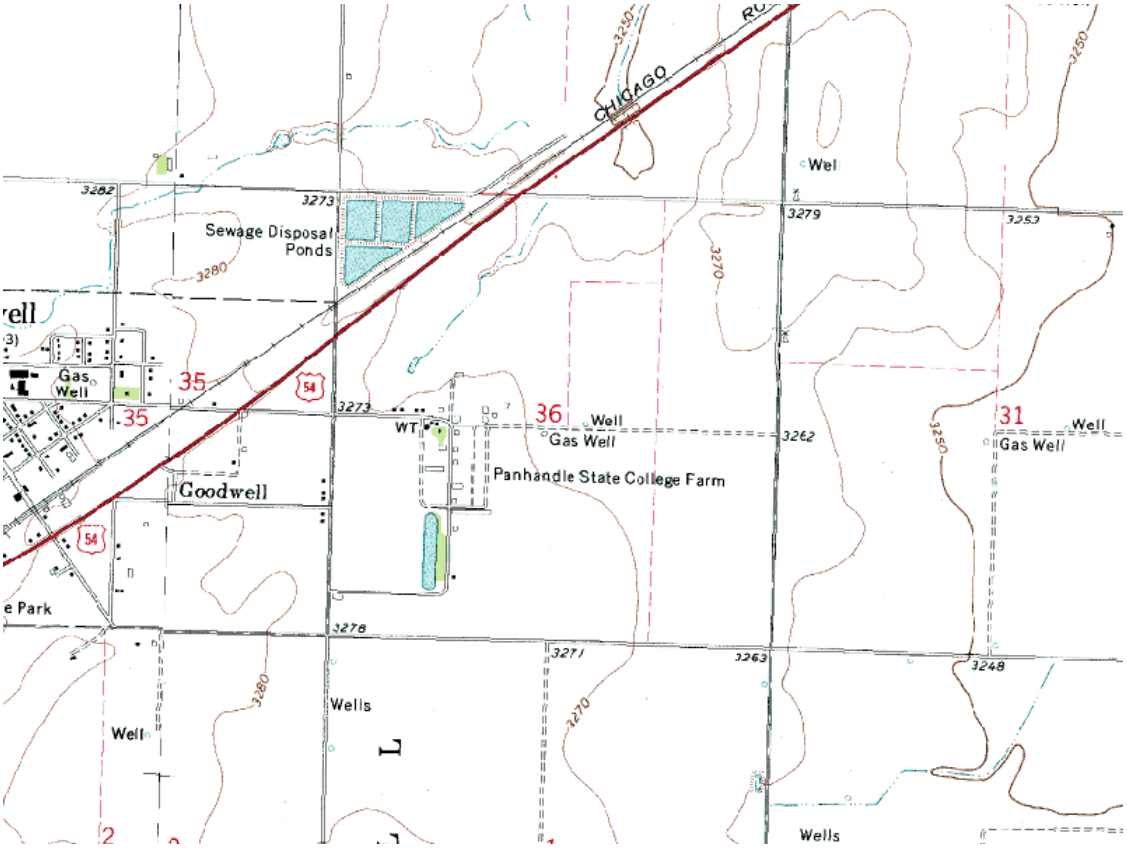
APPENDICES

Appendix A: Site Topographical Map



Appendix B: Soil Analysis

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe	NO_3-N
		g	g	g	g	g				mg/L
E16 10 0-6	18-Jun-03	16.74	267.20	331.07	250.46	63.87	1.23	0.26	8.04	12.00
E16 20 0-6	18-Jun-03	16.54	229.26	299.52	212.72	70.26	1.04	0.33	7.97	1.00
E16 30 0-6	18-Jun-03	16.44	245.22	324.00	228.78	78.78	1.12	0.34	7.93	5.00
E16 10 6-12	18-Jun-03	16.51	269.50	343.12	252.99	73.62	1.24	0.29	7.84	12.00
E16 20 6-12	18-Jun-03	16.59	251.09	332.49	234.50	81.40	1.15	0.35	7.78	15.00
E16 30 6-12	18-Jun-03	16.60	263.62	349.03	247.02	85.41	1.21	0.35	7.98	1.00
E16 10 12-18	18-Jun-03	16.64	266.86	359.20	250.22	92.34	1.23	0.37	7.74	59.00
E16 20 12-18	18-Jun-03	16.56	255.71	344.78	239.15	89.07	1.17	0.37	7.92	51.00
E16 30 12-18	18-Jun-03	16.74	262.32	343.50	245.58	81.18	1.20	0.33	8.01	11.00
E16 10 18-24	18-Jun-03	15.75	281.50	376.72	265.75	95.22	1.30	0.36	8.01	54.00
E16 20 18-24	18-Jun-03	16.65	270.47	360.49	253.82	90.02	1.24	0.35	8.05	55.00
E16 30 18-24	18-Jun-03	16.75	279.18	373.18	262.43	94.00	1.29	0.36	7.92	19.00
W16 10 0-6	18-Jun-03	16.31	315.44	405.61	299.13	90.17	1.47	0.30	8.00	1.00
W16 20 0-6	18-Jun-03	17.19	277.47	353.30	260.28	75.83	1.28	0.29	8.04	15.00
W16 30 0-6	18-Jun-03	17.09	256.35	337.90	239.26	81.55	1.17	0.34	7.91	8.00
W16 10 6-12	18-Jun-03	16.63	293.13	393.88	276.50	100.75	1.36	0.36	7.90	28.00
W16 20 6-12	18-Jun-03	16.72	240.46	306.33	223.74	65.87	1.10	0.29	7.96	18.00
W16 30 6-12	18-Jun-03	16.43	271.95	359.10	255.52	87.15	1.25	0.34	7.94	42.00
W16 10 12-18	18-Jun-03	16.25	296.09	402.92	279.84	106.83	1.37	0.38	7.57	100.00
W16 20 12-18	18-Jun-03	16.70	243.38	334.45	226.68	91.07	1.11	0.40	7.80	43.00
W16 30 12-18	18-Jun-03	16.61	260.97	355.75	244.36	94.78	1.20	0.39	7.86	99.00
W16 10 18-24	18-Jun-03	16.28	277.45	394.76	261.17	117.31	1.28	0.45	8.27	150.00
W16 20 18-24	18-Jun-03	16.61	250.57	357.26	233.96	106.69	1.15	0.46	7.81	76.00
W16 30 18-24	18-Jun-03	16.62	298.98	417.02	282.36	118.04	1.38	0.42	7.72	66.00
E33 10 0-6	18-Jun-03	16.15	243.46	317.85	227.31	74.39	1.11	0.33	7.86	27.00
E33 20 0-6	18-Jun-03	16.22	250.65	326.05	234.43	75.40	1.15	0.32	7.93	12.00
E33 30 0-6	18-Jun-03	16.39	285.83	373.78	269.44	87.95	1.32	0.33	7.93	12.00
E33 10 6-12	18-Jun-03	16.14	284.31	379.51	268.17	95.20	1.32	0.35	8.00	19.00
E33 20 6-12	18-Jun-03	16.62	283.23	373.11	266.61	89.88	1.31	0.34	7.89	57.00
E33 30 6-12	18-Jun-03	17.01	199.95	262.27	182.94	62.32	0.90	0.34	7.80	81.00
E33 10 12-18	18-Jun-03	16.37	298.81	403.50	282.44	104.69	1.39	0.37	7.76	9.00
E33 20 12-18	18-Jun-03	16.71	268.90	363.37	252.19	94.47	1.24	0.37	7.88	74.00
E33 30 12-18	18-Jun-03	16.48	288.91	388.89	272.43	99.98	1.34	0.37	7.99	68.00
E33 10 18-24	18-Jun-03	16.75	256.58	344.55	239.83	87.97	1.18	0.37	7.65	49.00
E33 20 18-24	18-Jun-03	16.19	259.94	347.34	243.75	87.40	1.20	0.36	7.73	40.00
E33 30 18-24	18-Jun-03	16.68	258.97	339.59	242.29	80.62	1.19	0.33	7.92	37.00

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe	NO_3-N
		g	g	g	g	g				mg/L
W33 10 0-6	18-Jun-03	16.39	265.91	348.51	249.52	82.60	1.22	0.33	8.05	1.00
W33 20 0-6	18-Jun-03	16.82	246.99	325.11	230.17	78.12	1.13	0.34	8.15	14.00
W33 30 0-6	18-Jun-03	16.58	249.86	345.00	233.28	95.14	1.14	0.41	7.92	47.00
W33 10 6-12	18-Jun-03	16.68	267.28	352.98	250.60	85.70	1.23	0.34	8.05	41.00
W33 20 6-12	18-Jun-03	16.48	260.54	347.30	244.06	86.76	1.20	0.36	8.06	9.00
W33 30 6-12	18-Jun-03	16.60	266.62	365.00	250.02	98.38	1.23	0.39	7.98	25.00
W33 10 12-18	18-Jun-03	16.62	289.02	390.71	272.40	101.69	1.34	0.37	7.88	63.00
W33 20 12-18	18-Jun-03	17.20	278.85	378.52	261.65	99.67	1.28	0.38	8.13	26.00
W33 30 12-18	18-Jun-03	17.04	296.86	401.38	279.82	104.52	1.37	0.37	7.85	77.00
W33 10 18-24	18-Jun-03	17.14	254.67	341.38	237.53	86.71	1.16	0.37	7.57	46.00
W33 20 18-24	18-Jun-03	16.51	302.39	417.23	285.88	114.84	1.40	0.40	7.87	49.00
W33 30 18-24	18-Jun-03	16.62	292.29	405.43	275.67	113.14	1.35	0.41	7.80	63.00
E53 10 0-6	18-Jun-03	16.38	213.03	277.47	196.65	64.44	0.96	0.33	8.01	2.00
E53 20 0-6	18-Jun-03	16.54	256.77	341.83	240.23	85.06	1.18	0.35	7.76	4.00
E53 30 0-6	18-Jun-03	16.07	232.04	313.27	215.97	81.23	1.06	0.38	7.77	5.00
E53 10 6-12	18-Jun-03	16.65	230.88	301.71	214.23	70.83	1.05	0.33	8.02	5.00
E53 20 6-12	18-Jun-03	16.37	276.43	369.99	260.06	93.56	1.28	0.36	7.65	129.00
E53 30 6-12	18-Jun-03	17.06	277.85	375.00	260.79	97.15	1.28	0.37	7.74	50.00
E53 10 12-18	18-Jun-03	16.11	289.38	391.58	273.27	102.20	1.34	0.37	7.96	34.00
E53 20 12-18	18-Jun-03	16.50	265.06	360.38	248.56	95.32	1.22	0.38	7.83	51.00
E53 30 12-18	18-Jun-03	16.48	239.09	317.11	222.61	78.02	1.09	0.35	7.96	54.00
E53 10 18-24	18-Jun-03	16.35	208.49	280.69	192.14	72.20	0.94	0.38	8.05	9.00
E53 20 18-24	18-Jun-03	16.57	262.95	352.77	246.38	89.82	1.21	0.36	8.01	28.00
E53 30 18-24	18-Jun-03	16.50	295.38	390.95	278.88	95.57	1.37	0.34	7.80	40.00
W53 10 0-6	18-Jun-03	16.38	277.56	368.60	261.18	91.04	1.28	0.35	7.86	0.00
W53 20 0-6	18-Jun-03	16.41	258.76	343.79	242.35	85.03	1.19	0.35	7.84	1.00
W53 30 0-6	18-Jun-03	16.51	294.15	387.05	277.64	92.90	1.36	0.33	7.93	1.00
W53 10 6-12	18-Jun-03	16.12	281.06	375.68	264.94	94.62	1.30	0.36	7.89	2.00
W53 20 6-12	18-Jun-03	16.07	284.72	384.03	268.65	99.31	1.32	0.37	7.91	1.00
W53 30 6-12	18-Jun-03	16.67	262.06	351.53	245.39	89.47	1.20	0.36	7.94	1.00
W53 10 12-18	18-Jun-03	16.44	285.93	388.55	269.49	102.62	1.32	0.38	7.85	1.00
W53 20 12-18	18-Jun-03	16.41	262.81	354.17	246.40	91.36	1.21	0.37	8.21	3.00
W53 30 12-18	18-Jun-03	16.72	284.38	390.77	267.66	106.39	1.31	0.40	7.96	3.00
W53 10 18-24	18-Jun-03	16.44	276.37	382.33	259.93	105.96	1.27	0.41	7.99	2.00
W53 20 18-24	18-Jun-03	16.54	268.04	373.00	251.50	104.96	1.23	0.42	7.96	23.00
W53 30 18-24	18-Jun-03	16.65	283.11	399.51	266.46	116.40	1.31	0.44	7.95	19.00

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
E16 10 0-6	18-Jun-03	584	385.44	15.60	75.90	12.00	28.70	43.20	0.44	0.00
E16 20 0-6	18-Jun-03	499	329.34	8.10	73.90	11.90	26.70	26.90	0.23	0.00
E16 30 0-6	18-Jun-03	594	392.04	10.60	84.90	13.20	30.80	48.10	0.28	0.00
E16 10 6-12	18-Jun-03	599	395.34	21.30	80.30	16.00	11.40	101.90	0.57	0.00
E16 20 6-12	18-Jun-03	563	371.58	17.80	78.30	16.30	11.50	47.30	0.48	0.00
E16 30 6-12	18-Jun-03	457	301.62	15.00	61.90	12.80	10.70	34.30	0.45	0.00
E16 10 12-18	18-Jun-03	812	535.92	40.70	95.00	23.80	5.70	71.00	0.97	0.16
E16 20 12-18	18-Jun-03	710	468.60	38.40	75.90	19.40	5.20	43.40	1.02	0.24
E16 30 12-18	18-Jun-03	564	372.24	46.30	50.00	16.60	4.30	44.30	1.45	0.86
E16 10 18-24	18-Jun-03	757	499.62	57.80	69.70	21.30	3.70	62.60	1.55	1.01
E16 20 18-24	18-Jun-03	740	488.40	56.20	68.50	21.50	3.30	47.00	1.52	0.96
E16 30 18-24	18-Jun-03	691	456.06	78.30	49.30	15.60	3.00	53.00	2.49	2.34
W16 10 0-6	18-Jun-03	679	448.14	35.00	85.70	16.20	23.90	50.60	0.91	0.08
W16 20 0-6	18-Jun-03	557	367.62	22.00	70.80	12.70	21.00	27.90	0.63	0.00
W16 30 0-6	18-Jun-03	479	316.14	15.80	64.00	11.40	21.70	20.50	0.48	0.00
W16 10 6-12	18-Jun-03	931	614.46	73.00	101.80	22.10	8.60	208.30	1.71	1.23
W16 20 6-12	18-Jun-03	682	450.12	44.50	72.70	15.50	11.90	70.00	1.24	0.55
W16 30 6-12	18-Jun-03	849	560.34	46.60	100.40	22.00	14.90	98.00	1.10	0.35
W16 10 12-18	18-Jun-03	1243	820.38	86.90	128.00	31.80	7.30	138.50	1.78	1.34
W16 20 12-18	18-Jun-03	809	533.94	31.30	56.00	15.30	14.70	59.80	0.96	0.15
W16 30 12-18	18-Jun-03	1188	784.08	71.60	127.00	32.90	8.20	110.30	1.46	0.88
W16 10 18-24	18-Jun-03	2240	1478.40	182.80	222.00	61.00	12.60	401.10	2.80	2.77
W16 20 18-24	18-Jun-03	1088	718.08	83.90	105.60	30.30	5.70	163.00	1.85	1.44
W16 30 18-24	18-Jun-03	1081	713.46	83.10	101.20	29.50	5.40	165.40	1.87	1.46
E33 10 0-6	18-Jun-03	763	503.58	18.30	95.50	26.70	31.30	59.90	0.43	0.00
E33 20 0-6	18-Jun-03	532	351.12	14.60	67.60	18.40	18.20	32.70	0.41	0.00
E33 30 0-6	18-Jun-03	486	320.76	16.70	59.20	16.50	15.30	38.10	0.49	0.00
E33 10 6-12	18-Jun-03	595	392.70	34.70	64.30	19.30	7.50	94.00	0.97	0.17
E33 20 6-12	18-Jun-03	838	553.08	40.80	91.40	27.00	9.30	66.00	0.96	0.16
E33 30 6-12	18-Jun-03	1001	660.66	38.50	113.30	33.30	11.20	87.60	0.82	0.00
E33 10 12-18	18-Jun-03	760	501.60	22.90	57.40	14.10	14.10	31.00	0.70	0.00
E33 20 12-18	18-Jun-03	917	605.22	56.30	95.30	28.90	4.40	60.60	1.30	0.64
E33 30 12-18	18-Jun-03	871	574.86	49.70	93.40	28.10	5.80	45.10	1.16	0.44
E33 10 18-24	18-Jun-03	821	541.86	65.80	76.20	21.60	3.00	110.40	1.71	1.24
E33 20 18-24	18-Jun-03	718	473.88	58.30	66.30	19.20	2.60	93.30	1.62	1.11
E33 30 18-24	18-Jun-03	647	427.02	51.50	60.10	18.20	3.20	64.90	1.49	0.93

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
W33 10 0-6	18-Jun-03	604	398.64	26.50	72.60	18.00	22.00	36.10	0.72	0.00
W33 20 0-6	18-Jun-03	510	336.60	24.00	61.20	15.20	14.30	28.70	0.71	0.00
W33 30 0-6	18-Jun-03	482	318.12	54.20	75.70	23.00	3.40	68.60	1.40	0.79
W33 10 6-12	18-Jun-03	885	584.10	56.90	93.80	25.40	9.80	140.80	1.35	0.71
W33 20 6-12	18-Jun-03	504	332.64	44.00	48.60	13.60	7.40	59.40	1.44	0.84
W33 30 6-12	18-Jun-03	691	456.06	50.30	72.60	20.20	8.60	104.10	1.35	0.71
W33 10 12-18	18-Jun-03	882	582.12	63.30	83.50	24.60	7.60	86.00	1.56	1.03
W33 20 12-18	18-Jun-03	678	447.48	56.70	66.40	20.50	6.70	97.50	1.56	1.02
W33 30 12-18	18-Jun-03	1002	661.32	67.60	96.10	28.70	8.40	88.50	1.55	1.01
W33 10 18-24	18-Jun-03	914	603.24	87.50	68.50	21.90	6.40	101.90	2.36	2.15
W33 20 18-24	18-Jun-03	853	562.98	69.00	73.10	24.20	6.30	123.20	1.79	1.35
W33 30 18-24	18-Jun-03	874	576.84	69.40	77.00	25.10	7.00	108.90	1.76	1.30
E53 10 0-6	18-Jun-03	429	283.14	10.40	54.70	15.60	15.40	25.40	0.32	0.00
E53 20 0-6	18-Jun-03	538	355.08	16.40	68.80	19.40	18.10	51.30	0.45	0.00
E53 30 0-6	18-Jun-03	566	373.56	12.90	73.60	20.40	18.30	41.60	0.34	0.00
E53 10 6-12	18-Jun-03	386	254.76	22.00	41.70	13.00	7.70	34.50	0.76	0.00
E53 20 6-12	18-Jun-03	1331	878.46	34.90	157.30	47.60	14.10	76.20	0.63	0.00
E53 30 6-12	18-Jun-03	756	498.96	23.60	85.90	27.00	13.00	68.10	0.57	0.00
E53 10 12-18	18-Jun-03	633	417.78	44.40	61.30	21.40	8.10	55.70	1.24	0.56
E53 20 12-18	18-Jun-03	770	508.20	45.00	76.20	24.60	5.70	57.80	1.15	0.42
E53 30 12-18	18-Jun-03	779	514.14	47.40	74.30	24.80	6.40	49.60	1.22	0.52
E53 10 18-24	18-Jun-03	499	329.34	36.00	50.60	17.30	8.00	49.30	1.11	0.38
E53 20 18-24	18-Jun-03	547	361.02	49.90	47.20	16.80	3.10	52.80	1.59	1.06
E53 30 18-24	18-Jun-03	646	426.36	50.40	58.90	19.30	3.20	49.40	1.46	0.87
W53 10 0-6	18-Jun-03	429	283.14	28.70	45.40	14.20	9.30	49.20	0.95	0.14
W53 20 0-6	18-Jun-03	495	326.70	33.00	53.60	13.90	10.70	70.00	1.04	0.27
W53 30 0-6	18-Jun-03	515	339.90	31.90	55.80	15.20	14.60	60.30	0.98	0.18
W53 10 6-12	18-Jun-03	404	266.64	33.60	38.40	10.90	7.10	68.60	1.23	0.55
W53 20 6-12	18-Jun-03	514	339.24	47.90	50.10	13.70	8.30	112.30	1.55	1.00
W53 30 6-12	18-Jun-03	469	309.54	37.20	47.60	13.50	8.10	67.70	1.23	0.54
W53 10 12-18	18-Jun-03	392	258.72	37.30	34.30	9.90	5.10	79.90	1.44	0.85
W53 20 12-18	18-Jun-03	596	393.36	63.50	50.40	14.30	5.60	146.00	2.03	1.69
W53 30 12-18	18-Jun-03	456	300.96	49.90	38.80	10.90	4.30	86.90	1.82	1.40
W53 10 18-24	18-Jun-03	425	280.50	43.50	38.60	10.10	4.90	86.30	1.61	1.09
W53 20 18-24	18-Jun-03	837	552.42	78.30	78.30	22.00	7.00	245.40	2.01	1.67
W53 30 18-24	18-Jun-03	625	412.50	61.90	52.20	15.10	6.10	136.10	1.94	1.56

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe
		g	g	g	g	g			
E16 10 0-6	23-Jul-03	138.78	499.63	654.46	360.85	154.83	1.77	0.43	7.89
E16 20 0-6	23-Jul-03	136.26	438.93	574.53	302.67	135.60	1.48	0.45	7.61
E16 30 0-6	23-Jul-03	136.32	445.38	559.15	309.06	113.77	1.52	0.37	7.71
E16 10 6-12	23-Jul-03	146.29	475.60	619.94	329.31	144.34	1.61	0.44	7.76
E16 20 6-12	23-Jul-03	135.40	446.15	557.82	310.75	111.67	1.52	0.36	7.50
E16 30 6-12	23-Jul-03	140.26	473.48	585.54	333.22	112.06	1.63	0.34	7.59
E16 10 12-18	23-Jul-03	130.26	478.95	631.92	348.69	152.97	1.71	0.44	7.82
E16 20 12-18	23-Jul-03	147.35	506.17	622.51	358.82	116.34	1.76	0.32	7.48
E16 30 12-18	23-Jul-03	134.60	469.89	582.14	335.29	112.25	1.64	0.33	7.63
E16 10 18-24	23-Jul-03	129.46	450.13	593.63	320.67	143.50	1.57	0.45	7.97
E16 20 18-24	23-Jul-03	123.62	443.57	572.98	319.95	129.41	1.57	0.40	7.44
E16 30 18-24	23-Jul-03	134.93	438.71	543.67	303.78	104.96	1.49	0.35	7.64
W16 10 0-6	23-Jul-03	140.92	484.62	601.01	343.70	116.39	1.69	0.34	8.01
W16 20 0-6	23-Jul-03	139.09	451.81	604.80	312.72	152.99	1.53	0.49	8.01
W16 30 0-6	23-Jul-03	128.54	448.81	575.20	320.27	126.39	1.57	0.39	7.96
W16 10 6-12	23-Jul-03	128.06	431.62	533.41	303.56	101.79	1.49	0.34	7.92
W16 20 6-12	23-Jul-03	129.32	460.79	592.41	331.47	131.62	1.63	0.40	7.99
W16 30 6-12	23-Jul-03	135.33	427.45	526.64	292.12	99.19	1.43	0.34	7.98
W16 10 12-18	23-Jul-03	136.38	439.94	560.29	303.56	120.35	1.49	0.40	7.76
W16 20 12-18	23-Jul-03	130.31	469.21	608.71	338.90	139.50	1.66	0.41	7.77
W16 30 12-18	23-Jul-03	140.19	464.73	598.43	324.54	133.70	1.59	0.41	7.81
W16 10 18-24	23-Jul-03	135.58	436.36	558.80	300.78	122.44	1.48	0.41	7.76
W16 20 18-24	23-Jul-03	139.18	475.30	623.74	336.12	148.44	1.65	0.44	7.63
W16 30 18-24	23-Jul-03	125.97	432.83	573.33	306.86	140.50	1.50	0.46	7.68
E33 10 0-6	23-Jul-03	130.20	473.03	598.84	342.83	125.81	1.68	0.37	7.95
E33 20 0-6	23-Jul-03	136.60	458.23	606.23	321.63	148.00	1.58	0.46	7.69
E33 30 0-6	23-Jul-03	138.82	489.93	644.94	351.11	155.01	1.72	0.44	7.88
E33 10 6-12	23-Jul-03	121.98	452.53	579.21	330.55	126.68	1.62	0.38	7.90
E33 20 6-12	23-Jul-03	135.74	435.50	570.44	299.76	134.94	1.47	0.45	7.73
E33 30 6-12	23-Jul-03	126.58	419.73	547.36	293.15	127.63	1.44	0.44	7.91
E33 10 12-18	23-Jul-03	131.61	432.67	550.60	301.06	117.93	1.48	0.39	7.93
E33 20 12-18	23-Jul-03	140.70	435.88	572.69	295.18	136.81	1.45	0.46	7.88
E33 30 12-18	23-Jul-03	127.66	442.90	590.19	315.24	147.29	1.55	0.47	7.76
E33 10 18-24	23-Jul-03	125.74	434.50	573.71	308.76	139.21	1.51	0.45	7.81
E33 20 18-24	23-Jul-03	134.22	429.59	565.95	295.37	136.36	1.45	0.46	7.94
E33 30 18-24	23-Jul-03	125.61	433.21	576.89	307.60	143.68	1.51	0.47	7.83

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe
		g	g	g	g	g			
W33 10 0-6	23-Jul-03	141.03	447.62	594.15	306.59	146.53	1.50	0.48	8.04
W33 20 0-6	23-Jul-03	138.77	479.30	613.11	340.53	133.81	1.67	0.39	8.02
W33 30 0-6	23-Jul-03	140.63	415.34	554.78	274.71	139.44	1.35	0.51	7.85
W33 10 6-12	23-Jul-03	131.49	430.35	558.60	298.86	128.25	1.47	0.43	7.90
W33 20 6-12	23-Jul-03	141.43	472.91	599.83	331.48	126.92	1.63	0.38	7.95
W33 30 6-12	23-Jul-03	140.99	458.74	577.44	317.75	118.70	1.56	0.37	7.98
W33 10 12-18	23-Jul-03	121.37	434.36	571.38	312.99	137.02	1.53	0.44	7.92
W33 20 12-18	23-Jul-03	132.61	475.93	613.34	343.32	137.41	1.68	0.40	8.00
W33 30 12-18	23-Jul-03	140.52	468.00	602.67	327.48	134.67	1.61	0.41	7.61
W33 10 18-24	23-Jul-03	134.60	427.81	562.20	293.21	134.39	1.44	0.46	7.93
W33 20 18-24	23-Jul-03	124.04	273.00	338.50	148.96	65.50	0.73	0.44	7.95
W33 30 18-24	23-Jul-03	140.58	473.65	622.76	333.07	149.11	1.63	0.45	7.66
E53 10 0-6	23-Jul-03	126.00	418.59	530.25	292.59	111.66	1.43	0.38	7.70
E53 20 0-6	23-Jul-03	136.35	467.80	601.34	331.45	133.54	1.63	0.40	7.94
E53 30 0-6	23-Jul-03	120.77	469.20	595.70	348.43	126.50	1.71	0.36	7.98
E53 10 6-12	23-Jul-03	129.31	428.12	534.89	298.81	106.77	1.47	0.36	7.59
E53 20 6-12	23-Jul-03	123.14	412.50	524.36	289.36	111.86	1.42	0.39	7.87
E53 30 6-12	23-Jul-03	126.02	437.66	568.64	311.64	130.98	1.53	0.42	7.92
E53 10 12-18	23-Jul-03	120.26	447.04	579.84	326.78	132.80	1.60	0.41	7.65
E53 20 12-18	23-Jul-03	134.62	437.05	574.86	302.43	137.81	1.48	0.46	7.77
E53 30 12-18	23-Jul-03	121.40	429.00	552.05	307.60	123.05	1.51	0.40	7.84
E53 10 18-24	23-Jul-03	127.59	435.93	556.54	308.34	120.61	1.51	0.39	7.58
E53 20 18-24	23-Jul-03	129.66	433.08	545.59	303.42	112.51	1.49	0.37	7.89
E53 30 18-24	23-Jul-03	124.17	423.85	529.00	299.68	105.15	1.47	0.35	7.91
W53 10 0-6	23-Jul-03	136.38	389.11	496.30	252.73	107.19	1.24	0.42	7.51
W53 20 0-6	23-Jul-03	137.75	453.72	556.49	315.97	102.77	1.55	0.33	7.53
W53 30 0-6	23-Jul-03	136.34	446.56	573.16	310.22	126.60	1.52	0.41	7.69
W53 10 6-12	23-Jul-03	125.91	430.43	540.43	304.52	110.00	1.49	0.36	7.79
W53 20 6-12	23-Jul-03	125.71	431.34	545.47	305.63	114.13	1.50	0.37	7.63
W53 30 6-12	23-Jul-03	138.55	439.64	563.98	301.09	124.34	1.48	0.41	7.75
W53 10 12-18	23-Jul-03	128.36	438.49	571.75	310.13	133.26	1.52	0.43	7.94
W53 20 12-18	23-Jul-03	124.90	445.30	554.90	320.40	109.60	1.57	0.34	7.69
W53 30 12-18	23-Jul-03	125.88	443.17	575.83	317.29	132.66	1.56	0.42	7.76
W53 10 18-24	23-Jul-03	135.71	428.18	556.30	292.47	128.12	1.43	0.44	7.96
W53 20 18-24	23-Jul-03	130.76	457.24	584.85	326.48	127.61	1.60	0.39	7.66
W53 30 18-24	23-Jul-03	134.41	452.83	576.25	318.42	123.42	1.56	0.39	7.62

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
E16 10 0-6	23-Jul-03	625	412.50	14.78	69.84	18.87	9.50	34.63	0.41	0.00
E16 20 0-6	23-Jul-03	518	341.88	10.84	56.81	15.42	12.05	30.49	0.33	0.00
E16 30 0-6	23-Jul-03	480	316.80	8.89	51.45	14.06	8.44	25.13	0.28	0.00
E16 10 6-12	23-Jul-03	1007	664.62	35.86	97.37	29.84	5.58	39.87	0.82	0.00
E16 20 6-12	23-Jul-03	806	531.96	25.13	80.09	23.77	5.84	59.28	0.63	0.00
E16 30 6-12	23-Jul-03	435	287.10	18.13	40.27	12.35	3.37	38.27	0.64	0.00
E16 10 12-18	23-Jul-03	802	529.32	41.04	66.61	22.21	3.07	51.98	1.11	0.37
E16 20 12-18	23-Jul-03	1150	759.00	47.49	104.52	33.50	3.56	41.08	1.03	0.26
E16 30 12-18	23-Jul-03	654	431.64	31.35	55.83	18.14	1.53	55.09	0.93	0.11
E16 10 18-24	23-Jul-03	563	371.58	43.24	41.00	14.62	2.60	102.97	1.48	0.90
E16 20 18-24	23-Jul-03	584	385.44	41.23	42.26	14.79	1.80	72.84	1.39	0.78
E16 30 18-24	23-Jul-03	786	518.76	48.07	60.57	20.89	1.96	67.76	1.36	0.73
W16 10 0-6	23-Jul-03	452	298.32	15.87	54.78	9.23	12.85	24.38	0.52	0.00
W16 20 0-6	23-Jul-03	356	234.96	13.34	40.15	6.96	8.27	20.83	0.51	0.00
W16 30 0-6	23-Jul-03	443	292.38	14.99	55.66	9.57	13.28	31.72	0.49	0.00
W16 10 6-12	23-Jul-03	597	394.02	33.73	64.69	13.26	9.17	79.16	1.00	0.21
W16 20 6-12	23-Jul-03	651	429.66	37.40	64.80	13.12	6.21	109.01	1.11	0.37
W16 30 6-12	23-Jul-03	552	364.32	31.55	56.88	12.51	7.88	60.37	0.99	0.19
W16 10 12-18	23-Jul-03	1204	794.64	58.90	122.41	28.78	6.27	190.31	1.24	0.56
W16 20 12-18	23-Jul-03	1295	854.70	68.12	126.30	29.63	6.66	163.52	1.42	0.81
W16 30 12-18	23-Jul-03	1198	790.68	58.55	114.94	28.23	6.42	143.94	1.27	0.60
W16 10 18-24	23-Jul-03	1478	975.48	77.85	137.42	36.60	4.91	172.62	1.52	0.97
W16 20 18-24	23-Jul-03	1565	1032.90	87.92	150.43	40.10	5.97	208.69	1.65	1.14
W16 30 18-24	23-Jul-03	1250	825.00	68.77	107.14	29.89	4.92	153.83	1.51	0.95
E33 10 0-6	23-Jul-03	831	548.46	16.35	99.21	25.81	17.42	74.81	0.38	0.00
E33 20 0-6	23-Jul-03	469	309.54	9.21	49.91	12.96	9.97	23.66	0.30	0.00
E33 30 0-6	23-Jul-03	562	370.92	11.31	62.35	16.68	10.75	39.42	0.33	0.00
E33 10 6-12	23-Jul-03	499	329.34	26.34	49.02	13.62	3.57	54.76	0.86	0.00
E33 20 6-12	23-Jul-03	682	450.12	24.76	70.80	20.00	6.42	50.23	0.67	0.00
E33 30 6-12	23-Jul-03	669	441.54	37.89	58.20	16.39	2.02	51.98	1.13	0.40
E33 10 12-18	23-Jul-03	747	493.02	40.93	65.78	18.49	2.19	71.78	1.15	0.43
E33 20 12-18	23-Jul-03	741	489.06	32.25	68.04	19.60	2.81	38.53	0.89	0.04
E33 30 12-18	23-Jul-03	903	595.98	34.77	88.21	24.63	3.27	42.56	0.84	0.00
E33 10 18-24	23-Jul-03	785	518.10	48.91	66.92	18.53	2.16	119.26	1.36	0.74
E33 20 18-24	23-Jul-03	418	275.88	28.25	34.48	9.56	1.66	50.80	1.10	0.35
E33 30 18-24	23-Jul-03	840	554.40	25.96	86.19	24.24	7.09	66.71	0.64	0.00

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
W33 10 0-6	23-Jul-03	378	249.48	14.54	44.73	10.58	8.24	31.54	0.51	0.00
W33 20 0-6	23-Jul-03	373	246.18	13.88	40.77	9.20	7.81	21.58	0.51	0.00
W33 30 0-6	23-Jul-03	352	232.32	11.54	40.42	9.51	7.05	17.25	0.42	0.00
W33 10 6-12	23-Jul-03	520	343.20	26.97	48.66	12.95	4.82	66.63	0.89	0.04
W33 20 6-12	23-Jul-03	434	286.44	26.33	39.68	10.51	4.26	55.08	0.96	0.15
W33 30 6-12	23-Jul-03	427	281.82	28.11	35.68	9.34	4.19	49.54	1.08	0.33
W33 10 12-18	23-Jul-03	640	422.40	39.28	60.14	17.04	4.25	86.00	1.15	0.43
W33 20 12-18	23-Jul-03	662	436.92	40.22	59.49	17.48	4.79	88.76	1.18	0.47
W33 30 12-18	23-Jul-03	657	433.62	41.10	54.31	15.74	4.36	113.33	1.26	0.59
W33 10 18-24	23-Jul-03	703	463.98	43.74	54.90	17.05	4.24	95.57	1.32	0.68
W33 20 18-24	23-Jul-03	671	442.86	44.68	52.36	16.58	5.10	92.78	1.38	0.76
W33 30 18-24	23-Jul-03	958	632.28	56.27	77.34	24.09	6.00	129.66	1.43	0.84
E53 10 0-6	23-Jul-03	602	397.32	6.99	84.01	12.22	27.58	30.11	0.19	0.00
E53 20 0-6	23-Jul-03	527	347.82	6.71	64.46	9.98	17.30	21.04	0.21	0.00
E53 30 0-6	23-Jul-03	507	334.62	7.21	62.59	10.35	14.84	29.51	0.22	0.00
E53 10 6-12	23-Jul-03	475	313.50	13.21	55.91	10.43	6.11	39.17	0.43	0.00
E53 20 6-12	23-Jul-03	539	355.74	14.32	62.56	12.64	6.52	36.42	0.43	0.00
E53 30 6-12	23-Jul-03	456	300.96	15.67	52.49	11.05	5.22	52.76	0.51	0.00
E53 10 12-18	23-Jul-03	679	448.14	28.89	69.88	16.63	3.36	67.63	0.81	0.00
E53 20 12-18	23-Jul-03	1080	712.80	36.47	109.63	26.21	3.84	43.37	0.81	0.00
E53 30 12-18	23-Jul-03	701	462.66	32.45	63.74	16.12	3.41	41.04	0.94	0.12
E53 10 18-24	23-Jul-03	935	617.10	48.29	82.03	23.22	2.13	46.67	1.21	0.52
E53 20 18-24	23-Jul-03	1020	673.20	51.68	89.84	25.97	2.65	41.04	1.24	0.55
E53 30 18-24	23-Jul-03	702	463.32	46.10	57.67	17.34	2.94	52.34	1.37	0.74
W53 10 0-6	23-Jul-03	707	466.62	72.27	237.58	64.98	80.34	47.71	1.07	0.31
W53 20 0-6	23-Jul-03	691	456.06	29.88	65.22	15.47	9.29	46.66	0.86	0.01
W53 30 0-6	23-Jul-03	628	414.48	26.80	58.59	14.30	11.90	37.38	0.81	0.00
W53 10 6-12	23-Jul-03	580	382.80	27.42	52.61	14.04	6.49	51.12	0.87	0.02
W53 20 6-12	23-Jul-03	511	337.26	27.68	44.36	11.50	4.06	60.60	0.96	0.15
W53 30 6-12	23-Jul-03	479	316.14	26.80	42.43	11.14	4.85	66.11	0.95	0.13
W53 10 12-18	23-Jul-03	441	291.06	27.50	37.09	9.90	3.87	58.47	1.04	0.26
W53 20 12-18	23-Jul-03	454	299.64	34.72	35.68	9.33	2.61	91.52	1.34	0.70
W53 30 12-18	23-Jul-03	444	293.04	32.40	34.29	8.92	3.09	82.08	1.27	0.61
W53 10 18-24	23-Jul-03	451	297.66	30.62	37.29	9.47	3.66	78.89	1.16	0.44
W53 20 18-24	23-Jul-03	498	328.68	41.03	37.15	9.69	2.93	127.39	1.55	1.01
W53 30 18-24	23-Jul-03	582	384.12	46.17	43.74	11.00	3.64	149.34	1.62	1.10

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe
		g	g	g	g	g			
E16 10 0-6	5-Aug-03	140.60	432.98	551.65	292.38	118.67	1.43	0.41	7.67
E16 20 0-6	5-Aug-03	138.98	414.00	551.84	275.02	137.84	1.35	0.50	7.78
E16 30 0-6	5-Aug-03	125.93	434.86	563.69	308.93	128.83	1.51	0.42	7.45
E16 10 6-12	5-Aug-03	139.29	430.87	536.67	291.58	105.80	1.43	0.36	7.69
E16 20 6-12	5-Aug-03	135.57	432.14	552.53	296.57	120.39	1.45	0.41	7.69
E16 30 6-12	5-Aug-03	125.93	432.37	553.62	306.44	121.25	1.50	0.40	7.70
E16 10 12-18	5-Aug-03	134.85	431.42	560.28	296.57	128.86	1.45	0.43	7.52
E16 20 12-18	5-Aug-03	137.80	428.66	560.36	290.86	131.70	1.43	0.45	7.54
E16 30 12-18	5-Aug-03	131.87	425.71	557.94	293.84	132.23	1.44	0.45	7.64
E16 10 18-24	5-Aug-03	121.03	440.71	581.41	319.68	140.70	1.57	0.44	7.45
E16 20 18-24	5-Aug-03	128.90	425.51	553.31	296.61	127.80	1.45	0.43	7.68
E16 30 18-24	5-Aug-03	140.00	442.30	588.02	302.30	145.72	1.48	0.48	7.72
W16 10 0-6	5-Aug-03	128.15	409.10	552.13	280.95	143.03	1.38	0.51	7.83
W16 20 0-6	5-Aug-03	136.10	393.21	511.86	257.11	118.65	1.26	0.46	7.74
W16 30 0-6	5-Aug-03	135.48	401.35	514.80	265.87	113.45	1.30	0.43	7.66
W16 10 6-12	5-Aug-03	138.89	412.61	535.23	273.72	122.62	1.34	0.45	7.85
W16 20 6-12	5-Aug-03	137.77	445.56	589.48	307.79	143.92	1.51	0.47	7.72
W16 30 6-12	5-Aug-03	125.77	400.84	511.46	275.07	110.62	1.35	0.40	7.80
W16 10 12-18	5-Aug-03	140.26	466.72	625.94	326.46	159.22	1.60	0.49	7.74
W16 20 12-18	5-Aug-03	125.74	445.34	608.43	319.60	163.09	1.57	0.51	7.59
W16 30 12-18	5-Aug-03	131.23	447.73	573.18	316.50	125.45	1.55	0.40	7.74
W16 10 18-24	5-Aug-03	141.22	442.83	595.96	301.61	153.13	1.48	0.51	7.61
W16 20 18-24	5-Aug-03	139.12	467.46	615.23	328.34	147.77	1.61	0.45	7.49
W16 30 18-24	5-Aug-03	139.04	452.35	583.62	313.31	131.27	1.54	0.42	7.15
E33 10 0-6	5-Aug-03	134.08	428.92	552.71	294.84	123.79	1.45	0.42	7.76
E33 20 0-6	5-Aug-03	125.47	407.76	529.53	282.29	121.77	1.38	0.43	7.68
E33 30 0-6	5-Aug-03	125.75	416.40	558.45	290.65	142.05	1.43	0.49	7.83
E33 10 6-12	5-Aug-03	131.89	444.57	577.90	312.68	133.33	1.53	0.43	7.69
E33 20 6-12	5-Aug-03	140.43	460.17	605.31	319.74	145.14	1.57	0.45	7.46
E33 30 6-12	5-Aug-03	125.75	423.93	588.65	298.18	164.72	1.46	0.55	7.55
E33 10 12-18	5-Aug-03	125.86	427.90	569.44	302.04	141.54	1.48	0.47	7.62
E33 20 12-18	5-Aug-03	137.82	462.57	618.83	324.75	156.26	1.59	0.48	7.55
E33 30 12-18	5-Aug-03	125.93	446.92	593.80	320.99	146.88	1.57	0.46	7.55
E33 10 18-24	5-Aug-03	122.78	415.07	563.26	292.29	148.19	1.43	0.51	7.29
E33 20 18-24	5-Aug-03	134.57	417.70	549.63	283.13	131.93	1.39	0.47	7.70
E33 30 18-24	5-Aug-03	131.73	421.85	556.30	290.12	134.45	1.42	0.46	7.61

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe
		g	g	g	g	g			
W33 10 0-6	5-Aug-03	125.51	358.84	481.24	233.33	122.40	1.14	0.52	7.82
W33 20 0-6	5-Aug-03	130.11	428.72	567.62	298.61	138.90	1.46	0.47	7.69
W33 30 0-6	5-Aug-03	125.86	379.63	500.84	253.77	121.21	1.24	0.48	7.82
W33 10 6-12	5-Aug-03	136.37	404.82	551.33	268.45	146.51	1.32	0.55	7.79
W33 20 6-12	5-Aug-03	129.35	410.98	533.61	281.63	122.63	1.38	0.44	7.81
W33 30 6-12	5-Aug-03	140.06	422.37	560.66	282.31	138.29	1.38	0.49	7.79
W33 10 12-18	5-Aug-03	130.23	448.80	592.42	318.57	143.62	1.56	0.45	7.70
W33 20 12-18	5-Aug-03	130.10	479.24	638.57	349.14	159.33	1.71	0.46	7.78
W33 30 12-18	5-Aug-03	136.21	450.47	599.03	314.26	148.56	1.54	0.47	7.76
W33 10 18-24	5-Aug-03	130.23	448.80	592.42	318.57	143.62	1.56	0.45	7.84
W33 20 18-24	5-Aug-03	131.04	465.98	620.74	334.94	154.76	1.64	0.46	7.74
W33 30 18-24	5-Aug-03	135.81	438.61	590.61	302.80	152.00	1.48	0.50	7.72
E53 10 0-6	5-Aug-03	128.13	362.14	473.59	234.01	111.45	1.15	0.48	7.80
E53 20 0-6	5-Aug-03	133.01	380.55	497.80	247.54	117.25	1.21	0.47	7.57
E53 30 0-6	5-Aug-03	126.19	398.56	542.27	272.37	143.71	1.34	0.53	7.73
E53 10 6-12	5-Aug-03	130.00	425.76	566.93	295.76	141.17	1.45	0.48	7.62
E53 20 6-12	5-Aug-03	133.57	423.75	576.76	290.18	153.01	1.42	0.53	7.51
E53 30 6-12	5-Aug-03	134.83	422.05	566.23	287.22	144.18	1.41	0.50	7.57
E53 10 12-18	5-Aug-03	128.36	473.86	629.86	345.50	156.00	1.69	0.45	7.64
E53 20 12-18	5-Aug-03	135.57	460.67	601.03	325.10	140.36	1.59	0.43	7.36
E53 30 12-18	5-Aug-03	138.83	482.27	644.84	343.44	162.57	1.68	0.47	7.83
E53 10 18-24	5-Aug-03	136.31	547.10	722.73	410.79	175.63	2.01	0.43	7.67
E53 20 18-24	5-Aug-03	129.10	491.88	636.02	362.78	144.14	1.78	0.40	7.73
E53 30 18-24	5-Aug-03	125.61	480.54	650.13	354.93	169.59	1.74	0.48	7.73
W53 10 0-6	5-Aug-03	130.93	401.45	543.13	270.52	141.68	1.33	0.52	7.44
W53 20 0-6	5-Aug-03	137.55	427.00	562.43	289.45	135.43	1.42	0.47	7.58
W53 30 0-6	5-Aug-03	129.33	412.94	547.89	283.61	134.95	1.39	0.48	7.62
W53 10 6-12	5-Aug-03	128.53	438.86	578.40	310.33	139.54	1.52	0.45	7.64
W53 20 6-12	5-Aug-03	134.73	464.08	612.50	329.35	148.42	1.62	0.45	7.72
W53 30 6-12	5-Aug-03	136.43	434.50	583.39	298.07	148.89	1.46	0.50	7.65
W53 10 12-18	5-Aug-03	128.03	455.81	607.75	327.78	151.94	1.61	0.46	7.81
W53 20 12-18	5-Aug-03	136.33	470.42	639.00	334.09	168.58	1.64	0.50	7.59
W53 30 12-18	5-Aug-03	125.58	450.88	580.79	325.30	129.91	1.60	0.40	7.72
W53 10 18-24	5-Aug-03	139.27	439.78	595.10	300.51	155.32	1.47	0.52	7.75
W53 20 18-24	5-Aug-03	140.19	440.27	597.86	300.08	157.59	1.47	0.53	7.65
W53 30 18-24	5-Aug-03	126.29	417.94	570.28	291.65	152.34	1.43	0.52	7.59

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
E16 10 0-6	5-Aug-03	600	396.00	9.21	75.99	12.61	18.40	30.58	0.26	0.00
E16 20 0-6	5-Aug-03	390	257.40	7.84	49.01	8.37	18.52	21.24	0.27	0.00
E16 30 0-6	5-Aug-03	471	310.86	6.55	54.36	9.22	15.61	20.99	0.22	0.00
E16 10 6-12	5-Aug-03	524	345.84	20.61	61.37	13.05	6.68	38.25	0.62	0.00
E16 20 6-12	5-Aug-03	502	331.32	15.88	60.68	12.89	6.75	48.86	0.48	0.00
E16 30 6-12	5-Aug-03	481	317.46	14.40	50.63	11.05	5.49	35.12	0.48	0.00
E16 10 12-18	5-Aug-03	660	435.60	33.49	69.44	18.63	3.08	82.52	0.92	0.09
E16 20 12-18	5-Aug-03	937	618.42	35.80	95.74	25.32	3.97	64.54	0.84	0.00
E16 30 12-18	5-Aug-03	627	413.82	28.38	54.12	14.61	2.82	41.01	0.88	0.04
E16 10 18-24	5-Aug-03	928	612.48	52.53	79.29	25.04	2.97	55.43	1.32	0.67
E16 20 18-24	5-Aug-03	1048	691.68	56.00	91.70	28.79	2.71	36.65	1.31	0.66
E16 30 18-24	5-Aug-03	685	452.10	38.63	52.05	16.68	2.34	33.90	1.19	0.49
W16 10 0-6	5-Aug-03	333	219.78	8.87	37.90	7.42	12.39	16.63	0.34	0.00
W16 20 0-6	5-Aug-03	372	245.52	8.28	39.75	7.15	10.48	14.36	0.32	0.00
W16 30 0-6	5-Aug-03	543	358.38	9.41	60.64	11.04	15.44	16.99	0.29	0.00
W16 10 6-12	5-Aug-03	406	267.96	27.31	39.41	8.64	5.37	40.96	1.03	0.25
W16 20 6-12	5-Aug-03	545	359.70	22.99	49.97	10.53	8.73	23.08	0.77	0.00
W16 30 6-12	5-Aug-03	449	296.34	17.21	42.95	9.50	7.56	16.19	0.62	0.00
W16 10 12-18	5-Aug-03	698	460.68	47.85	61.56	15.71	4.79	114.41	1.41	0.80
W16 20 12-18	5-Aug-03	769	507.54	42.03	63.56	15.93	5.37	94.30	1.22	0.53
W16 30 12-18	5-Aug-03	705	465.30	42.39	56.68	14.84	4.55	94.47	1.30	0.64
W16 10 18-24	5-Aug-03	1215	801.90	76.67	106.10	30.98	5.58	203.79	1.68	1.20
W16 20 18-24	5-Aug-03	1474	972.84	75.25	122.83	35.11	5.13	170.05	1.54	0.99
W16 30 18-24	5-Aug-03	1439	949.74	76.11	115.06	33.59	4.93	161.11	1.61	1.09
E33 10 0-6	5-Aug-03	506	333.96	12.03	54.54	15.16	12.89	35.99	0.37	0.00
E33 20 0-6	5-Aug-03	464	306.24	12.99	49.14	13.87	12.23	31.38	0.42	0.00
E33 30 0-6	5-Aug-03	452	298.32	10.24	50.75	14.21	12.25	35.35	0.33	0.00
E33 10 6-12	5-Aug-03	663	437.58	28.51	66.45	20.31	5.37	76.43	0.79	0.00
E33 20 6-12	5-Aug-03	635	419.10	24.38	62.31	19.06	6.73	61.99	0.69	0.00
E33 30 6-12	5-Aug-03	538	355.08	19.92	51.41	16.04	5.35	61.29	0.62	0.00
E33 10 12-18	5-Aug-03	805	531.30	42.22	72.66	22.42	2.69	67.00	1.11	0.37
E33 20 12-18	5-Aug-03	985	650.10	41.59	90.13	27.48	4.22	41.90	0.98	0.19
E33 30 12-18	5-Aug-03	943	622.38	39.78	87.14	26.86	3.68	53.60	0.96	0.14
E33 10 18-24	5-Aug-03	949	626.34	53.40	78.96	23.31	2.11	85.95	1.36	0.73
E33 20 18-24	5-Aug-03	706	465.96	44.72	60.38	17.75	2.62	65.46	1.30	0.65
E33 30 18-24	5-Aug-03	727	479.82	42.48	61.29	17.79	2.37	51.95	1.23	0.54

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
W33 10 0-6	5-Aug-03	433	285.78	14.15	45.17	11.49	9.23	29.36	0.49	0.00
W33 20 0-6	5-Aug-03	526	347.16	17.19	58.05	14.68	9.36	28.71	0.52	0.00
W33 30 0-6	5-Aug-03	354	233.64	11.94	41.30	10.56	7.81	22.97	0.43	0.00
W33 10 6-12	5-Aug-03	510	336.60	25.21	49.34	13.59	4.97	68.77	0.82	0.00
W33 20 6-12	5-Aug-03	420	277.20	24.52	40.11	11.43	4.31	32.30	0.88	0.03
W33 30 6-12	5-Aug-03	379	250.14	22.67	35.99	10.49	4.45	32.02	0.86	0.00
W33 10 12-18	5-Aug-03	712	469.92	37.55	65.15	19.90	4.61	88.32	1.04	0.27
W33 20 12-18	5-Aug-03	631	416.46	37.63	57.34	18.37	4.80	67.29	1.11	0.36
W33 30 12-18	5-Aug-03	538	355.08	34.37	46.97	14.93	4.12	87.18	1.12	0.38
W33 10 18-24	5-Aug-03	713	470.58	42.53	57.89	19.39	4.11	77.02	1.24	0.55
W33 20 18-24	5-Aug-03	600	396.00	41.36	45.24	15.76	4.18	72.59	1.35	0.72
W33 30 18-24	5-Aug-03	619	408.54	42.60	49.54	16.90	4.31	80.46	1.33	0.69
E53 10 0-6	5-Aug-03	833	549.78	12.36	67.07	21.63	51.59	34.74	0.34	0.00
E53 20 0-6	5-Aug-03	620	409.20	8.55	63.72	18.45	16.25	37.05	0.24	0.00
E53 30 0-6	5-Aug-03	359	236.94	9.89	37.21	11.56	6.94	23.79	0.36	0.00
E53 10 6-12	5-Aug-03	612	403.92	19.40	54.20	17.46	7.05	39.49	0.59	0.00
E53 20 6-12	5-Aug-03	450	297.00	11.44	39.91	12.77	5.27	25.45	0.40	0.00
E53 30 6-12	5-Aug-03	394	260.04	18.29	36.76	12.67	4.25	37.08	0.66	0.00
E53 10 12-18	5-Aug-03	793	523.38	34.47	63.87	22.10	3.71	41.76	0.95	0.13
E53 20 12-18	5-Aug-03	634	418.44	25.31	50.56	17.05	3.57	37.01	0.79	0.00
E53 30 12-18	5-Aug-03	496	327.36	27.62	41.88	14.84	2.52	46.02	0.93	0.11
E53 10 18-24	5-Aug-03	780	514.80	41.59	54.89	20.47	2.28	56.68	1.22	0.52
E53 20 18-24	5-Aug-03	808	533.28	40.15	60.99	21.74	2.47	43.87	1.12	0.39
E53 30 18-24	5-Aug-03	555	366.30	40.17	40.96	15.60	2.35	57.90	1.35	0.72
W53 10 0-6	5-Aug-03	1219	804.54	48.35	96.92	31.71	45.97	35.77	1.09	0.34
W53 20 0-6	5-Aug-03	1016	670.56	47.46	85.81	22.76	21.71	39.95	1.18	0.47
W53 30 0-6	5-Aug-03	626	413.16	23.11	55.72	14.69	10.31	42.35	0.71	0.00
W53 10 6-12	5-Aug-03	682	450.12	34.03	62.17	18.00	7.58	43.98	0.98	0.18
W53 20 6-12	5-Aug-03	570	376.20	34.96	48.95	14.25	5.83	74.63	1.13	0.40
W53 30 6-12	5-Aug-03	571	376.86	29.62	46.09	13.41	5.60	52.76	0.99	0.19
W53 10 12-18	5-Aug-03	490	323.40	31.57	43.48	12.63	4.24	60.27	1.08	0.33
W53 20 12-18	5-Aug-03	482	318.12	36.28	36.81	10.81	3.08	95.99	1.35	0.72
W53 30 12-18	5-Aug-03	492	324.72	35.51	35.39	10.30	3.07	92.53	1.35	0.72
W53 10 18-24	5-Aug-03	442	291.72	32.57	35.28	10.19	3.65	80.20	1.24	0.56
W53 20 18-24	5-Aug-03	538	355.08	44.08	38.83	11.18	3.23	127.64	1.60	1.08
W53 30 18-24	5-Aug-03	561	370.26	41.31	39.55	10.98	3.16	128.04	1.50	0.93

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe
		g	g	g	g	g			
E16 10 0-6	9-Sep-03	133.27	418.50	529.68	285.23	111.18	1.40	0.39	7.75
E16 20 0-6	9-Sep-03	133.45	464.69	596.10	331.24	131.41	1.62	0.40	7.80
E16 30 0-6	9-Sep-03	133.48	448.42	561.50	314.94	113.08	1.54	0.36	7.86
E16 10 6-12	9-Sep-03	128.73	402.32	521.60	273.59	119.28	1.34	0.44	7.80
E16 20 6-12	9-Sep-03	128.21	425.87	551.21	297.66	125.34	1.46	0.42	7.81
E16 30 6-12	9-Sep-03	133.49	419.61	531.11	286.12	111.50	1.40	0.39	7.79
E16 10 12-18	9-Sep-03	134.81	419.96	545.18	285.15	125.22	1.40	0.44	7.80
E16 20 12-18	9-Sep-03	133.23	412.30	553.42	279.07	141.12	1.37	0.51	7.65
E16 30 12-18	9-Sep-03	133.20	429.97	564.07	296.77	134.10	1.46	0.45	7.80
E16 10 18-24	9-Sep-03	128.77	278.45	347.54	149.68	69.09	0.73	0.46	7.76
E16 20 18-24	9-Sep-03	133.14	440.01	574.35	306.87	134.34	1.50	0.44	7.68
E16 30 18-24	9-Sep-03	133.28	442.23	572.88	308.95	130.65	1.52	0.42	7.78
W16 10 0-6	9-Sep-03	128.68	396.60	502.34	267.92	105.74	1.31	0.39	7.84
W16 20 0-6	9-Sep-03	133.29	399.39	501.10	266.10	101.71	1.30	0.38	7.89
W16 30 0-6	9-Sep-03	133.41	405.53	515.73	272.12	110.20	1.33	0.40	7.81
W16 10 6-12	9-Sep-03	128.74	431.13	560.66	302.39	129.53	1.48	0.43	7.80
W16 20 6-12	9-Sep-03	133.25	357.32	451.66	224.07	94.34	1.10	0.42	7.58
W16 30 6-12	9-Sep-03	128.85	431.31	551.13	302.46	119.82	1.48	0.40	7.80
W16 10 12-18	9-Sep-03	133.18	452.46	600.86	319.28	148.40	1.57	0.46	7.71
W16 20 12-18	9-Sep-03	133.21	434.05	570.28	300.84	136.23	1.48	0.45	7.71
W16 30 12-18	9-Sep-03	128.76	414.18	552.09	285.42	137.91	1.40	0.48	7.80
W16 10 18-24	9-Sep-03	133.43	433.44	597.11	300.01	163.67	1.47	0.55	7.61
W16 20 18-24	9-Sep-03	133.66	457.55	623.42	323.89	165.87	1.59	0.51	7.62
W16 30 18-24	9-Sep-03	128.21	411.87	567.37	283.66	155.50	1.39	0.55	7.88
E33 10 0-6	9-Sep-03	128.26	422.19	551.98	293.93	129.79	1.44	0.44	7.64
E33 20 0-6	9-Sep-03	128.72	428.37	544.98	299.65	116.61	1.47	0.39	7.79
E33 30 0-6	9-Sep-03	133.49	419.28	539.62	285.79	120.34	1.40	0.42	7.47
E33 10 6-12	9-Sep-03	128.78	412.26	538.98	283.48	126.72	1.39	0.45	7.48
E33 20 6-12	9-Sep-03	128.74	432.36	556.84	303.62	124.48	1.49	0.41	7.71
E33 30 6-12	9-Sep-03	128.75	419.19	541.16	290.44	121.97	1.42	0.42	7.53
E33 10 12-18	9-Sep-03	130.47	447.66	606.94	317.19	159.28	1.56	0.50	7.66
E33 20 12-18	9-Sep-03	128.77	408.82	532.62	280.05	123.80	1.37	0.44	7.34
E33 30 12-18	9-Sep-03	133.21	405.84	523.27	272.63	117.43	1.34	0.43	7.60
E33 10 18-24	9-Sep-03	128.84	416.63	553.16	287.79	136.53	1.41	0.47	7.78
E33 20 18-24	9-Sep-03	128.22	.	506.17	.	.	.	.	7.70
E33 30 18-24	9-Sep-03	133.24	427.59	549.00	294.35	121.41	1.44	0.41	7.62

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe
		g	g	g	g	g			
W33 10 0-6	9-Sep-03	133.35	423.00	533.64	289.65	110.64	1.42	0.38	7.62
W33 20 0-6	9-Sep-03	133.38	407.48	524.97	274.10	117.49	1.34	0.43	7.62
W33 30 0-6	9-Sep-03	135.09	419.05	555.11	283.96	136.06	1.39	0.48	7.74
W33 10 6-12	9-Sep-03	133.16	438.15	562.19	304.99	124.04	1.50	0.41	7.46
W33 20 6-12	9-Sep-03	133.22	411.42	538.00	278.20	126.58	1.36	0.45	7.74
W33 30 6-12	9-Sep-03	128.85	414.53	571.53	285.68	157.00	1.40	0.55	7.75
W33 10 12-18	9-Sep-03	133.35	438.54	579.01	305.19	140.47	1.50	0.46	7.46
W33 20 12-18	9-Sep-03	133.76	445.92	590.30	312.16	144.38	1.53	0.46	7.62
W33 30 12-18	9-Sep-03	133.32	462.65	627.48	329.33	164.83	1.62	0.50	7.83
W33 10 18-24	9-Sep-03	128.74	449.59	594.98	320.85	145.39	1.57	0.45	7.60
W33 20 18-24	9-Sep-03	133.19	.	594.81	.	.	.	.	7.54
W33 30 18-24	9-Sep-03	133.24	461.23	627.50	327.99	166.27	1.61	0.51	7.84
E53 10 0-6	9-Sep-03	133.23	397.85	515.71	264.62	117.86	1.30	0.45	7.76
E53 20 0-6	9-Sep-03	133.37	430.77	556.56	297.40	125.79	1.46	0.42	7.69
E53 30 0-6	9-Sep-03	132.93	376.27	493.08	243.34	116.81	1.19	0.48	7.65
E53 10 6-12	9-Sep-03	128.74	402.28	519.02	273.54	116.74	1.34	0.43	7.77
E53 20 6-12	9-Sep-03	133.22	431.66	559.80	298.44	128.14	1.46	0.43	7.52
E53 30 6-12	9-Sep-03	135.10	404.59	532.43	269.49	127.84	1.32	0.47	7.75
E53 10 12-18	9-Sep-03	133.51	453.34	603.72	319.83	150.38	1.57	0.47	7.88
E53 20 12-18	9-Sep-03	133.33	425.00	556.97	291.67	131.97	1.43	0.45	7.55
E53 30 12-18	9-Sep-03	133.41	444.72	587.86	311.31	143.14	1.53	0.46	7.88
E53 10 18-24	9-Sep-03	128.25	433.46	571.83	305.21	138.37	1.50	0.45	7.72
E53 20 18-24	9-Sep-03	133.22	437.28	574.02	304.06	136.74	1.49	0.45	6.68
E53 30 18-24	9-Sep-03	133.32	437.92	571.87	304.60	133.95	1.49	0.44	7.86
W53 10 0-6	9-Sep-03	128.83	386.36	490.42	257.53	104.06	1.26	0.40	7.28
W53 20 0-6	9-Sep-03	133.44	419.11	545.60	285.67	126.49	1.40	0.44	7.56
W53 30 0-6	9-Sep-03	128.75	407.10	538.71	278.35	131.61	1.37	0.47	7.76
W53 10 6-12	9-Sep-03	133.26	372.41	481.29	239.15	108.88	1.17	0.46	7.59
W53 20 6-12	9-Sep-03	133.34	436.45	577.26	303.11	140.81	1.49	0.46	7.64
W53 30 6-12	9-Sep-03	133.16	425.18	578.47	292.02	153.29	1.43	0.52	7.64
W53 10 12-18	9-Sep-03	138.16	430.10	574.99	291.94	144.89	1.43	0.50	7.53
W53 20 12-18	9-Sep-03	133.18	438.87	592.66	305.69	153.79	1.50	0.50	7.84
W53 30 12-18	9-Sep-03	128.76	441.58	603.45	312.82	161.87	1.53	0.52	7.82
W53 10 18-24	9-Sep-03	133.45	437.33	576.05	303.88	138.72	1.49	0.46	7.76
W53 20 18-24	9-Sep-03	133.20	438.21	592.24	305.01	154.03	1.50	0.50	7.66
W53 30 18-24	9-Sep-03	133.26	432.09	583.77	298.83	151.68	1.47	0.51	7.78

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
E16 10 0-6	9-Sep-03	737	486.42	16.40	128.10	19.00	41.80	67.10	0.36	0.00
E16 20 0-6	9-Sep-03	539	355.74	13.60	90.10	14.00	26.60	46.40	0.35	0.00
E16 30 0-6	9-Sep-03	519	342.54	13.50	64.20	10.40	19.20	42.30	0.41	0.00
E16 10 6-12	9-Sep-03	460	303.60	19.50	84.70	15.90	10.90	60.30	0.51	0.00
E16 20 6-12	9-Sep-03	512	337.92	19.30	63.90	13.50	8.40	57.90	0.57	0.00
E16 30 6-12	9-Sep-03	343	226.38	17.40	40.00	8.30	6.60	24.60	0.65	0.00
E16 10 12-18	9-Sep-03	552	364.32	44.10	77.80	18.50	4.80	100.50	1.17	0.45
E16 20 12-18	9-Sep-03	745	491.70	37.10	76.80	20.10	3.60	43.50	0.97	0.17
E16 30 12-18	9-Sep-03	430	283.80	31.80	40.20	10.30	3.10	54.60	1.16	0.44
E16 10 18-24	9-Sep-03	813	536.58	59.70	90.70	24.50	6.30	73.60	1.44	0.84
E16 20 18-24	9-Sep-03	764	504.24	52.60	66.30	20.90	3.00	34.50	1.44	0.85
E16 30 18-24	9-Sep-03	561	370.26	45.00	43.30	13.20	2.60	41.00	1.54	0.99
W16 10 0-6	9-Sep-03	547	361.02	20.87	70.80	13.62	22.88	34.82	0.60	0.00
W16 20 0-6	9-Sep-03	552	364.32	17.95	71.09	13.18	24.01	29.99	0.51	0.00
W16 30 0-6	9-Sep-03	485	320.10	12.22	65.34	12.37	22.33	20.18	0.36	0.00
W16 10 6-12	9-Sep-03	567	374.22	41.10	60.12	13.71	10.68	79.37	1.24	0.56
W16 20 6-12	9-Sep-03	617	407.22	29.52	69.32	14.81	17.04	37.47	0.84	0.00
W16 30 6-12	9-Sep-03	561	370.26	24.98	66.05	14.39	15.19	32.05	0.73	0.00
W16 10 12-18	9-Sep-03	779	514.14	58.71	78.55	20.10	9.20	155.49	1.53	0.98
W16 20 12-18	9-Sep-03	794	524.04	51.66	80.38	19.73	11.25	121.91	1.34	0.70
W16 30 12-18	9-Sep-03	667	440.22	44.92	67.49	16.95	9.66	62.89	1.27	0.60
W16 10 18-24	9-Sep-03	1225	808.50	82.01	122.00	33.96	10.23	229.31	1.69	1.21
W16 20 18-24	9-Sep-03	1132	747.12	70.89	108.32	28.56	10.08	169.24	1.57	1.03
W16 30 18-24	9-Sep-03	1063	701.58	67.33	106.87	29.38	9.13	136.63	1.49	0.92
E33 10 0-6	9-Sep-03	683	450.78	18.50	72.50	20.00	15.40	53.60	0.50	0.00
E33 20 0-6	9-Sep-03	802	529.32	23.90	94.90	24.90	21.80	49.50	0.56	0.00
E33 30 0-6	9-Sep-03	498	328.68	12.20	53.40	14.60	14.50	32.30	0.38	0.00
E33 10 6-12	9-Sep-03	747	493.02	33.70	72.60	21.50	8.50	66.60	0.89	0.05
E33 20 6-12	9-Sep-03	601	396.66	32.10	57.50	16.70	6.40	47.50	0.96	0.15
E33 30 6-12	9-Sep-03	455	300.30	21.30	43.60	13.10	6.50	46.20	0.73	0.00
E33 10 12-18	9-Sep-03	885	584.10	46.20	82.20	24.80	4.30	56.20	1.15	0.42
E33 20 12-18	9-Sep-03	940	620.40	54.10	82.10	24.70	3.60	63.10	1.34	0.71
E33 30 12-18	9-Sep-03	703	463.98	39.40	65.10	19.90	3.40	62.20	1.10	0.35
E33 10 18-24	9-Sep-03	902	595.32	62.10	75.80	22.90	3.20	84.40	1.60	1.08
E33 20 18-24	9-Sep-03	765	504.90	65.80	55.90	17.60	2.40	76.80	1.97	1.60
E33 30 18-24	9-Sep-03	758	500.28	48.60	64.80	19.60	2.30	41.20	1.36	0.73

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
W33 10 0-6	9-Sep-03	722	476.52	27.90	81.38	20.48	17.37	43.98	0.72	0.00
W33 20 0-6	9-Sep-03	710	468.60	22.94	81.57	20.41	17.22	37.88	0.59	0.00
W33 30 0-6	9-Sep-03	758	500.28	23.85	90.28	22.54	15.35	46.92	0.58	0.00
W33 10 6-12	9-Sep-03	600	396.00	39.92	61.26	17.39	8.41	130.61	1.16	0.44
W33 20 6-12	9-Sep-03	467	308.22	38.38	40.77	11.86	7.67	45.88	1.36	0.73
W33 30 6-12	9-Sep-03	402	265.32	31.59	41.84	12.52	7.86	55.23	1.10	0.36
W33 10 12-18	9-Sep-03	622	410.52	44.70	56.33	17.62	6.84	115.70	1.33	0.69
W33 20 12-18	9-Sep-03	524	345.84	46.37	41.29	13.74	6.67	100.39	1.60	1.07
W33 30 12-18	9-Sep-03	478	315.48	39.70	45.82	14.53	7.49	111.22	1.31	0.66
W33 10 18-24	9-Sep-03	734	484.44	51.65	62.50	21.02	8.10	115.59	1.44	0.85
W33 20 18-24	9-Sep-03	692	456.72	52.77	56.62	19.18	7.70	102.40	1.55	1.00
W33 30 18-24	9-Sep-03	590	389.40	48.72	50.90	17.58	8.00	104.68	1.50	0.94
E53 10 0-6	9-Sep-03	430	283.80	12.00	48.90	13.70	12.40	33.60	0.39	0.00
E53 20 0-6	9-Sep-03	624	411.84	19.00	66.50	18.10	13.00	43.20	0.53	0.00
E53 30 0-6	9-Sep-03	412	271.92	16.06	48.21	15.27	12.56	29.80	0.52	0.00
E53 10 6-12	9-Sep-03	391	258.06	20.80	37.30	11.50	5.50	35.40	0.76	0.00
E53 20 6-12	9-Sep-03	604	398.64	27.10	56.60	17.70	6.40	52.40	0.81	0.00
E53 30 6-12	9-Sep-03	318	209.88	18.78	36.43	12.75	7.57	30.52	0.68	0.00
E53 10 12-18	9-Sep-03	544	359.04	37.10	46.30	15.30	3.70	46.70	1.21	0.51
E53 20 12-18	9-Sep-03	728	480.48	39.70	61.30	20.60	3.60	44.60	1.12	0.38
E53 30 12-18	9-Sep-03	457	301.62	36.21	42.96	15.29	6.28	43.80	1.21	0.51
E53 10 18-24	9-Sep-03	704	464.64	49.30	56.20	19.50	3.20	63.00	1.44	0.85
E53 20 18-24	9-Sep-03	769	507.54	54.61	60.95	22.19	6.02	60.93	1.52	0.97
E53 30 18-24	9-Sep-03	521	343.86	42.79	45.73	17.18	6.18	60.80	1.37	0.75
W53 10 0-6	9-Sep-03	2650	1749.00	120.98	228.97	61.39	102.61	37.33	1.83	1.41
W53 20 0-6	9-Sep-03	2100	1386.00	81.27	210.23	51.82	56.01	54.17	1.30	0.65
W53 30 0-6	9-Sep-03	760	501.60	32.19	82.28	21.24	18.49	42.23	0.82	0.00
W53 10 6-12	9-Sep-03	785	518.10	44.57	72.98	21.20	12.50	42.45	1.18	0.47
W53 20 6-12	9-Sep-03	716	472.56	41.29	69.61	19.71	11.36	56.33	1.13	0.39
W53 30 6-12	9-Sep-03	460	303.60	28.44	46.21	13.83	9.78	46.63	0.94	0.13
W53 10 12-18	9-Sep-03	468	308.88	33.00	42.85	13.00	7.04	58.31	1.13	0.40
W53 20 12-18	9-Sep-03	501	330.66	38.92	46.05	13.48	7.36	84.62	1.30	0.64
W53 30 12-18	9-Sep-03	440	290.40	38.48	38.26	11.96	7.23	76.77	1.39	0.78
W53 10 18-24	9-Sep-03	476	314.16	41.41	40.46	12.03	6.67	87.30	1.47	0.89
W53 20 18-24	9-Sep-03	582	384.12	48.94	52.14	15.04	7.85	144.73	1.54	0.99
W53 30 18-24	9-Sep-03	490	323.40	42.96	44.62	13.16	7.50	108.11	1.45	0.87

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe
		g	g	g	g	g			
E16 10 0-6	26-Sep-03	133.00	275.40	348.70	142.40	73.30	0.70	0.51	4.82
E16 20 0-6	26-Sep-03	133.00	344.70	444.30	211.70	99.60	1.04	0.47	7.78
E16 30 0-6	26-Sep-03	133.10	344.30	455.50	211.20	111.20	1.04	0.53	7.79
E16 10 6-12	26-Sep-03	128.60	253.50	311.90	124.90	58.40	0.61	0.47	7.59
E16 20 6-12	26-Sep-03	133.20	340.10	439.00	206.90	98.90	1.01	0.48	7.25
E16 30 6-12	26-Sep-03	132.80	345.50	459.30	212.70	113.80	1.04	0.54	7.40
E16 10 12-18	26-Sep-03	128.50	333.00	452.80	204.50	119.80	1.00	0.59	7.70
E16 20 12-18	26-Sep-03	133.20	337.90	447.40	204.70	109.50	1.00	0.53	7.45
E16 30 12-18	26-Sep-03	132.90	277.80	370.60	144.90	92.80	0.71	0.64	7.73
E16 10 18-24	26-Sep-03	134.70	353.00	464.20	218.30	111.20	1.07	0.51	7.46
E16 20 18-24	26-Sep-03	133.10	305.40	398.30	172.30	92.90	0.84	0.54	7.27
E16 30 18-24	26-Sep-03	132.90	308.50	400.00	175.60	91.50	0.86	0.52	7.58
W16 10 0-6	26-Sep-03	129.70	338.60	435.10	208.90	96.50	1.02	0.46	7.86
W16 20 0-6	26-Sep-03	133.20	359.30	478.90	226.10	119.60	1.11	0.53	7.87
W16 30 0-6	26-Sep-03	127.60	351.40	452.40	223.80	101.00	1.10	0.45	7.96
W16 10 6-12	26-Sep-03	128.00	333.50	438.30	205.50	104.80	1.01	0.51	7.86
W16 20 6-12	26-Sep-03	127.80	332.10	408.00	204.30	75.90	1.00	0.37	7.83
W16 30 6-12	26-Sep-03	127.70	358.40	469.70	230.70	111.30	1.13	0.48	7.82
W16 10 12-18	26-Sep-03	128.60	313.00	417.10	184.40	104.10	0.90	0.56	7.81
W16 20 12-18	26-Sep-03	128.60	321.10	428.50	192.50	107.40	0.94	0.56	7.88
W16 30 12-18	26-Sep-03	128.50	328.00	439.40	199.50	111.40	0.98	0.56	7.72
W16 10 18-24	26-Sep-03	128.60	318.30	427.40	189.70	109.10	0.93	0.58	7.82
W16 20 18-24	26-Sep-03	129.40	315.60	425.80	186.20	110.20	0.91	0.59	7.71
W16 30 18-24	26-Sep-03	132.90	309.50	425.20	176.60	115.70	0.87	0.66	7.71
E33 10 0-6	26-Sep-03	129.00	315.40	406.90	186.40	91.50	0.91	0.49	7.73
E33 20 0-6	26-Sep-03	128.60	338.10	438.80	209.50	100.70	1.03	0.48	7.62
E33 30 0-6	26-Sep-03	127.50	301.00	383.10	173.50	82.10	0.85	0.47	7.69
E33 10 6-12	26-Sep-03	128.70	360.40	471.40	231.70	111.00	1.14	0.48	7.74
E33 20 6-12	26-Sep-03	133.10	355.50	461.80	222.40	106.30	1.09	0.48	7.71
E33 30 6-12	26-Sep-03	133.20	350.90	453.10	217.70	102.20	1.07	0.47	7.84
E33 10 12-18	26-Sep-03	128.50	339.20	438.70	210.70	99.50	1.03	0.47	7.76
E33 20 12-18	26-Sep-03	128.70	292.90	379.70	164.20	86.80	0.81	0.53	7.80
E33 30 12-18	26-Sep-03	128.10	331.40	425.50	203.30	94.10	1.00	0.46	7.59
E33 10 18-24	26-Sep-03	128.70	333.10	436.10	204.40	103.00	1.00	0.50	7.78
E33 20 18-24	26-Sep-03	128.70	287.10	373.90	158.40	86.80	0.78	0.55	7.49
E33 30 18-24	26-Sep-03	133.20	329.50	425.90	196.30	96.40	0.96	0.49	7.78

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe
		g	g	g	g	g			
W33 10 0-6	26-Sep-03	128.60	298.20	382.40	169.60	84.20	0.83	0.50	7.97
W33 20 0-6	26-Sep-03	128.50	324.50	438.20	196.00	113.70	0.96	0.58	7.85
W33 30 0-6	26-Sep-03	128.50	338.50	445.80	210.00	107.30	1.03	0.51	7.85
W33 10 6-12	26-Sep-03	128.50	343.80	470.60	215.30	126.80	1.06	0.59	7.81
W33 20 6-12	26-Sep-03	128.00	340.70	459.00	212.70	118.30	1.04	0.56	7.85
W33 30 6-12	26-Sep-03	128.70	349.70	480.10	221.00	130.40	1.08	0.59	7.79
W33 10 12-18	26-Sep-03	133.10	348.90	458.90	215.80	110.00	1.06	0.51	7.73
W33 20 12-18	26-Sep-03	128.50	325.00	442.10	196.50	117.10	0.96	0.60	7.54
W33 30 12-18	26-Sep-03	133.20	325.10	429.50	191.90	104.40	0.94	0.54	7.88
W33 10 18-24	26-Sep-03	128.60	339.30	458.00	210.70	118.70	1.03	0.56	7.87
W33 20 18-24	26-Sep-03	133.20	220.50	273.90	87.30	53.40	0.43	0.61	7.82
W33 30 18-24	26-Sep-03	128.50	315.20	427.80	186.70	112.60	0.92	0.60	7.77
E53 10 0-6	26-Sep-03	128.60	303.50	398.60	174.90	95.10	0.86	0.54	7.86
E53 20 0-6	26-Sep-03	127.70	354.70	468.60	227.00	113.90	1.11	0.50	7.87
E53 30 0-6	26-Sep-03	128.60	303.90	387.20	175.30	83.30	0.86	0.48	7.73
E53 10 6-12	26-Sep-03	132.90	285.20	364.10	152.30	78.90	0.75	0.52	7.68
E53 20 6-12	26-Sep-03	128.80	333.50	431.40	204.70	97.90	1.00	0.48	7.61
E53 30 6-12	26-Sep-03	128.50	310.00	388.70	181.50	78.70	0.89	0.43	7.74
E53 10 12-18	26-Sep-03	133.10	359.40	474.60	226.30	115.20	1.11	0.51	7.90
E53 20 12-18	26-Sep-03	133.70	352.90	476.30	219.20	123.40	1.07	0.56	7.86
E53 30 12-18	26-Sep-03	127.80	331.60	433.30	203.80	101.70	1.00	0.50	7.85
E53 10 18-24	26-Sep-03	129.00	316.80	408.90	187.80	92.10	0.92	0.49	7.84
E53 20 18-24	26-Sep-03	128.70	317.10	412.70	188.40	95.60	0.92	0.51	7.61
E53 30 18-24	26-Sep-03	128.60	316.10	404.20	187.50	88.10	0.92	0.47	7.73
W53 10 0-6	26-Sep-03	127.70	323.30	431.80	195.60	108.50	0.96	0.55	7.66
W53 20 0-6	26-Sep-03	132.90	299.30	383.60	166.40	84.30	0.82	0.51	7.75
W53 30 0-6	26-Sep-03	128.60	328.20	426.00	199.60	97.80	0.98	0.49	7.42
W53 10 6-12	26-Sep-03	128.60	346.80	470.10	218.20	123.30	1.07	0.57	7.77
W53 20 6-12	26-Sep-03	127.90	285.20	362.00	157.30	76.80	0.77	0.49	7.89
W53 30 6-12	26-Sep-03	128.60	341.80	464.70	213.20	122.90	1.05	0.58	7.74
W53 10 12-18	26-Sep-03	133.20	304.70	402.70	171.50	98.00	0.84	0.57	7.78
W53 20 12-18	26-Sep-03	128.60	352.30	460.40	223.70	108.10	1.10	0.48	7.96
W53 30 12-18	26-Sep-03	128.00	309.90	441.80	181.90	131.90	0.89	0.73	7.66
W53 10 18-24	26-Sep-03	128.50	297.90	388.10	169.40	90.20	0.83	0.53	7.61
W53 20 18-24	26-Sep-03	133.50	298.60	377.90	165.10	79.30	0.81	0.48	7.85
W53 30 18-24	26-Sep-03	128.60	288.40	372.30	159.80	83.90	0.78	0.53	7.76

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
E16 10 0-6	26-Sep-03	947	625.02	17.26	115.07	18.47	46.19	67.31	0.39	0.00
E16 20 0-6	26-Sep-03	556	366.96	10.45	71.73	11.01	27.62	47.30	0.30	0.00
E16 30 0-6	26-Sep-03	402	265.32	18.11	44.86	9.69	8.97	36.09	0.64	0.00
E16 10 6-12	26-Sep-03	663	437.58	33.51	72.22	13.86	10.39	33.04	0.95	0.13
E16 20 6-12	26-Sep-03	849	560.34	52.69	80.83	16.16	11.53	49.10	1.40	0.79
E16 30 6-12	26-Sep-03	493	325.38	15.46	58.36	11.96	8.64	57.39	0.48	0.00
E16 10 12-18	26-Sep-03	510	336.60	31.83	50.90	13.35	5.24	45.69	1.03	0.25
E16 20 12-18	26-Sep-03	851	561.66	40.06	92.35	22.83	6.27	75.72	0.97	0.16
E16 30 12-18	26-Sep-03	560	369.60	36.77	49.95	14.45	4.41	43.26	1.18	0.47
E16 10 18-24	26-Sep-03	707	466.62	55.93	54.04	16.43	6.11	57.60	1.71	1.23
E16 20 18-24	26-Sep-03	933	615.78	58.07	81.19	25.58	5.82	57.30	1.44	0.85
E16 30 18-24	26-Sep-03	762	502.92	61.11	57.45	19.86	5.48	53.83	1.77	1.32
W16 10 0-6	26-Sep-03	443	292.38	14.90	54.85	9.25	19.85	26.25	0.49	0.00
W16 20 0-6	26-Sep-03	400	264.00	16.30	47.71	7.92	17.79	31.79	0.58	0.00
W16 30 0-6	26-Sep-03	532	351.12	21.13	62.82	9.81	25.87	35.55	0.65	0.00
W16 10 6-12	26-Sep-03	765	504.90	78.91	59.47	11.83	12.79	93.59	2.45	2.28
W16 20 6-12	26-Sep-03	629	415.14	40.38	68.69	13.15	14.38	78.55	1.17	0.46
W16 30 6-12	26-Sep-03	798	526.68	38.16	89.38	16.81	18.43	79.24	0.97	0.17
W16 10 12-18	26-Sep-03	999	659.34	71.29	98.13	23.54	10.64	175.88	1.68	1.19
W16 20 12-18	26-Sep-03	1174	774.84	66.89	125.32	27.15	12.79	170.01	1.41	0.81
W16 30 12-18	26-Sep-03	1299	857.34	65.27	143.61	32.98	14.00	167.66	1.28	0.61
W16 10 18-24	26-Sep-03	1407	928.62	95.91	134.51	36.62	12.55	266.99	1.89	1.49
W16 20 18-24	26-Sep-03	1570	1036.20	88.51	157.28	40.47	12.95	187.60	1.63	1.12
W16 30 18-24	26-Sep-03	1393	919.38	77.25	140.71	36.97	12.44	169.01	1.50	0.93
E33 10 0-6	26-Sep-03	516	340.56	10.61	65.61	16.47	17.85	44.04	0.30	0.00
E33 20 0-6	26-Sep-03	1091	720.06	17.56	129.61	32.94	25.50	76.47	0.36	0.00
E33 30 0-6	26-Sep-03	456	300.96	8.28	56.11	15.31	15.23	31.44	0.25	0.00
E33 10 6-12	26-Sep-03	655	432.30	23.53	75.18	21.75	11.38	59.41	0.61	0.00
E33 20 6-12	26-Sep-03	719	474.54	25.86	79.42	22.68	11.28	70.05	0.66	0.00
E33 30 6-12	26-Sep-03	444	293.04	16.61	48.21	14.92	9.04	32.39	0.54	0.00
E33 10 12-18	26-Sep-03	992	654.72	45.98	106.04	32.41	8.66	65.97	1.00	0.21
E33 20 12-18	26-Sep-03	980	646.80	45.46	98.46	30.83	8.05	54.21	1.02	0.24
E33 30 12-18	26-Sep-03	824	543.84	37.53	87.83	26.56	7.65	52.95	0.90	0.06
E33 10 18-24	26-Sep-03	942	621.72	57.52	87.60	27.18	6.74	74.10	1.38	0.76
E33 20 18-24	26-Sep-03	871	574.86	53.12	78.62	24.36	5.56	70.93	1.34	0.71
E33 30 18-24	26-Sep-03	905	597.30	54.89	84.68	25.83	6.46	48.77	1.34	0.70

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
W33 10 0-6	26-Sep-03	767	506.22	22.81	92.05	19.50	24.11	52.95	0.56	0.00
W33 20 0-6	26-Sep-03	450	297.00	17.35	52.04	11.60	13.77	33.63	0.57	0.00
W33 30 0-6	26-Sep-03	437	288.42	14.88	51.37	11.59	12.94	30.24	0.49	0.00
W33 10 6-12	26-Sep-03	697	460.02	40.22	68.93	16.55	11.04	64.54	1.13	0.40
W33 20 6-12	26-Sep-03	552	364.32	29.19	58.38	14.60	9.66	55.61	0.89	0.04
W33 30 6-12	26-Sep-03	535	353.10	30.52	52.22	13.87	9.26	53.05	0.97	0.17
W33 10 12-18	26-Sep-03	975	643.50	62.22	93.28	24.42	11.24	86.35	1.48	0.91
W33 20 12-18	26-Sep-03	734	484.44	42.46	71.87	19.39	9.44	84.33	1.15	0.42
W33 30 12-18	26-Sep-03	763	503.58	46.87	74.95	20.33	9.80	111.79	1.24	0.56
W33 10 18-24	26-Sep-03	844	557.04	53.64	77.94	22.66	10.20	84.84	1.38	0.75
W33 20 18-24	26-Sep-03	718	473.88	44.19	67.28	18.97	8.76	70.60	1.23	0.54
W33 30 18-24	26-Sep-03	788	520.08	53.39	69.89	20.53	9.81	106.04	1.44	0.85
E53 10 0-6	26-Sep-03	427	281.82	9.09	49.56	13.96	17.70	26.08	0.29	0.00
E53 20 0-6	26-Sep-03	576	380.16	18.48	67.50	18.23	14.94	54.32	0.52	0.00
E53 30 0-6	26-Sep-03	523	345.18	12.09	65.69	17.75	16.31	50.66	0.34	0.00
E53 10 6-12	26-Sep-03	370	244.20	13.19	41.38	13.00	7.60	23.88	0.46	0.00
E53 20 6-12	26-Sep-03	490	323.40	22.16	51.84	15.62	8.41	61.65	0.69	0.00
E53 30 6-12	26-Sep-03	446	294.36	17.87	48.93	15.00	9.77	39.66	0.57	0.00
E53 10 12-18	26-Sep-03	466	307.56	28.22	46.69	14.67	6.31	42.09	0.92	0.10
E53 20 12-18	26-Sep-03	705	465.30	34.94	72.79	22.13	7.86	50.15	0.92	0.09
E53 30 12-18	26-Sep-03	475	313.50	27.88	48.58	15.15	6.41	42.37	0.90	0.06
E53 10 18-24	26-Sep-03	666	439.56	42.26	58.18	19.35	6.56	55.01	1.23	0.54
E53 20 18-24	26-Sep-03	730	481.80	45.60	64.31	20.70	6.58	61.00	1.27	0.60
E53 30 18-24	26-Sep-03	580	382.80	39.80	51.95	16.87	6.44	57.73	1.23	0.54
W53 10 0-6	26-Sep-03	2300	1518.00	123.76	181.02	47.51	77.86	53.90	2.12	1.81
W53 20 0-6	26-Sep-03	1864	1230.24	69.39	189.43	45.03	48.54	41.57	1.18	0.47
W53 30 0-6	26-Sep-03	1263	833.58	42.03	136.03	31.79	27.37	58.88	0.84	0.00
W53 10 6-12	26-Sep-03	750	495.00	34.93	74.58	19.14	15.25	43.89	0.93	0.11
W53 20 6-12	26-Sep-03	781	515.46	45.02	72.80	18.01	14.10	52.06	1.22	0.54
W53 30 6-12	26-Sep-03	608	401.28	37.18	58.74	14.86	11.89	52.64	1.12	0.39
W53 10 12-18	26-Sep-03	653	430.98	33.78	66.96	16.59	10.20	52.38	0.96	0.15
W53 20 12-18	26-Sep-03	747	493.02	56.36	66.93	16.58	9.82	67.66	1.60	1.08
W53 30 12-18	26-Sep-03	516	340.56	38.89	43.48	11.10	7.10	58.97	1.36	0.74
W53 10 18-24	26-Sep-03	762	502.92	55.29	65.30	15.82	10.11	57.77	1.59	1.07
W53 20 18-24	26-Sep-03	667	440.22	54.05	58.37	14.57	9.13	95.47	1.64	1.13
W53 30 18-24	26-Sep-03	739	487.74	58.18	64.96	15.95	9.96	115.23	1.68	1.19

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe
		g	g	g	g	g			
E16 10 0-6	10-Nov-03	133.00	418.70	532.90	285.70	114.20	1.40	0.40	7.70
E16 20 0-6	10-Nov-03	128.60	428.20	541.50	299.60	113.30	1.47	0.38	7.87
E16 30 0-6	10-Nov-03	133.30	342.80	416.30	209.50	73.50	1.03	0.35	7.85
E16 10 6-12	10-Nov-03	133.40	415.90	543.60	282.50	127.70	1.39	0.45	7.75
E16 20 6-12	10-Nov-03	127.90	403.60	526.30	275.70	122.70	1.35	0.45	7.65
E16 30 6-12	10-Nov-03	133.30	377.60	472.20	244.30	94.60	1.20	0.39	7.74
E16 10 12-18	10-Nov-03	133.00	356.30	468.00	223.30	111.70	1.10	0.50	7.80
E16 20 12-18	10-Nov-03	133.10	391.20	511.40	258.10	120.20	1.27	0.47	7.72
E16 30 12-18	10-Nov-03	133.10	361.20	467.80	228.10	106.60	1.12	0.47	7.78
E16 10 18-24	10-Nov-03	133.10	.	524.20	.	.	.	.	7.63
E16 20 18-24	10-Nov-03	128.50	394.90	540.70	266.40	145.80	1.31	0.55	7.67
E16 30 18-24	10-Nov-03	128.80	390.60	510.60	261.80	120.00	1.28	0.46	7.14
W16 10 0-6	10-Nov-03	128.10	401.00	494.00	272.90	93.00	1.34	0.34	7.74
W16 20 0-6	10-Nov-03	127.60	405.60	485.00	278.00	79.40	1.36	0.29	7.95
W16 30 0-6	10-Nov-03	133.10	400.20	502.40	267.10	102.20	1.31	0.38	7.99
W16 10 6-12	10-Nov-03	132.70	400.80	450.40	268.10	49.60	1.31	0.19	7.91
W16 20 6-12	10-Nov-03	132.80	410.60	500.20	277.80	89.60	1.36	0.32	7.79
W16 30 6-12	10-Nov-03	128.10	360.60	454.10	232.50	93.50	1.14	0.40	7.86
W16 10 12-18	10-Nov-03	132.50	422.30	554.00	289.80	131.70	1.42	0.45	7.70
W16 20 12-18	10-Nov-03	132.50	418.20	550.70	285.70	132.50	1.40	0.46	7.57
W16 30 12-18	10-Nov-03	128.70	.	559.40	.	.	.	.	7.72
W16 10 18-24	10-Nov-03	132.60	405.00	490.00	272.40	85.00	1.34	0.31	7.46
W16 20 18-24	10-Nov-03	132.50	364.00	464.80	231.50	100.80	1.14	0.44	7.16
W16 30 18-24	10-Nov-03	133.20	409.40	558.00	276.20	148.60	1.35	0.54	7.67
E33 10 0-6	10-Nov-03	128.50	360.80	475.40	232.30	114.60	1.14	0.49	7.70
E33 20 0-6	10-Nov-03	133.00	392.60	506.90	259.60	114.30	1.27	0.44	7.71
E33 30 0-6	10-Nov-03	133.00	378.30	509.90	245.30	131.60	1.20	0.54	7.50
E33 10 6-12	10-Nov-03	132.90	387.80	524.30	254.90	136.50	1.25	0.54	7.64
E33 20 6-12	10-Nov-03	132.90	426.10	572.30	293.20	146.20	1.44	0.50	7.56
E33 30 6-12	10-Nov-03	133.00	405.50	530.80	272.50	125.30	1.34	0.46	7.69
E33 10 12-18	10-Nov-03	133.00	407.70	554.90	274.70	147.20	1.35	0.54	7.61
E33 20 12-18	10-Nov-03	133.00	429.30	574.90	296.30	145.60	1.45	0.49	7.64
E33 30 12-18	10-Nov-03	132.80	379.70	519.40	246.90	139.70	1.21	0.57	7.62
E33 10 18-24	10-Nov-03	133.00	350.00	469.60	217.00	119.60	1.06	0.55	7.52
E33 20 18-24	10-Nov-03	133.00	396.00	533.30	263.00	137.30	1.29	0.52	7.78
E33 30 18-24	10-Nov-03	128.40	373.60	496.30	245.20	122.70	1.20	0.50	7.78

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe
		g	g	g	g	g			
W33 10 0-6	10-Nov-03	128.10	408.20	487.80	280.10	79.60	1.37	0.28	7.80
W33 20 0-6	10-Nov-03	134.60	423.80	554.90	289.20	131.10	1.42	0.45	7.90
W33 30 0-6	10-Nov-03	133.40	404.20	517.50	270.80	113.30	1.33	0.42	7.81
W33 10 6-12	10-Nov-03	127.20	412.60	476.60	285.40	64.00	1.40	0.22	7.62
W33 20 6-12	10-Nov-03	133.10	364.90	488.70	231.80	123.80	1.14	0.53	7.80
W33 30 6-12	10-Nov-03	127.90	392.60	505.60	264.70	113.00	1.30	0.43	7.86
W33 10 12-18	10-Nov-03	128.10	422.70	540.60	294.60	117.90	1.44	0.40	7.66
W33 20 12-18	10-Nov-03	128.50	434.40	586.60	305.90	152.20	1.50	0.50	7.82
W33 30 12-18	10-Nov-03	133.10	441.60	586.30	308.50	144.70	1.51	0.47	7.80
W33 10 18-24	10-Nov-03	132.60	418.10	562.30	285.50	144.20	1.40	0.51	7.72
W33 20 18-24	10-Nov-03	132.90	410.50	553.80	277.60	143.30	1.36	0.52	7.66
W33 30 18-24	10-Nov-03	133.20	411.90	569.90	278.70	158.00	1.37	0.57	7.86
E53 10 0-6	10-Nov-03	133.20	377.50	489.10	244.30	111.60	1.20	0.46	7.84
E53 20 0-6	10-Nov-03	128.00	398.00	480.50	270.00	82.50	1.32	0.31	7.79
E53 30 0-6	10-Nov-03	133.00	367.40	485.60	234.40	118.20	1.15	0.50	7.68
E53 10 6-12	10-Nov-03	134.60	385.40	520.30	250.80	134.90	1.23	0.54	7.87
E53 20 6-12	10-Nov-03	132.80	387.30	464.90	254.50	77.60	1.25	0.30	7.72
E53 30 6-12	10-Nov-03	133.10	347.50	454.40	214.40	106.90	1.05	0.50	7.65
E53 10 12-18	10-Nov-03	133.00	422.30	558.50	289.30	136.20	1.42	0.47	7.86
E53 20 12-18	10-Nov-03	132.80	403.20	496.30	270.40	93.10	1.33	0.34	7.86
E53 30 12-18	10-Nov-03	133.00	402.60	540.70	269.60	138.10	1.32	0.51	7.81
E53 10 18-24	10-Nov-03	128.50	358.70	481.50	230.20	122.80	1.13	0.53	7.82
E53 20 18-24	10-Nov-03	129.70	.	552.00	.	.	.	.	7.83
E53 30 18-24	10-Nov-03	133.20	386.70	517.80	253.50	131.10	1.24	0.52	7.80
W53 10 0-6	10-Nov-03	134.20	413.40	483.50	279.20	70.10	1.37	0.25	7.57
W53 20 0-6	10-Nov-03	128.80	367.90	444.20	239.10	76.30	1.17	0.32	7.47
W53 30 0-6	10-Nov-03	133.20	427.10	565.50	293.90	138.40	1.44	0.47	7.85
W53 10 6-12	10-Nov-03	132.80	374.20	471.70	241.40	97.50	1.18	0.40	7.58
W53 20 6-12	10-Nov-03	132.40	393.50	431.20	261.10	37.70	1.28	0.14	7.66
W53 30 6-12	10-Nov-03	133.40	423.90	576.70	290.50	152.80	1.42	0.53	7.73
W53 10 12-18	10-Nov-03	132.60	423.60	544.70	291.00	121.10	1.43	0.42	7.64
W53 20 12-18	10-Nov-03	132.60	434.50	546.50	301.90	112.00	1.48	0.37	7.57
W53 30 12-18	10-Nov-03	128.50	422.50	580.70	294.00	158.20	1.44	0.54	7.80
W53 10 18-24	10-Nov-03	128.00	392.10	439.50	264.10	47.40	1.30	0.18	7.75
W53 20 18-24	10-Nov-03	132.50	388.50	489.20	256.00	100.70	1.26	0.39	7.53
W53 30 18-24	10-Nov-03	128.50	.	574.50	.	.	.	.	7.89

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
E16 10 0-6	10-Nov-03	936	617.76	8.79	171.60	24.93	38.87	26.41	0.17	0.00
E16 20 0-6	10-Nov-03	678	447.48	13.26	133.40	18.01	29.61	35.70	0.29	0.00
E16 30 0-6	10-Nov-03	1029	679.14	17.58	121.47	26.92	26.71	92.42	0.38	0.00
E16 10 6-12	10-Nov-03	460	303.60	13.96	66.99	13.63	10.17	33.26	0.41	0.00
E16 20 6-12	10-Nov-03	476	314.16	15.36	72.89	15.15	9.57	28.09	0.43	0.00
E16 30 6-12	10-Nov-03	663	437.58	19.96	106.53	19.84	10.54	74.77	0.47	0.00
E16 10 12-18	10-Nov-03	636	419.76	31.46	87.46	20.86	5.76	89.80	0.78	0.00
E16 20 12-18	10-Nov-03	750	495.00	35.89	101.57	25.61	5.99	71.74	0.82	0.00
E16 30 12-18	10-Nov-03	842	555.72	40.25	124.07	27.46	6.98	85.22	0.85	0.00
E16 10 18-24	10-Nov-03	895	590.70	54.30	99.01	29.43	5.75	52.98	1.23	0.55
E16 20 18-24	10-Nov-03	887	585.42	55.64	102.12	30.48	5.73	43.98	1.24	0.56
E16 30 18-24	10-Nov-03	965	636.90	62.91	104.61	30.47	6.17	45.67	1.39	0.78
W16 10 0-6	10-Nov-03	677	446.82	24.50	129.54	19.14	17.58	81.06	0.53	0.00
W16 20 0-6	10-Nov-03	702	463.32	19.89	138.57	19.90	25.33	70.03	0.42	0.00
W16 30 0-6	10-Nov-03	686	452.76	15.44	79.37	21.19	22.91	35.69	0.40	0.00
W16 10 6-12	10-Nov-03	646	426.36	47.06	91.26	17.51	10.12	133.47	1.18	0.47
W16 20 6-12	10-Nov-03	843	556.38	42.58	151.21	25.59	15.26	158.84	0.84	0.00
W16 30 6-12	10-Nov-03	614	405.24	31.71	86.18	17.74	10.60	45.76	0.81	0.00
W16 10 12-18	10-Nov-03	1079	712.14	72.85	165.36	34.41	9.57	274.62	1.35	0.71
W16 20 12-18	10-Nov-03	1205	795.30	69.85	194.60	39.67	11.17	300.99	1.19	0.49
W16 30 12-18	10-Nov-03	1071	706.86	60.97	146.37	31.25	9.38	213.22	1.19	0.49
W16 10 18-24	10-Nov-03	1404	926.64	94.26	201.49	48.88	10.28	332.37	1.55	1.00
W16 20 18-24	10-Nov-03	1385	914.10	84.90	204.31	48.01	10.12	300.13	1.39	0.77
W16 30 18-24	10-Nov-03	1335	881.10	78.87	190.78	43.98	9.24	244.93	1.34	0.70
E33 10 0-6	10-Nov-03	595	392.70	16.37	90.40	23.26	16.09	58.05	0.40	0.00
E33 20 0-6	10-Nov-03	573	378.18	13.01	93.84	23.93	15.62	55.59	0.31	0.00
E33 30 0-6	10-Nov-03	490	323.40	13.97	71.38	20.03	13.03	42.73	0.38	0.00
E33 10 6-12	10-Nov-03	715	471.90	28.35	103.30	29.81	10.03	76.36	0.63	0.00
E33 20 6-12	10-Nov-03	826	545.16	29.58	131.99	34.56	10.33	109.49	0.59	0.00
E33 30 6-12	10-Nov-03	576	380.16	21.33	84.20	24.27	8.92	93.13	0.53	0.00
E33 10 12-18	10-Nov-03	1153	760.98	51.64	165.41	46.07	7.71	72.79	0.92	0.09
E33 20 12-18	10-Nov-03	1138	751.08	53.35	166.06	44.37	7.49	58.45	0.95	0.14
E33 30 12-18	10-Nov-03	796	525.36	38.69	107.95	31.23	6.40	61.88	0.84	0.00
E33 10 18-24	10-Nov-03	882	582.12	51.09	118.74	33.28	5.09	79.96	1.07	0.31
E33 20 18-24	10-Nov-03	701	462.66	50.88	76.03	23.79	4.98	91.50	1.31	0.65
E33 30 18-24	10-Nov-03	875	577.50	52.51	104.49	32.49	5.82	70.29	1.15	0.43

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
W33 10 0-6	10-Nov-03	778	513.48	32.18	139.38	28.70	14.26	151.84	0.65	0.00
W33 20 0-6	10-Nov-03	544	359.04	15.24	99.00	21.75	13.73	39.07	0.36	0.00
W33 30 0-6	10-Nov-03	1035	683.10	33.22	150.29	35.31	23.02	86.56	0.63	0.00
W33 10 6-12	10-Nov-03	957	631.62	49.16	151.24	35.85	10.35	267.54	0.93	0.11
W33 20 6-12	10-Nov-03	409	269.94	24.03	58.89	15.24	5.98	32.12	0.72	0.00
W33 30 6-12	10-Nov-03	593	391.38	41.37	58.90	17.48	8.31	77.26	1.22	0.52
W33 10 12-18	10-Nov-03	880	580.80	49.88	132.63	32.67	7.94	166.87	1.01	0.22
W33 20 12-18	10-Nov-03	539	355.74	41.15	52.05	15.90	7.03	71.28	1.28	0.62
W33 30 12-18	10-Nov-03	541	357.06	44.13	48.85	14.85	5.82	99.62	1.42	0.82
W33 10 18-24	10-Nov-03	789	520.74	55.56	93.94	28.43	7.21	154.78	1.29	0.63
W33 20 18-24	10-Nov-03	637	420.42	49.16	58.14	19.23	6.76	88.50	1.43	0.83
W33 30 18-24	10-Nov-03	578	381.48	52.58	51.19	16.51	5.92	156.94	1.64	1.13
E53 10 0-6	10-Nov-03	539	355.74	13.34	92.49	26.65	11.51	27.83	0.31	0.00
E53 20 0-6	10-Nov-03	685	452.10	16.81	69.01	32.34	13.69	79.91	0.42	0.00
E53 30 0-6	10-Nov-03	515	339.90	12.50	88.14	24.09	13.01	56.99	0.30	0.00
E53 10 6-12	10-Nov-03	440	290.40	24.39	58.62	18.69	5.28	35.89	0.71	0.00
E53 20 6-12	10-Nov-03	584	385.44	25.47	82.21	24.52	7.15	76.57	0.63	0.00
E53 30 6-12	10-Nov-03	425	280.50	19.41	59.54	18.66	6.64	76.98	0.56	0.00
E53 10 12-18	10-Nov-03	631	416.46	41.78	72.87	25.04	4.59	67.53	1.08	0.32
E53 20 12-18	10-Nov-03	692	456.72	41.75	79.71	27.15	5.42	62.31	1.03	0.25
E53 30 12-18	10-Nov-03	583	384.78	33.93	73.76	23.35	4.59	76.46	0.88	0.04
E53 10 18-24	10-Nov-03	641	423.06	50.04	68.63	24.76	4.74	112.52	1.32	0.67
E53 20 18-24	10-Nov-03	586	386.76	50.40	61.14	20.95	4.50	105.51	1.42	0.82
E53 30 18-24	10-Nov-03	620	409.20	45.24	64.61	23.67	4.42	80.93	1.22	0.53
W53 10 0-6	10-Nov-03	3380	2230.80	184.93	367.32	91.58	122.29	70.17	2.24	1.98
W53 20 0-6	10-Nov-03	5130	3385.80	226.39	594.54	167.96	150.98	106.71	2.11	1.81
W53 30 0-6	10-Nov-03	980	646.80	45.46	141.09	32.59	14.94	63.84	0.90	0.06
W53 10 6-12	10-Nov-03	1761	1162.26	88.10	217.36	55.71	26.33	42.79	1.38	0.76
W53 20 6-12	10-Nov-03	1419	936.54	68.75	183.72	46.62	17.71	53.75	1.17	0.46
W53 30 6-12	10-Nov-03	514	339.24	33.73	62.08	17.71	7.44	70.23	0.97	0.17
W53 10 12-18	10-Nov-03	1193	787.38	58.68	152.61	39.51	12.28	44.54	1.10	0.35
W53 20 12-18	10-Nov-03	1000	660.00	53.90	111.64	31.96	11.02	59.98	1.16	0.44
W53 30 12-18	10-Nov-03	495	326.70	41.09	54.69	15.31	5.85	118.07	1.27	0.60
W53 10 18-24	10-Nov-03	1069	705.54	63.83	117.55	32.77	15.59	58.05	1.34	0.71
W53 20 18-24	10-Nov-03	869	573.54	57.61	95.49	25.56	8.80	78.15	1.35	0.72
W53 30 18-24	10-Nov-03	629	415.14	56.96	68.29	18.78	7.25	177.54	1.57	1.04

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe
		g	g	g	g	g			
E16 10 0-6	21-Nov-03	128.20	396.10	510.80	267.90	114.70	1.31	0.43	7.71
E16 20 0-6	21-Nov-03	133.00	446.00	568.90	313.00	122.90	1.53	0.39	7.81
E16 30 0-6	21-Nov-03	128.60	420.90	547.10	292.30	126.20	1.43	0.43	7.85
E16 10 6-12	21-Nov-03	128.00	403.70	535.10	275.70	131.40	1.35	0.48	7.86
E16 20 6-12	21-Nov-03	128.40	419.10	550.80	290.70	131.70	1.43	0.45	7.83
E16 30 6-12	21-Nov-03	128.10	407.90	545.80	279.80	137.90	1.37	0.49	7.86
E16 10 12-18	21-Nov-03	128.60	431.90	572.90	303.30	141.00	1.49	0.46	7.87
E16 20 12-18	21-Nov-03	127.70	385.00	504.00	257.30	119.00	1.26	0.46	7.83
E16 30 12-18	21-Nov-03	128.50	407.60	554.20	279.10	146.60	1.37	0.53	7.87
E16 10 18-24	21-Nov-03	132.60	417.70	554.70	285.10	137.00	1.40	0.48	7.82
E16 20 18-24	21-Nov-03	128.50	433.50	576.50	305.00	143.00	1.50	0.47	7.76
E16 30 18-24	21-Nov-03	128.60	396.50	530.20	267.90	133.70	1.31	0.50	7.83
W16 10 0-6	21-Nov-03	128.60	427.80	546.70	299.20	118.90	1.47	0.40	7.85
W16 20 0-6	21-Nov-03	133.10	438.70	566.70	305.60	128.00	1.50	0.42	7.83
W16 30 0-6	21-Nov-03	128.70	425.50	535.00	296.80	109.50	1.46	0.37	7.46
W16 10 6-12	21-Nov-03	128.40	429.20	556.40	300.80	127.20	1.48	0.42	7.85
W16 20 6-12	21-Nov-03	133.30	415.20	544.80	281.90	129.60	1.38	0.46	7.86
W16 30 6-12	21-Nov-03	133.10	425.00	554.39	291.90	129.39	1.43	0.44	7.70
W16 10 12-18	21-Nov-03	128.30	434.80	579.10	306.50	144.30	1.50	0.47	7.83
W16 20 12-18	21-Nov-03	133.00	433.40	576.40	300.40	143.00	1.47	0.48	7.68
W16 30 12-18	21-Nov-03	133.10	437.40	588.00	304.30	150.60	1.49	0.49	7.82
W16 10 18-24	21-Nov-03	128.50	429.30	586.00	300.80	156.70	1.48	0.52	7.67
W16 20 18-24	21-Nov-03	128.70	431.80	593.50	303.10	161.70	1.49	0.53	7.53
W16 30 18-24	21-Nov-03	127.90	434.50	593.20	306.60	158.70	1.50	0.52	7.94
E33 10 0-6	21-Nov-03	128.50	452.50	597.10	324.00	144.60	1.59	0.45	7.80
E33 20 0-6	21-Nov-03	128.50	416.80	547.90	288.30	131.10	1.41	0.45	7.75
E33 30 0-6	21-Nov-03	128.60	420.90	547.10	292.30	126.20	1.43	0.43	7.85
E33 10 6-12	21-Nov-03	128.80	424.20	555.70	295.40	131.50	1.45	0.45	7.63
E33 20 6-12	21-Nov-03	133.10	407.00	540.70	273.90	133.70	1.34	0.49	7.85
E33 30 6-12	21-Nov-03	128.10	407.90	545.80	279.80	137.90	1.37	0.49	7.86
E33 10 12-18	21-Nov-03	128.30	404.90	531.30	276.60	126.40	1.36	0.46	7.72
E33 20 12-18	21-Nov-03	133.10	426.90	575.10	293.80	148.20	1.44	0.50	7.74
E33 30 12-18	21-Nov-03	128.50	407.60	554.20	279.10	146.60	1.37	0.53	7.87
E33 10 18-24	21-Nov-03	133.70	371.00	482.80	237.30	111.80	1.16	0.47	7.73
E33 20 18-24	21-Nov-03	133.10	445.70	620.00	312.60	174.30	1.53	0.56	7.84
E33 30 18-24	21-Nov-03	128.60	396.50	530.20	267.90	133.70	1.31	0.50	7.83

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe
		g	g	g	g	g			
W33 10 0-6	21-Nov-03	133.00	377.10	494.30	244.10	117.20	1.20	0.48	7.86
W33 20 0-6	21-Nov-03	132.80	414.50	544.30	281.70	129.80	1.38	0.46	7.65
W33 30 0-6	21-Nov-03	133.30	349.80	455.60	216.50	105.80	1.06	0.49	7.59
W33 10 6-12	21-Nov-03	129.30	419.50	550.30	290.20	130.80	1.42	0.45	7.76
W33 20 6-12	21-Nov-03	128.10	413.50	552.50	285.40	139.00	1.40	0.49	7.61
W33 30 6-12	21-Nov-03	128.50	379.40	493.20	250.90	113.80	1.23	0.45	7.58
W33 10 12-18	21-Nov-03	128.40	427.70	563.30	299.30	135.60	1.47	0.45	7.72
W33 20 12-18	21-Nov-03	128.40	423.00	566.50	294.60	143.50	1.44	0.49	7.60
W33 30 12-18	21-Nov-03	128.40	353.40	461.60	225.00	108.20	1.10	0.48	7.61
W33 10 18-24	21-Nov-03	127.60	440.60	593.00	313.00	152.40	1.53	0.49	7.67
W33 20 18-24	21-Nov-03	128.50	422.40	562.70	293.90	140.30	1.44	0.48	7.86
W33 30 18-24	21-Nov-03	129.70	423.60	565.80	293.90	142.20	1.44	0.48	7.90
E53 10 0-6	21-Nov-03	128.60	377.90	519.30	249.30	141.40	1.22	0.57	7.71
E53 20 0-6	21-Nov-03	128.60	405.10	534.20	276.50	129.10	1.36	0.47	7.64
E53 30 0-6	21-Nov-03	133.00	398.30	521.00	265.30	122.70	1.30	0.46	7.43
E53 10 6-12	21-Nov-03	128.80	360.20	470.10	231.40	109.90	1.13	0.47	7.80
E53 20 6-12	21-Nov-03	128.00	359.40	483.20	231.40	123.80	1.13	0.54	7.72
E53 30 6-12	21-Nov-03	133.50	379.30	522.40	245.80	143.10	1.21	0.58	7.57
E53 10 12-18	21-Nov-03	133.30	370.80	525.30	237.50	154.50	1.16	0.65	7.69
E53 20 12-18	21-Nov-03	132.90	366.50	504.20	233.60	137.70	1.15	0.59	7.71
E53 30 12-18	21-Nov-03	133.10	385.40	513.30	252.30	127.90	1.24	0.51	7.89
E53 10 18-24	21-Nov-03	133.20	406.40	531.20	273.20	124.80	1.34	0.46	7.61
E53 20 18-24	21-Nov-03	128.70	406.50	549.10	277.80	142.60	1.36	0.51	7.81
E53 30 18-24	21-Nov-03	128.10	418.10	.	290.00	.	1.42	.	7.88
W53 10 0-6	21-Nov-03	128.50	409.20	534.20	280.70	125.00	1.38	0.45	7.40
W53 20 0-6	21-Nov-03	128.50	414.80	568.60	286.30	153.80	1.40	0.54	7.46
W53 30 0-6	21-Nov-03	133.00	426.20	551.80	293.20	125.60	1.44	0.43	7.48
W53 10 6-12	21-Nov-03	127.90	403.60	536.00	275.70	132.40	1.35	0.48	7.58
W53 20 6-12	21-Nov-03	128.80	403.20	538.40	274.40	135.20	1.35	0.49	7.47
W53 30 6-12	21-Nov-03	128.30	384.70	498.10	256.40	113.40	1.26	0.44	7.58
W53 10 12-18	21-Nov-03	133.30	430.60	571.40	297.30	140.80	1.46	0.47	7.65
W53 20 12-18	21-Nov-03	127.90	432.70	574.70	304.80	142.00	1.49	0.47	7.55
W53 30 12-18	21-Nov-03	132.90	427.60	564.30	294.70	136.70	1.45	0.46	7.66
W53 10 18-24	21-Nov-03	128.40	417.90	562.00	289.50	144.10	1.42	0.50	7.75
W53 20 18-24	21-Nov-03	133.20	362.50	480.70	229.30	118.20	1.12	0.52	7.77
W53 30 18-24	21-Nov-03	133.60	406.30	542.80	272.70	136.50	1.34	0.50	7.87

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
E16 10 0-6	21-Nov-03	826	545.16	8.51	99.10	14.97	32.71	40.57	0.21	0.00
E16 20 0-6	21-Nov-03	819	540.54	14.09	101.51	14.17	23.20	51.95	0.35	0.00
E16 30 0-6	21-Nov-03	559	368.94	6.95	67.40	9.72	17.85	31.81	0.21	0.00
E16 10 6-12	21-Nov-03	422	278.52	15.69	44.22	9.23	6.37	25.81	0.56	0.00
E16 20 6-12	21-Nov-03	595	392.70	17.67	66.81	12.85	7.80	39.06	0.52	0.00
E16 30 6-12	21-Nov-03	419	276.54	13.40	45.34	8.91	5.97	25.28	0.48	0.00
E16 10 12-18	21-Nov-03	371	244.86	26.18	28.21	7.69	2.91	41.50	1.13	0.39
E16 20 12-18	21-Nov-03	571	376.86	32.30	48.48	12.32	3.00	68.74	1.07	0.31
E16 30 12-18	21-Nov-03	446	294.36	26.20	37.54	9.51	2.48	60.73	0.99	0.19
E16 10 18-24	21-Nov-03	465	306.90	40.82	29.66	9.51	2.60	52.38	1.67	1.18
E16 20 18-24	21-Nov-03	706	465.96	49.40	48.61	14.95	2.82	48.63	1.59	1.06
E16 30 18-24	21-Nov-03	586	386.76	43.30	40.28	12.60	2.40	48.82	1.53	0.97
W16 10 0-6	21-Nov-03	653	430.98	15.58	67.64	11.22	22.86	34.86	0.46	0.00
W16 20 0-6	21-Nov-03	566	373.56	16.61	56.50	9.88	19.64	35.30	0.54	0.00
W16 30 0-6	21-Nov-03	980	646.80	26.38	96.03	16.11	26.68	54.96	0.66	0.00
W16 10 6-12	21-Nov-03	521	343.86	31.93	42.44	8.82	6.72	68.59	1.16	0.45
W16 20 6-12	21-Nov-03	626	413.16	32.56	55.02	11.24	8.59	52.24	1.05	0.28
W16 30 6-12	21-Nov-03	825	544.50	30.33	79.72	14.52	13.76	67.18	0.82	0.00
W16 10 12-18	21-Nov-03	864	570.24	58.02	69.48	15.97	5.60	169.14	1.63	1.12
W16 20 12-18	21-Nov-03	1040	686.40	57.42	93.37	20.44	6.35	145.18	1.40	0.79
W16 30 12-18	21-Nov-03	1244	821.04	57.11	115.33	26.12	8.49	147.22	1.25	0.57
W16 10 18-24	21-Nov-03	1203	793.98	77.84	93.95	24.70	5.56	212.67	1.85	1.43
W16 20 18-24	21-Nov-03	1287	849.42	74.33	107.75	28.21	5.61	175.73	1.65	1.15
W16 30 18-24	21-Nov-03	1320	871.20	72.12	110.91	28.44	5.42	172.65	1.58	1.05
E33 10 0-6	21-Nov-03	694	458.04	31.38	56.84	14.51	16.16	58.53	0.96	0.15
E33 20 0-6	21-Nov-03	637	420.42	17.36	63.16	13.97	14.13	43.10	0.51	0.00
E33 30 0-6	21-Nov-03	713	470.58	8.23	73.02	17.45	17.16	44.91	0.22	0.00
E33 10 6-12	21-Nov-03	665	438.90	26.22	55.68	16.01	7.52	67.82	0.80	0.00
E33 20 6-12	21-Nov-03	601	396.66	30.76	51.96	13.17	6.13	51.60	0.99	0.19
E33 30 6-12	21-Nov-03	554	365.64	18.18	49.08	13.99	7.37	61.72	0.59	0.00
E33 10 12-18	21-Nov-03	901	594.66	45.82	73.26	21.41	3.53	65.58	1.21	0.52
E33 20 12-18	21-Nov-03	634	418.44	36.01	49.26	13.65	5.36	88.19	1.17	0.46
E33 30 12-18	21-Nov-03	819	540.54	30.73	69.90	20.09	5.30	59.56	0.83	0.00
E33 10 18-24	21-Nov-03	884	583.44	50.08	67.04	20.14	2.74	102.98	1.38	0.76
E33 20 18-24	21-Nov-03	702	463.32	51.09	47.38	14.41	5.80	84.64	1.67	1.17
E33 30 18-24	21-Nov-03	841	555.06	50.91	59.00	17.67	3.53	53.39	1.49	0.92

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
W33 10 0-6	21-Nov-03	729	481.14	20.42	70.52	14.57	14.88	57.77	0.58	0.00
W33 20 0-6	21-Nov-03	712	469.92	11.50	70.04	16.73	18.34	45.47	0.32	0.00
W33 30 0-6	21-Nov-03	670	442.20	21.03	64.43	14.42	11.27	43.98	0.62	0.00
W33 10 6-12	21-Nov-03	845	557.70	36.69	77.95	18.53	7.06	125.29	0.97	0.17
W33 20 6-12	21-Nov-03	593	391.38	22.30	50.30	14.14	7.91	48.42	0.72	0.00
W33 30 6-12	21-Nov-03	641	423.06	37.09	50.64	13.72	6.60	95.72	1.19	0.49
W33 10 12-18	21-Nov-03	853	562.98	44.58	68.53	18.47	5.91	103.43	1.23	0.55
W33 20 12-18	21-Nov-03	886	584.76	43.25	70.63	19.81	4.32	50.44	1.17	0.46
W33 30 12-18	21-Nov-03	714	471.24	41.61	55.09	15.26	6.00	132.81	1.28	0.61
W33 10 18-24	21-Nov-03	767	506.22	46.91	53.04	15.87	5.63	92.24	1.45	0.86
W33 20 18-24	21-Nov-03	786	518.76	47.21	58.52	16.99	3.06	77.02	1.40	0.79
W33 30 18-24	21-Nov-03	845	557.70	58.87	61.02	17.92	6.02	133.77	1.70	1.23
E53 10 0-6	21-Nov-03	728	480.48	12.51	68.45	17.82	21.60	29.78	0.35	0.00
E53 20 0-6	21-Nov-03	675	445.50	11.41	66.36	16.97	17.50	53.94	0.32	0.00
E53 30 0-6	21-Nov-03	618	407.88	22.93	54.05	15.33	10.61	78.57	0.71	0.00
E53 10 6-12	21-Nov-03	362	238.92	16.12	29.93	9.00	5.06	24.53	0.66	0.00
E53 20 6-12	21-Nov-03	535	353.10	19.20	46.53	14.22	5.76	40.56	0.63	0.00
E53 30 6-12	21-Nov-03	328	216.48	12.69	26.93	8.36	5.34	28.84	0.55	0.00
E53 10 12-18	21-Nov-03	400	264.00	21.78	30.11	9.72	3.19	45.59	0.88	0.04
E53 20 12-18	21-Nov-03	599	395.34	27.76	47.41	14.84	3.34	31.98	0.90	0.07
E53 30 12-18	21-Nov-03	781	515.46	74.94	35.67	11.85	3.98	34.62	2.78	2.74
E53 10 18-24	21-Nov-03	633	417.78	35.47	46.50	15.01	2.68	59.19	1.16	0.44
E53 20 18-24	21-Nov-03	581	383.46	34.46	41.21	13.80	2.20	51.09	1.19	0.48
E53 30 18-24	21-Nov-03	517	341.22	29.25	38.45	12.35	2.60	41.16	1.05	0.28
W53 10 0-6	21-Nov-03	5010	3306.60	190.18	437.19	114.71	139.54	84.01	2.09	1.78
W53 20 0-6	21-Nov-03	2780	1834.80	123.24	219.12	51.40	88.82	48.16	1.95	1.57
W53 30 0-6	21-Nov-03	3210	2118.60	127.68	266.65	62.85	75.39	48.65	1.83	1.40
W53 10 6-12	21-Nov-03	1650	1089.00	61.95	143.40	34.96	17.07	34.69	1.20	0.50
W53 20 6-12	21-Nov-03	1855	1224.30	70.99	152.90	37.40	44.24	31.07	1.33	0.70
W53 30 6-12	21-Nov-03	1133	747.78	44.30	97.56	23.55	13.27	40.94	1.04	0.27
W53 10 12-18	21-Nov-03	840	554.40	37.28	66.28	16.90	5.98	41.21	1.06	0.29
W53 20 12-18	21-Nov-03	1212	799.92	50.05	98.72	24.73	22.86	34.61	1.17	0.45
W53 30 12-18	21-Nov-03	651	429.66	30.80	50.75	12.95	5.75	54.13	1.00	0.21
W53 10 18-24	21-Nov-03	680	448.80	35.68	51.48	13.03	4.81	53.23	1.15	0.43
W53 20 18-24	21-Nov-03	873	576.18	44.76	67.77	16.24	8.77	45.84	1.27	0.60
W53 30 18-24	21-Nov-03	529	349.14	31.97	39.01	9.59	4.16	58.26	1.19	0.48

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe
		g	g	g	g	g			
E16 10 0-6	19-Apr-03	133.00	419.60	536.70	286.60	117.10	1.41	0.41	7.86
E16 20 0-6	19-Apr-03	130.90	432.70	561.30	301.80	128.60	1.48	0.43	7.88
E16 30 0-6	19-Apr-03	128.40	414.00	519.80	285.60	105.80	1.40	0.37	7.95
E16 10 6-12	19-Apr-03	128.50	416.80	546.20	288.30	129.40	1.41	0.45	7.74
E16 20 6-12	19-Apr-03	128.80	435.20	565.50	306.40	130.30	1.50	0.43	7.88
E16 30 6-12	19-Apr-03	132.80	423.80	578.20	291.00	154.40	1.43	0.53	7.84
E16 10 12-18	19-Apr-03	128.40	406.40	544.80	278.00	138.40	1.36	0.50	7.09
E16 20 12-18	19-Apr-03	128.80	398.60	534.40	269.80	135.80	1.32	0.50	7.74
E16 30 12-18	19-Apr-03	128.50	425.80	563.80	297.30	138.00	1.46	0.46	7.87
E16 10 18-24	19-Apr-03	127.70	430.70	564.50	303.00	133.80	1.49	0.44	7.91
E16 20 18-24	19-Apr-03	133.00	405.60	525.80	272.60	120.20	1.34	0.44	7.90
E16 30 18-24	19-Apr-03	132.90	384.20	497.20	251.30	113.00	1.23	0.45	7.87
W16 10 0-6	19-Apr-03	128.50	401.90	528.60	273.40	126.70	1.34	0.46	7.79
W16 20 0-6	19-Apr-03	128.50	414.20	538.50	285.70	124.30	1.40	0.44	7.61
W16 30 0-6	19-Apr-03	133.20	430.30	548.30	297.10	118.00	1.46	0.40	7.92
W16 10 6-12	19-Apr-03	128.50	446.60	586.00	318.10	139.40	1.56	0.44	7.69
W16 20 6-12	19-Apr-03	133.00	443.80	576.80	310.80	133.00	1.52	0.43	7.72
W16 30 6-12	19-Apr-03	138.70	434.70	556.50	296.00	121.80	1.45	0.41	7.73
W16 10 12-18	19-Apr-03	132.90	438.90	580.60	306.00	141.70	1.50	0.46	7.64
W16 20 12-18	19-Apr-03	128.50	431.20	574.70	302.70	143.50	1.48	0.47	7.86
W16 30 12-18	19-Apr-03	133.50	428.30	573.90	294.80	145.60	1.45	0.49	7.75
W16 10 18-24	19-Apr-03	134.80	429.90	580.60	295.10	150.70	1.45	0.51	7.74
W16 20 18-24	19-Apr-03	128.50	443.10	599.70	314.60	156.60	1.54	0.50	7.69
W16 30 18-24	19-Apr-03	128.90	442.30	604.70	313.40	162.40	1.54	0.52	7.71
E33 10 0-6	19-Apr-03	133.40	445.70	572.90	312.30	127.20	1.53	0.41	7.74
E33 20 0-6	19-Apr-03	128.60	419.00	551.40	290.40	132.40	1.42	0.46	7.67
E33 30 0-6	19-Apr-03	127.90	395.20	512.50	267.30	117.30	1.31	0.44	7.82
E33 10 6-12	19-Apr-03	133.00	446.30	588.60	313.30	142.30	1.54	0.45	7.82
E33 20 6-12	19-Apr-03	133.00	444.50	597.70	311.50	153.20	1.53	0.49	7.65
E33 30 6-12	19-Apr-03	128.50	424.70	567.10	296.20	142.40	1.45	0.48	7.69
E33 10 12-18	19-Apr-03	127.90	472.90	629.60	345.00	156.70	1.69	0.45	7.76
E33 20 12-18	19-Apr-03	133.40	392.00	523.20	258.60	131.20	1.27	0.51	7.61
E33 30 12-18	19-Apr-03	127.90	380.30	512.00	252.40	131.70	1.24	0.52	7.77
E33 10 18-24	19-Apr-03	.	.	.	.	.	.	.	.
E33 20 18-24	19-Apr-03	130.00	221.30	273.80	91.30	52.50	0.45	0.58	7.79
E33 30 18-24	19-Apr-03	128.50	319.10	431.50	190.60	112.40	0.93	0.59	7.90

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe
		g	g	g	g	g			
W33 10 0-6	19-Apr-03	127.60	410.20	538.90	282.60	128.70	1.39	0.46	7.82
W33 20 0-6	19-Apr-03	133.10	418.30	568.40	285.20	150.10	1.40	0.53	7.84
W33 30 0-6	19-Apr-03	133.60	397.20	529.90	263.60	132.70	1.29	0.50	7.74
W33 10 6-12	19-Apr-03	133.10	450.80	604.80	317.70	154.00	1.56	0.48	7.67
W33 20 6-12	19-Apr-03	132.90	390.80	525.10	257.90	134.30	1.26	0.52	7.64
W33 30 6-12	19-Apr-03	128.80	381.60	500.80	252.80	119.20	1.24	0.47	7.70
W33 10 12-18	19-Apr-03	128.60	443.70	601.20	315.10	157.50	1.55	0.50	7.66
W33 20 12-18	19-Apr-03	133.20	445.90	600.20	312.70	154.30	1.53	0.49	7.72
W33 30 12-18	19-Apr-03	133.10	431.60	579.10	298.50	147.50	1.46	0.49	7.78
W33 10 18-24	19-Apr-03	128.50	434.30	587.50	305.80	153.20	1.50	0.50	7.73
W33 20 18-24	19-Apr-03	128.50	445.10	602.80	316.60	157.70	1.55	0.50	7.55
W33 30 18-24	19-Apr-03	128.20	429.40	580.20	301.20	150.80	1.48	0.50	7.86
E53 10 0-6	19-Apr-03	132.90	412.10	546.70	279.20	134.60	1.37	0.48	7.58
E53 20 0-6	19-Apr-03	128.60	320.40	415.30	191.80	94.90	0.94	0.49	6.78
E53 30 0-6	19-Apr-03	128.60	369.10	489.00	240.50	119.90	1.18	0.50	7.73
E53 10 6-12	19-Apr-03	127.90	454.20	607.60	326.30	153.40	1.60	0.47	7.31
E53 20 6-12	19-Apr-03	133.00	425.30	566.70	292.30	141.40	1.43	0.48	7.60
E53 30 6-12	19-Apr-03	133.20	442.60	594.60	309.40	152.00	1.52	0.49	7.10
E53 10 12-18	19-Apr-03	133.00	457.20	598.50	324.20	141.30	1.59	0.44	7.89
E53 20 12-18	19-Apr-03	128.50	431.80	567.90	303.30	136.10	1.49	0.45	7.90
E53 30 12-18	19-Apr-03	128.70	447.50	601.10	318.80	153.60	1.56	0.48	7.76
E53 10 18-24	19-Apr-03	128.50	396.20	526.40	267.70	130.20	1.31	0.49	7.81
E53 20 18-24	19-Apr-03	128.50	428.30	566.30	299.80	138.00	1.47	0.46	7.96
E53 30 18-24	19-Apr-03	128.60	442.50	585.80	313.90	143.30	1.54	0.46	7.37
W53 10 0-6	19-Apr-03	128.50	413.70	555.90	285.20	142.20	1.40	0.50	7.35
W53 20 0-6	19-Apr-03	132.90	420.90	574.70	288.00	153.80	1.41	0.53	7.44
W53 30 0-6	19-Apr-03	128.50	413.30	542.90	284.80	129.60	1.40	0.46	7.39
W53 10 6-12	19-Apr-03	128.30	429.40	575.10	301.10	145.70	1.48	0.48	7.49
W53 20 6-12	19-Apr-03	127.90	424.40	572.80	296.50	148.40	1.45	0.50	6.80
W53 30 6-12	19-Apr-03	128.70	439.70	577.20	311.00	137.50	1.53	0.44	7.38
W53 10 12-18	19-Apr-03	128.80	421.20	570.10	292.40	148.90	1.43	0.51	7.62
W53 20 12-18	19-Apr-03	133.00	433.70	579.70	300.70	146.00	1.47	0.49	7.56
W53 30 12-18	19-Apr-03	133.00	437.70	599.60	304.70	161.90	1.49	0.53	7.58
W53 10 18-24	19-Apr-03	133.30	437.50	586.90	304.20	149.40	1.49	0.49	8.34
W53 20 18-24	19-Apr-03	128.60	412.50	555.30	283.90	142.80	1.39	0.50	7.70
W53 30 18-24	19-Apr-03	128.50	420.20	566.50	291.70	146.30	1.43	0.50	7.88

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
E16 10 0-6	19-Apr-03	573	378.18	14.68	60.88	8.71	23.16	16.23	0.47	0.00
E16 20 0-6	19-Apr-03	551	363.66	20.04	59.72	10.48	23.58	41.71	0.63	0.00
E16 30 0-6	19-Apr-03	413	272.58	8.61	47.54	7.17	16.06	15.56	0.31	0.00
E16 10 6-12	19-Apr-03	700	462.00	14.75	82.95	15.09	9.89	52.22	0.39	0.00
E16 20 6-12	19-Apr-03	848	559.68	22.83	107.72	18.65	11.86	80.33	0.53	0.00
E16 30 6-12	19-Apr-03	513	338.58	15.93	55.71	10.70	7.23	41.59	0.51	0.00
E16 10 12-18	19-Apr-03	709	467.94	35.25	60.74	14.69	4.18	44.91	1.05	0.29
E16 20 12-18	19-Apr-03	935	617.10	46.04	101.17	23.53	5.01	98.43	1.07	0.31
E16 30 12-18	19-Apr-03	701	462.66	34.69	64.73	15.82	3.27	59.18	1.00	0.21
E16 10 18-24	19-Apr-03	619	408.54	44.19	45.69	13.51	3.29	66.36	1.48	0.90
E16 20 18-24	19-Apr-03	895	590.70	57.68	81.80	22.24	8.77	54.72	1.46	0.88
E16 30 18-24	19-Apr-03	684	451.44	47.53	49.31	14.63	2.57	49.09	1.53	0.97
W16 10 0-6	19-Apr-03	761	502.26	21.27	80.51	13.00	27.70	35.18	0.58	0.00
W16 20 0-6	19-Apr-03	604	398.64	32.83	50.17	8.02	17.91	18.92	1.14	0.41
W16 30 0-6	19-Apr-03	591	390.06	43.85	48.27	7.78	19.08	19.31	1.54	1.00
W16 10 6-12	19-Apr-03	932	615.12	55.24	82.25	16.12	10.60	75.33	1.46	0.87
W16 20 6-12	19-Apr-03	867	572.22	49.23	80.52	15.42	9.86	79.76	1.32	0.67
W16 30 6-12	19-Apr-03	803	529.98	44.26	83.05	16.25	11.03	71.83	1.16	0.45
W16 10 12-18	19-Apr-03	1062	700.92	70.47	89.50	20.36	7.01	209.19	1.75	1.29
W16 20 12-18	19-Apr-03	1471	970.86	100.70	129.02	29.16	8.59	201.54	2.08	1.77
W16 30 12-18	19-Apr-03	1172	773.52	71.71	122.01	27.87	8.77	177.57	1.52	0.97
W16 10 18-24	19-Apr-03	1334	880.44	92.56	115.36	31.14	5.61	347.72	1.97	1.61
W16 20 18-24	19-Apr-03	1583	1044.78	92.02	147.63	38.72	7.64	258.31	1.74	1.28
W16 30 18-24	19-Apr-03	1262	832.92	82.09	128.15	34.29	6.34	233.71	1.66	1.17
E33 10 0-6	19-Apr-03	577	380.82	14.55	56.69	14.26	16.04	32.50	0.45	0.00
E33 20 0-6	19-Apr-03	538	355.08	14.57	59.10	14.78	19.52	44.06	0.44	0.00
E33 30 0-6	19-Apr-03	698	460.68	11.39	72.03	18.04	19.37	30.97	0.31	0.00
E33 10 6-12	19-Apr-03	727	479.82	31.60	64.12	18.96	9.28	57.71	0.89	0.05
E33 20 6-12	19-Apr-03	763	503.58	28.77	81.32	23.51	10.05	64.15	0.72	0.00
E33 30 6-12	19-Apr-03	678	447.48	20.31	65.94	18.75	9.01	67.09	0.57	0.00
E33 10 12-18	19-Apr-03	1016	670.56	48.70	92.98	27.87	4.93	64.76	1.14	0.41
E33 20 12-18	19-Apr-03	906	597.96	44.72	90.82	27.16	5.54	57.75	1.06	0.29
E33 30 12-18	19-Apr-03	974	642.84	37.81	89.00	26.27	6.17	70.95	0.91	0.07
E33 10 18-24	19-Apr-03	.	.	.	.	.	.	.	.	.
E33 20 18-24	19-Apr-03	831	548.46	47.18	74.77	22.45	6.23	53.52	1.23	0.54
E33 30 18-24	19-Apr-03	744	491.04	41.65	58.80	17.64	3.29	42.60	1.22	0.53

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
W33 10 0-6	19-Apr-03	723	477.18	26.61	81.19	17.50	19.46	58.26	0.70	0.00
W33 20 0-6	19-Apr-03	663	437.58	25.80	62.80	13.63	14.89	39.34	0.77	0.00
W33 30 0-6	19-Apr-03	609	401.94	19.74	66.86	15.33	14.68	39.76	0.57	0.00
W33 10 6-12	19-Apr-03	940	620.40	45.95	100.91	25.49	9.47	110.66	1.06	0.29
W33 20 6-12	19-Apr-03	810	534.60	40.29	68.26	17.83	7.66	73.00	1.12	0.39
W33 30 6-12	19-Apr-03	646	426.36	35.98	60.89	16.69	8.00	58.28	1.05	0.29
W33 10 12-18	19-Apr-03	815	537.90	49.18	76.18	21.00	6.76	92.43	1.29	0.63
W33 20 12-18	19-Apr-03	922	608.52	51.30	79.62	22.25	8.10	123.16	1.31	0.66
W33 30 12-18	19-Apr-03	648	427.68	43.54	56.31	16.17	6.13	112.04	1.32	0.67
W33 10 18-24	19-Apr-03	721	475.86	54.19	59.06	17.97	6.03	89.78	1.58	1.06
W33 20 18-24	19-Apr-03	991	654.06	74.60	70.71	20.30	7.51	104.42	2.01	1.67
W33 30 18-24	19-Apr-03	707	466.62	52.99	57.90	17.64	5.50	134.99	1.56	1.03
E53 10 0-6	19-Apr-03	508	335.28	11.38	49.04	13.58	15.43	27.79	0.37	0.00
E53 20 0-6	19-Apr-03	643	424.38	23.11	49.90	12.96	16.32	27.47	0.75	0.00
E53 30 0-6	19-Apr-03	410	270.60	10.58	48.00	12.91	12.33	27.40	0.35	0.00
E53 10 6-12	19-Apr-03	758	500.28	36.93	61.58	17.71	6.98	42.55	1.07	0.31
E53 20 6-12	19-Apr-03	951	627.66	61.65	67.14	19.05	8.00	53.45	1.71	1.24
E53 30 6-12	19-Apr-03	443	292.38	19.10	40.42	12.79	7.10	40.33	0.67	0.00
E53 10 12-18	19-Apr-03	571	376.86	32.35	46.39	15.00	2.96	46.53	1.06	0.29
E53 20 12-18	19-Apr-03	570	376.20	30.15	47.55	15.00	3.32	40.25	0.98	0.17
E53 30 12-18	19-Apr-03	388	256.08	22.44	35.14	11.54	3.31	36.74	0.84	0.00
E53 10 18-24	19-Apr-03	574	378.84	40.50	40.74	14.51	2.63	62.06	1.39	0.77
E53 20 18-24	19-Apr-03	550	363.00	37.37	38.40	13.17	2.80	51.69	1.33	0.68
E53 30 18-24	19-Apr-03	421	277.86	33.50	32.70	10.93	2.26	45.50	1.30	0.64
W53 10 0-6	19-Apr-03	4450	2937.00	211.22	398.54	102.54	183.53	76.26	2.44	2.27
W53 20 0-6	19-Apr-03	2080	1372.80	119.71	128.07	32.66	155.58	42.11	2.44	2.27
W53 30 0-6	19-Apr-03	1904	1256.64	80.50	173.61	49.99	70.52	42.50	1.39	0.77
W53 10 6-12	19-Apr-03	2110	1392.60	94.70	205.71	50.87	43.00	37.32	1.53	0.98
W53 20 6-12	19-Apr-03	2710	1788.60	105.96	249.10	61.19	139.27	28.84	1.56	1.02
W53 30 6-12	19-Apr-03	1837	1212.42	68.71	207.29	50.34	17.17	46.94	1.11	0.37
W53 10 12-18	19-Apr-03	1333	879.78	69.66	125.98	32.40	13.60	39.68	1.43	0.84
W53 20 12-18	19-Apr-03	1708	1127.28	69.63	177.91	43.46	32.68	28.67	1.21	0.52
W53 30 12-18	19-Apr-03	851	561.66	46.49	80.19	20.47	7.61	52.50	1.20	0.50
W53 10 18-24	19-Apr-03	1371	904.86	125.39	92.12	23.96	12.00	49.69	3.01	3.06
W53 20 18-24	19-Apr-03	1091	720.06	59.66	103.12	26.38	12.97	41.60	1.36	0.73
W53 30 18-24	19-Apr-03	625	412.50	51.54	49.83	12.54	4.76	64.98	1.69	1.21

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe
		g	g	g	g	g			
E16 10 0-6	10-May-03	128.90	422.30	555.00	293.40	132.70	1.44	0.45	7.86
E16 20 0-6	10-May-03	127.90	430.80	546.60	302.90	115.80	1.49	0.38	7.79
E16 30 0-6	10-May-03	133.00	445.00	566.30	312.00	121.30	1.53	0.39	7.85
E16 10 6-12	10-May-03	133.70	455.10	598.10	321.40	143.00	1.58	0.44	7.74
E16 20 6-12	10-May-03	128.50	428.10	545.10	299.60	117.00	1.47	0.39	7.77
E16 30 6-12	10-May-03	128.00	435.50	578.00	307.50	142.50	1.51	0.46	7.71
E16 10 12-18	10-May-03	133.50	406.10	531.40	272.60	125.30	1.34	0.46	7.73
E16 20 12-18	10-May-03	133.10	409.70	536.80	276.60	127.10	1.36	0.46	7.67
E16 30 12-18	10-May-03	128.50	389.20	505.90	260.70	116.70	1.28	0.45	7.83
E16 10 18-24	10-May-03	129.40	419.20	564.90	289.80	145.70	1.42	0.50	7.83
E16 20 18-24	10-May-03	133.40	394.70	529.10	261.30	134.40	1.28	0.51	7.66
E16 30 18-24	10-May-03	128.50	257.00	323.00	128.50	66.00	0.63	0.51	7.95
W16 10 0-6	10-May-03	128.50	407.40	525.70	278.90	118.30	1.37	0.42	7.79
W16 20 0-6	10-May-03	128.30	369.20	520.70	240.90	151.50	1.18	0.63	7.85
W16 30 0-6	10-May-03	133.10	420.50	539.50	287.40	119.00	1.41	0.41	7.82
W16 10 6-12	10-May-03	132.90	434.00	555.90	301.10	121.90	1.48	0.40	7.84
W16 20 6-12	10-May-03	132.90	429.50	574.70	296.60	145.20	1.45	0.49	7.78
W16 30 6-12	10-May-03	128.40	408.30	527.80	279.90	119.50	1.37	0.43	7.68
W16 10 12-18	10-May-03	133.10	368.80	481.70	235.70	112.90	1.16	0.48	7.72
W16 20 12-18	10-May-03	132.80	425.10	539.20	292.30	114.10	1.43	0.39	7.64
W16 30 12-18	10-May-03	128.50	433.70	571.10	305.20	137.40	1.50	0.45	7.67
W16 10 18-24	10-May-03	133.10	340.40	467.70	207.30	127.30	1.02	0.61	7.55
W16 20 18-24	10-May-03	128.50	475.70	620.60	347.20	144.90	1.70	0.42	7.66
W16 30 18-24	10-May-03	133.00	446.20	591.10	313.20	144.90	1.54	0.46	7.70
E33 10 0-6	10-May-03	128.50	415.50	543.00	287.00	127.50	1.41	0.44	7.78
E33 20 0-6	10-May-03	128.60	366.90	472.80	238.30	105.90	1.17	0.44	7.79
E33 30 0-6	10-May-03	128.00	410.90	523.50	282.90	112.60	1.39	0.40	7.73
E33 10 6-12	10-May-03	128.40	453.70	589.60	325.30	135.90	1.60	0.42	7.56
E33 20 6-12	10-May-03	128.80	429.70	571.90	300.90	142.20	1.48	0.47	7.61
E33 30 6-12	10-May-03	128.50	439.60	565.20	311.10	125.60	1.53	0.40	7.57
E33 10 12-18	10-May-03	132.80	424.40	548.60	291.60	124.20	1.43	0.43	7.43
E33 20 12-18	10-May-03	129.00	363.00	482.80	234.00	119.80	1.15	0.51	7.72
E33 30 12-18	10-May-03	132.90	398.10	519.50	265.20	121.40	1.30	0.46	7.58
E33 10 18-24	10-May-03	128.50	242.80	301.70	114.30	58.90	0.56	0.52	7.79
E33 20 18-24	10-May-03	128.40	261.00	363.80	132.60	102.80	0.65	0.78	7.76
E33 30 18-24	10-May-03	128.60	253.60	320.80	125.00	67.20	0.61	0.54	7.76

Sample	Date	W1	W2	W3	Ms	Mw	ρb	θm	pHe
		g	g	g	g	g			
W33 10 0-6	10-May-03	127.60	406.70	529.00	279.10	122.30	1.37	0.44	7.73
W33 20 0-6	10-May-03	129.00	413.00	543.50	284.00	130.50	1.39	0.46	7.88
W33 30 0-6	10-May-03	133.00	420.50	553.10	287.50	132.60	1.41	0.46	7.77
W33 10 6-12	10-May-03	128.50	462.40	601.20	333.90	138.80	1.64	0.42	7.64
W33 20 6-12	10-May-03	129.20	434.30	568.10	305.10	133.80	1.50	0.44	7.70
W33 30 6-12	10-May-03	133.00	437.30	578.80	304.30	141.50	1.49	0.47	7.79
W33 10 12-18	10-May-03	128.60	450.10	587.90	321.50	137.80	1.58	0.43	7.64
W33 20 12-18	10-May-03	133.40	447.00	584.30	313.60	137.30	1.54	0.44	7.71
W33 30 12-18	10-May-03	128.60	449.30	574.70	320.70	125.40	1.57	0.39	7.64
W33 10 18-24	10-May-03	128.50	451.00	605.40	322.50	154.40	1.58	0.48	7.71
W33 20 18-24	10-May-03	128.70	446.20	587.70	317.50	141.50	1.56	0.45	7.86
W33 30 18-24	10-May-03	134.80	474.00	615.70	339.20	141.70	1.66	0.42	7.73
E53 10 0-6	10-May-03	132.80	412.80	545.30	280.00	132.50	1.37	0.47	7.73
E53 20 0-6	10-May-03	132.90	416.30	541.20	283.40	124.90	1.39	0.44	7.66
E53 30 0-6	10-May-03	128.60	429.10	556.20	300.50	127.10	1.47	0.42	7.96
E53 10 6-12	10-May-03	132.90	362.30	474.70	229.40	112.40	1.12	0.49	7.70
E53 20 6-12	10-May-03	138.20	426.20	543.90	288.00	117.70	1.41	0.41	7.48
E53 30 6-12	10-May-03	132.90	449.20	585.30	316.30	136.10	1.55	0.43	7.66
E53 10 12-18	10-May-03	128.50	437.10	557.80	308.60	120.70	1.51	0.39	7.81
E53 20 12-18	10-May-03	138.80	337.00	434.50	198.20	97.50	0.97	0.49	7.76
E53 30 12-18	10-May-03	133.50	444.00	575.60	310.50	131.60	1.52	0.42	7.88
E53 10 18-24	10-May-03	128.50	287.20	364.30	158.70	77.10	0.78	0.49	7.87
E53 20 18-24	10-May-03	128.60	224.20	289.00	95.60	64.80	0.47	0.68	7.85
E53 30 18-24	10-May-03	128.50	456.20	596.70	327.70	140.50	1.61	0.43	7.83
W53 10 0-6	10-May-03	133.00	396.80	551.50	263.80	154.70	1.29	0.59	7.54
W53 20 0-6	10-May-03	133.00	411.70	534.90	278.70	123.20	1.37	0.44	7.44
W53 30 0-6	10-May-03	129.30	385.70	528.80	256.40	143.10	1.26	0.56	7.16
W53 10 6-12	10-May-03	133.30	404.30	540.00	271.00	135.70	1.33	0.50	7.60
W53 20 6-12	10-May-03	128.40	438.20	574.30	309.80	136.10	1.52	0.44	7.45
W53 30 6-12	10-May-03	128.40	451.50	604.90	323.10	153.40	1.58	0.47	7.48
W53 10 12-18	10-May-03	133.30	396.80	509.30	263.50	112.50	1.29	0.43	7.67
W53 20 12-18	10-May-03	129.70	429.50	552.10	299.80	122.60	1.47	0.41	7.43
W53 30 12-18	10-May-03	128.10	435.60	585.00	307.50	149.40	1.51	0.49	7.59
W53 10 18-24	10-May-03	128.80	437.50	569.80	308.70	132.30	1.51	0.43	7.62
W53 20 18-24	10-May-03	128.00	421.20	538.20	293.20	117.00	1.44	0.40	7.58
W53 30 18-24	10-May-03	133.50	425.70	574.10	292.20	148.40	1.43	0.51	7.59

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO4	SAR	ESP
		μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
E16 10 0-6	10-May-03	435	287.10	8.22	53.09	7.59	20.68	21.00	0.28	0.00
E16 20 0-6	10-May-03	391	258.06	8.79	46.00	6.84	15.82	20.17	0.32	0.00
E16 30 0-6	10-May-03	385	254.10	11.34	44.73	6.51	16.63	30.51	0.42	0.00
E16 10 6-12	10-May-03	691	456.06	19.24	83.44	15.56	7.91	54.50	0.51	0.00
E16 20 6-12	10-May-03	611	403.26	18.31	71.39	13.55	7.00	62.77	0.52	0.00
E16 30 6-12	10-May-03	503	331.98	16.97	57.13	11.21	7.56	54.21	0.54	0.00
E16 10 12-18	10-May-03	687	453.42	35.80	65.23	16.25	3.13	67.26	1.03	0.25
E16 20 12-18	10-May-03	809	533.94	40.11	81.27	19.81	2.98	73.72	1.03	0.26
E16 30 12-18	10-May-03	539	355.74	33.20	50.64	12.29	2.40	73.06	1.09	0.33
E16 10 18-24	10-May-03	542	357.72	44.05	40.67	12.11	2.03	47.99	1.56	1.02
E16 20 18-24	10-May-03	696	459.36	49.25	54.99	16.43	2.00	41.10	1.50	0.93
E16 30 18-24	10-May-03	393	259.38	33.52	30.10	8.80	1.71	44.72	1.38	0.76
W16 10 0-6	10-May-03	428	282.48	16.10	48.72	8.53	15.47	17.39	0.56	0.00
W16 20 0-6	10-May-03	252	166.32	9.49	28.42	5.05	12.30	11.01	0.43	0.00
W16 30 0-6	10-May-03	543	358.38	22.03	58.70	9.33	24.86	27.36	0.70	0.00
W16 10 6-12	10-May-03	597	394.02	46.02	51.81	10.33	6.92	43.55	1.53	0.97
W16 20 6-12	10-May-03	383	252.78	24.61	38.17	7.71	7.99	31.41	0.95	0.14
W16 30 6-12	10-May-03	656	432.96	31.54	69.86	13.13	12.10	50.32	0.91	0.07
W16 10 12-18	10-May-03	892	588.72	65.74	84.07	19.28	6.21	135.68	1.68	1.19
W16 20 12-18	10-May-03	991	654.06	60.68	96.96	21.59	7.55	124.68	1.45	0.86
W16 30 12-18	10-May-03	1146	756.36	60.09	119.34	27.21	9.03	142.64	1.29	0.63
W16 10 18-24	10-May-03	1820	1201.20	88.05	202.89	51.90	22.52	178.22	1.43	0.83
W16 20 18-24	10-May-03	1256	828.96	82.31	122.94	30.84	4.83	169.84	1.72	1.25
W16 30 18-24	10-May-03	1150	759.00	75.85	109.31	29.11	4.40	158.63	1.67	1.17
E33 10 0-6	10-May-03	507	334.62	12.44	58.17	14.71	20.08	29.37	0.38	0.00
E33 20 0-6	10-May-03	324	213.84	8.75	35.45	9.25	14.69	15.11	0.34	0.00
E33 30 0-6	10-May-03	399	263.34	12.22	40.94	10.56	14.16	19.58	0.44	0.00
E33 10 6-12	10-May-03	724	477.84	29.38	71.20	20.36	8.74	59.96	0.79	0.00
E33 20 6-12	10-May-03	505	333.30	18.54	50.85	14.76	7.70	37.57	0.59	0.00
E33 30 6-12	10-May-03	507	334.62	18.46	51.73	15.23	8.39	50.68	0.58	0.00
E33 10 12-18	10-May-03	1011	667.26	50.60	100.50	29.63	4.49	62.76	1.14	0.41
E33 20 12-18	10-May-03	870	574.20	37.51	86.72	25.52	6.34	56.52	0.91	0.08
E33 30 12-18	10-May-03	894	590.04	39.47	87.09	25.87	6.76	68.46	0.95	0.14
E33 10 18-24	10-May-03	476	314.16	49.32	79.79	24.10	2.33	67.43	1.24	0.56
E33 20 18-24	10-May-03	600	396.00	32.51	55.24	16.27	3.41	27.81	0.99	0.19
E33 30 18-24	10-May-03	710	468.60	38.65	66.29	19.59	3.42	35.28	1.07	0.31

Sample	Date	EC	TSS	Na	Ca	Mg	K	SO_4	SAR	ESP
		μS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L		%
W33 10 0-6	10-May-03	655	432.30	24.40	75.39	15.90	16.43	62.11	0.67	0.00
W33 20 0-6	10-May-03	696	459.36	20.93	79.68	16.55	20.24	41.59	0.56	0.00
W33 30 0-6	10-May-03	554	365.64	20.62	60.87	13.24	15.08	33.78	0.62	0.00
W33 10 6-12	10-May-03	974	642.84	47.56	104.61	26.06	8.37	130.40	1.08	0.32
W33 20 6-12	10-May-03	788	520.08	38.95	79.80	19.39	7.63	65.87	1.01	0.23
W33 30 6-12	10-May-03	693	457.38	41.26	65.23	17.24	7.78	87.22	1.17	0.46
W33 10 12-18	10-May-03	888	586.08	51.80	86.11	24.38	6.49	103.18	1.27	0.60
W33 20 12-18	10-May-03	886	584.76	53.51	82.89	23.69	6.99	105.22	1.33	0.69
W33 30 12-18	10-May-03	976	644.16	61.28	95.56	27.12	7.91	157.25	1.42	0.83
W33 10 18-24	10-May-03	723	477.18	52.87	60.47	18.42	5.90	89.90	1.53	0.97
W33 20 18-24	10-May-03	785	518.10	55.94	63.45	19.30	6.12	85.82	1.58	1.05
W33 30 18-24	10-May-03	937	618.42	66.52	82.02	25.24	7.40	118.60	1.65	1.15
E53 10 0-6	10-May-03	469	309.54	13.04	50.65	13.57	17.00	14.46	0.42	0.00
E53 20 0-6	10-May-03	639	421.74	14.20	72.02	18.95	15.86	22.86	0.38	0.00
E53 30 0-6	10-May-03	451	297.66	14.09	50.45	13.85	15.31	27.68	0.45	0.00
E53 10 6-12	10-May-03	347	229.02	13.89	33.59	10.35	5.44	17.83	0.54	0.00
E53 20 6-12	10-May-03	656	432.96	24.94	64.74	19.49	6.90	47.31	0.70	0.00
E53 30 6-12	10-May-03	431	284.46	19.34	38.88	12.30	5.40	34.39	0.69	0.00
E53 10 12-18	10-May-03	463	305.58	26.78	39.62	12.56	3.22	39.82	0.95	0.14
E53 20 12-18	10-May-03	803	529.98	28.03	40.15	12.98	2.79	43.37	0.98	0.19
E53 30 12-18	10-May-03	459	302.94	37.91	77.44	24.21	6.54	56.37	0.96	0.16
E53 10 18-24	10-May-03	487	321.42	32.94	43.07	13.97	2.63	51.69	1.12	0.38
E53 20 18-24	10-May-03	714	471.24	35.59	72.48	22.06	15.39	39.62	0.94	0.12
E53 30 18-24	10-May-03	464	306.24	38.52	38.33	12.83	2.47	54.27	1.38	0.75
W53 10 0-6	10-May-03	1682	1110.12	91.02	132.01	32.66	84.75	32.97	1.84	1.42
W53 20 0-6	10-May-03	4520	2983.20	203.19	408.69	97.75	226.39	55.72	2.34	2.13
W53 30 0-6	10-May-03	3750	2475.00	173.94	358.06	87.62	144.29	54.92	2.14	1.84
W53 10 6-12	10-May-03	1222	806.52	62.90	111.22	28.96	19.60	31.76	1.37	0.75
W53 20 6-12	10-May-03	1760	1161.60	85.02	162.68	40.71	42.21	29.69	1.54	1.00
W53 30 6-12	10-May-03	1823	1203.18	75.54	190.86	46.34	27.02	38.24	1.27	0.61
W53 10 12-18	10-May-03	1034	682.44	54.74	99.78	25.50	9.41	36.07	1.27	0.60
W53 20 12-18	10-May-03	1102	727.32	52.44	105.24	26.94	12.81	32.81	1.18	0.47
W53 30 12-18	10-May-03	913	602.58	47.47	86.15	21.88	10.27	44.01	1.18	0.47
W53 10 18-24	10-May-03	935	617.10	57.89	79.97	20.74	11.78	46.76	1.49	0.92
W53 20 18-24	10-May-03	1004	662.64	53.83	92.11	22.69	11.39	38.10	1.30	0.65
W53 30 18-24	10-May-03	760	501.60	48.81	67.89	17.07	6.26	49.07	1.37	0.75

Note: The following legend corresponds with the soil sampling data.

W =	inlet end of plot
E =	distal end of plot
16 =	0.16 gph emitter
33 =	0.33 gph emitter
53 =	0.53 gph emitter
0-6 =	0-6 in depth
6-12 =	6-12 in depth
12-18 =	12-18 in depth
18-24 =	18-24 in depth
EC =	electrical conductivity
TSS =	total soluble salts
SAR =	sodium adsorption ratio
ESP =	exchangeable sodium percentage
W1 =	weight of the container
W2 =	dry weight + weight of the container
W3 =	saturated weight + weight of the container
Ms =	mass of the soil
Mw =	mass of soil + water
ρb =	bulk density
θm =	mass water content

Appendix C: Effluent Analysis

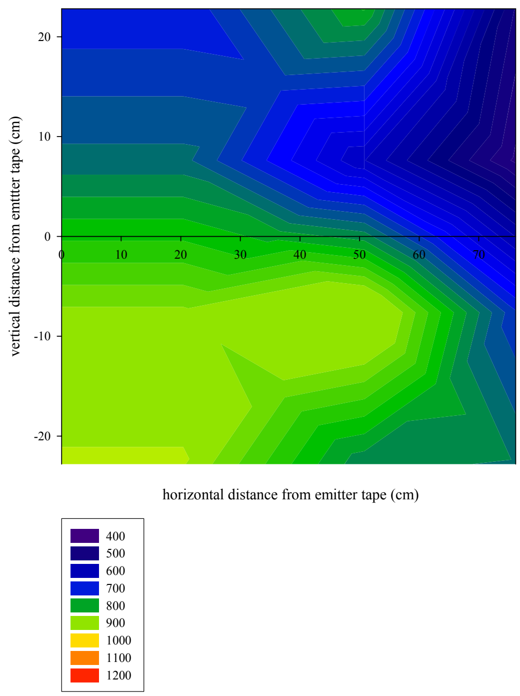
Date	Experiment Plot	pH (lab)	Na ppm	Ca ppm	Mg ppm	K ppm	SO_4 ppm	EC dS/m	TSS mg/L	SAR	Na %
Background		8.30	276.0	89.7	14.4	1226.0		6.49	4283.4	7.14	68%
10-Jul-03	SDI 49/50	8.45	283.0	100.8	15.72	884.4	36.7	6.64	4382.4	6.92	66%
11-Jul-03	SDI 51	8.48	294.3	91.3	17.75	964.8	33.8	6.69	4415.4	7.38	68%
16-Jul-03	SDI 53	8.14	275.3	62.3	17.65	905.8	27.5	7.14	4712.4	7.93	72%
03-Sep-03	SDI 49/50	8.40	310.5	80.9	22.35	918.0	32.5	6.90	4554.0	7.88	70%
03-Sep-03	SDI 51	8.30	283.3	80.9	21.83	850.5	31.5	6.70	4422.0	7.21	68%
03-Sep-03	SDI 53	8.40	326.0	80.0	22.83	924.5	28.2	6.90	4554.0	8.28	71%
28-Oct-03	SDI 49/50	7.94	322.8	78.8	21.60	913.5	54.8	7.17	4732.2	8.31	71%
29-Oct-03	SDI 51	8.08	324.1	93.8	22.45	942.7	28.5	7.37	4866.4	7.82	68%
29-Oct-03	SDI 53	8.08	319.3	87.7	21.84	928.6	28.9	7.26	4793.8	7.94	69%
14-Apr-04	SDI	7.87	212.9	119.5	17.39	825.9	40.8	8.23	5431.8	4.83	56%

Appendix D: HYDRUS-1D Input Parameters

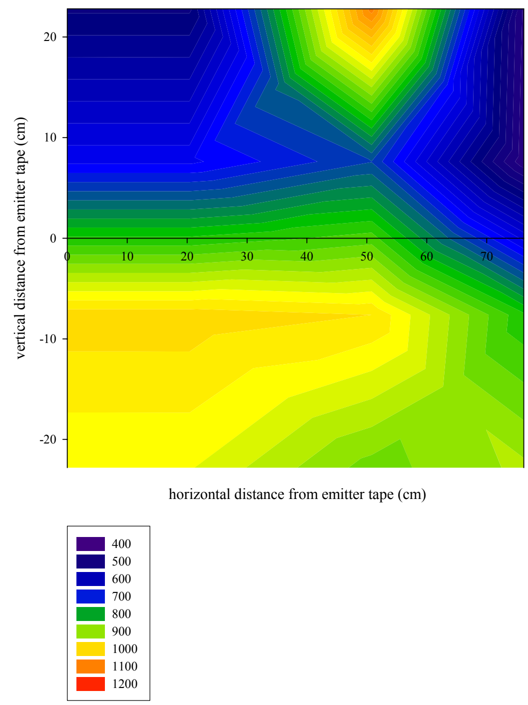
Option	Selection
Simulation Type	Solute Transport
Length Units	cm
Number of Soil Materials	1
Number of Layers for Mass Balance	4
Decline from Vertical Axes	1
Depth of Soil Profile	30
Time Units	Days
Initial Time	0
Final Time	50
Initial Time Step	0.002
Minimum Time Step	0.001
Maximum Time Step	49
Time Variable Boundary Conditions	Yes
Number of Time-Variable Boundary Records	51
Number of Print Times	5
Hydraulic Model	van Genuchten-Mualem
Hysteresis	No
Water Flow Parameters	Clay Loam
Upper Water Flow Boundary Condition	Atmospheric BC with Surface Layer
Lower Water Flow Boundary Condition	Free Drainage
Time Weighting Scheme	Crank-Nicholson Scheme
Space Weighting Scheme	Galerkin Finite Element
Mass Units	mg
Absolute Concentration Tolerance	0.01
Relative Concentration Tolerance	0.01
Maximum Number of Interations	50
Number of Solutes	1
Pulse Duration	1
Diffusion Coefficient in Water	1.1664
Diffusion Coefficient in Air	0
K_d	0.0693
Upper Solute Transport Boundary Condition	Concentration Flux BC
Lower Solute Transport Boundary Condition	Concentration Flux BC
Time Variable Boundary Conditions	Precipitation
	Bottom Concentration

Appendix E: EC Results for the Distal End of Plot 51

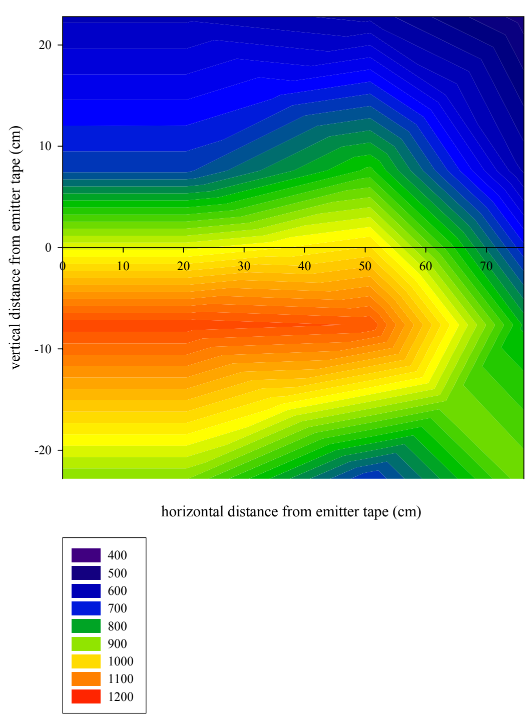
09/09/03 EC (uS/cm) for distal end of Plot 51
after effluent application



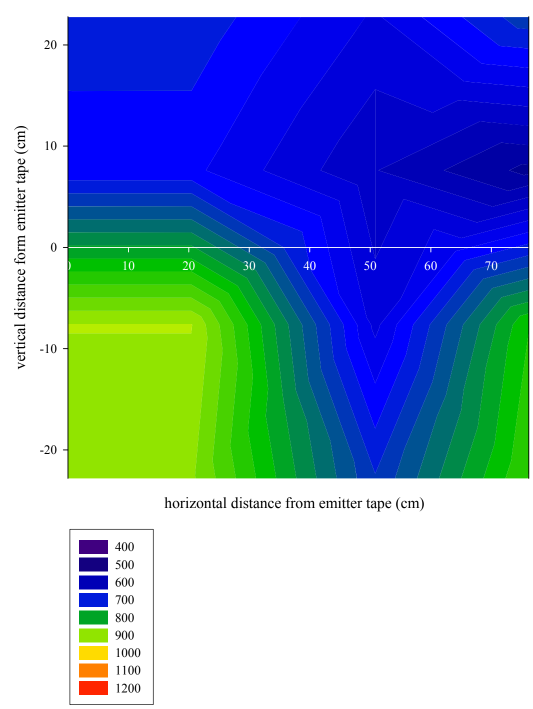
09/26/03 EC (uS/cm) for distal end of Plot 51
after 3.25 cm rainfall



11/10/03 EC (uS/cm) for Plot 51
after effluent application

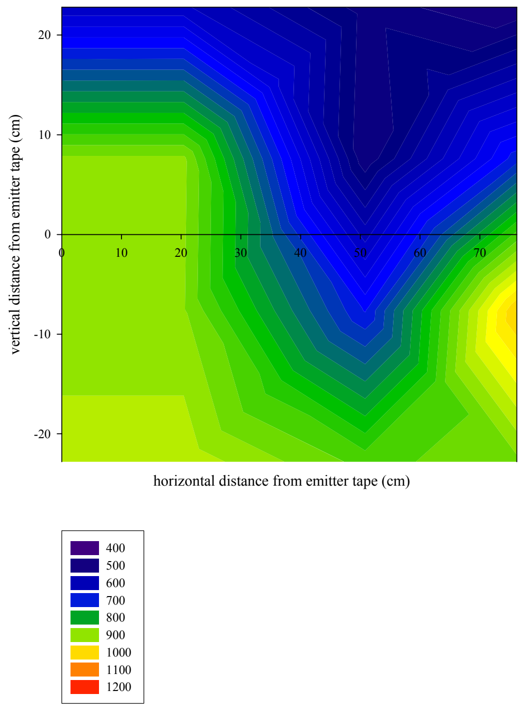


11/21/03 EC (uS/cm) for distal end of Plot 51
after 3.96 cm rainfall

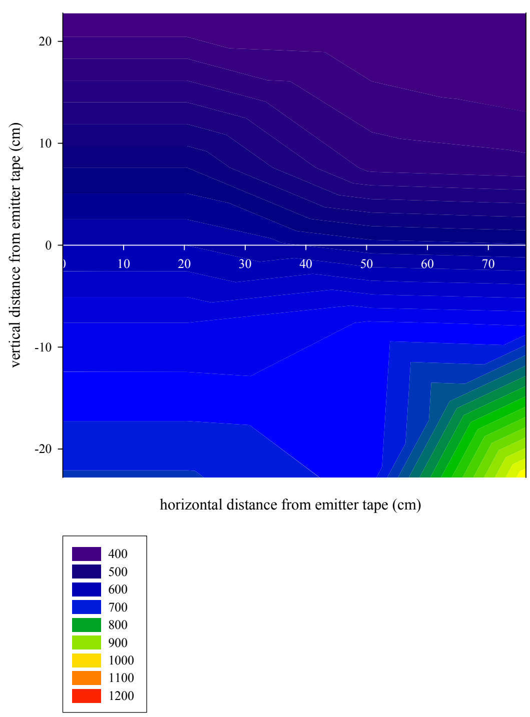


Appendix F: EC Results for the Inlet End of Plot 51

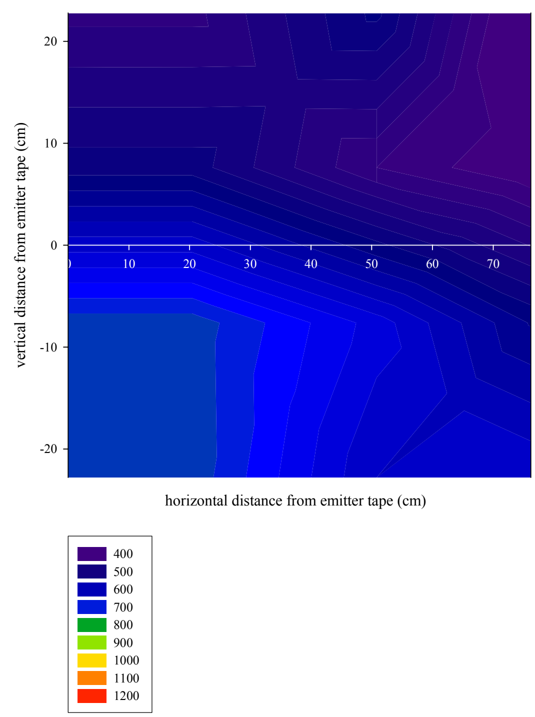
Background EC (uS/cm) for inlet end of Plot 51



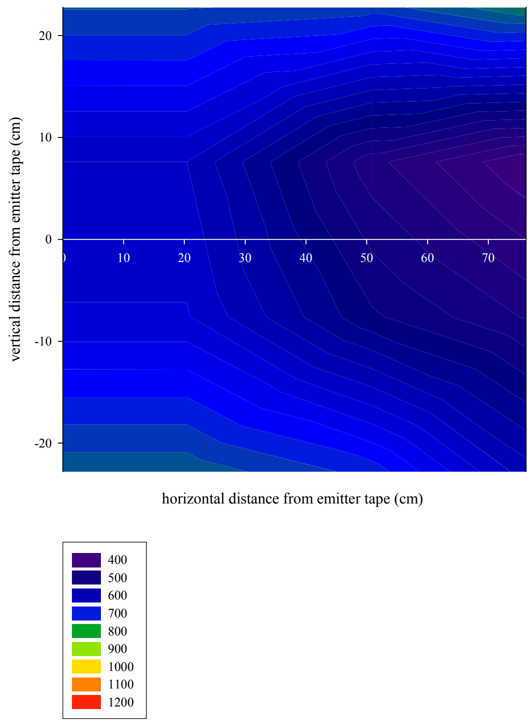
07/23/03 EC (uS/cm) for inlet end of Plot 51
after effluent application



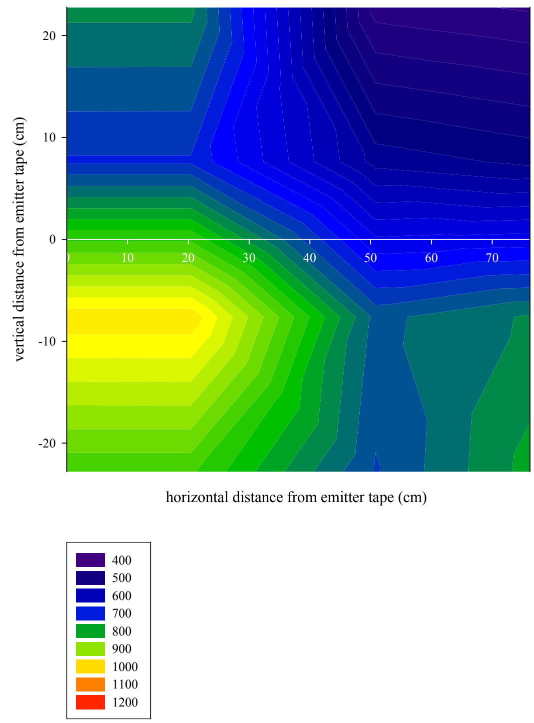
08/05/03 EC (uS/cm) for inlet end of Plot 51
after 4.01 cm rainfall



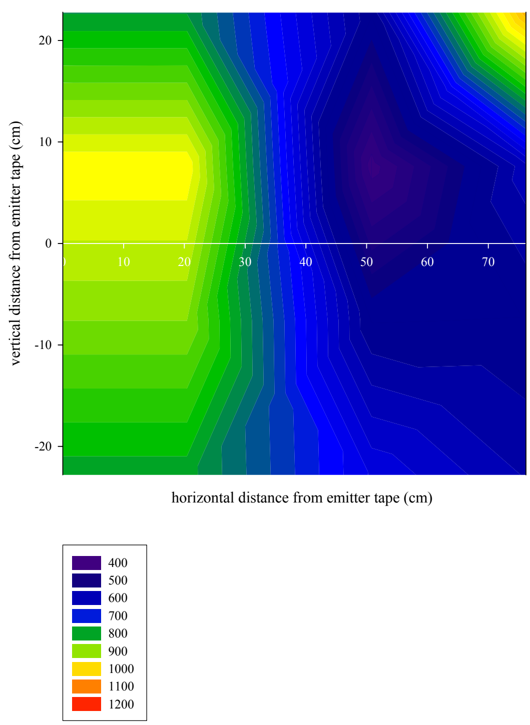
09/09/03 EC (uS/cm) for inlet end of Plot 51
after effluent application



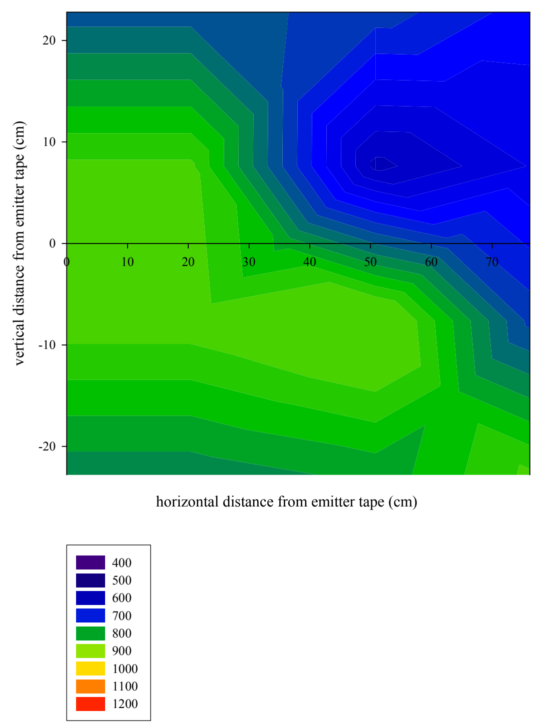
09/26/03 EC (uS/cm) for inlet end of Plot 51
after 3.25 cm rainfall



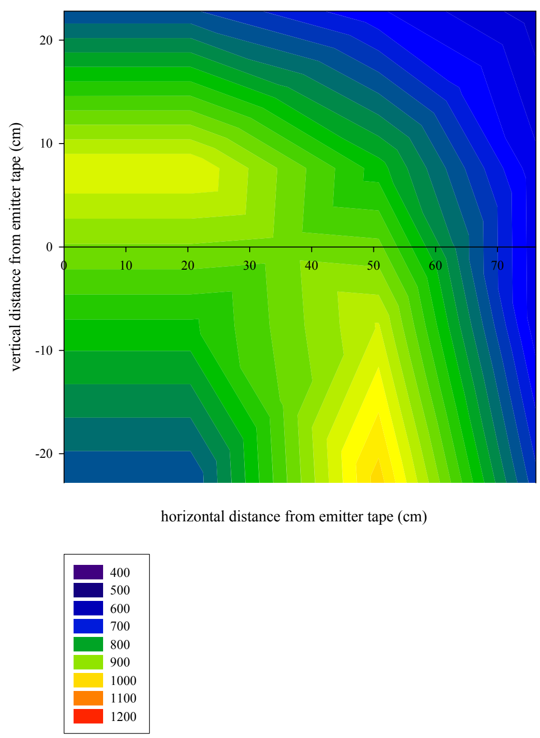
11/10/03 EC (uS/cm) for W 33
after effluent application



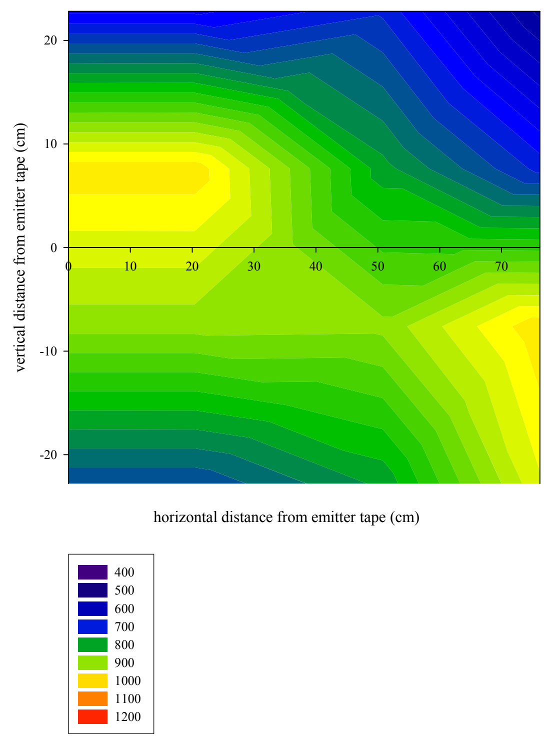
11/21/03 EC (uS/cm) for inlet end of Plot 51
after 3.96 cm rainfall



04/19/04 EC (uS/cm) for inlet end of Plot 51
after effluent application

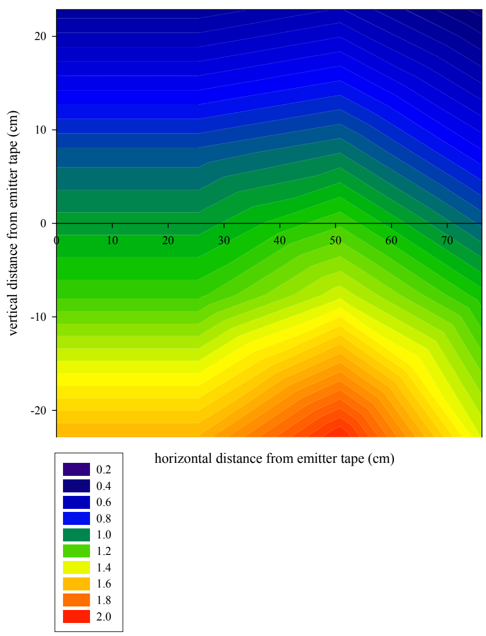


05/10/04 EC (uS/cm) for inlet end of Plot 51
after 1.70 cm rainfall

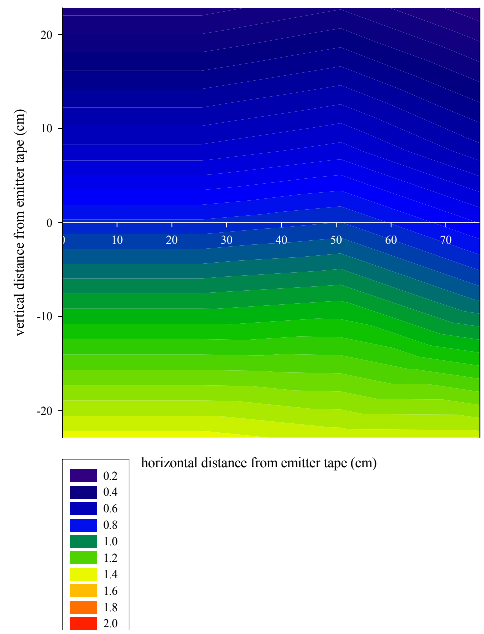


Appendix G: SAR Results for the Distal End of Plot 51

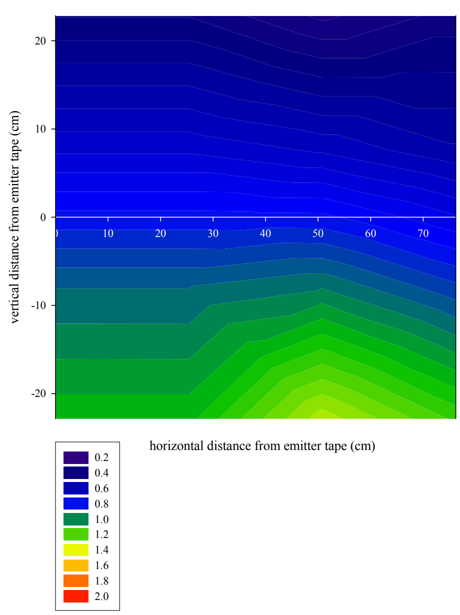
09/09/03 SAR for distal end of Plot 51
after effluent application



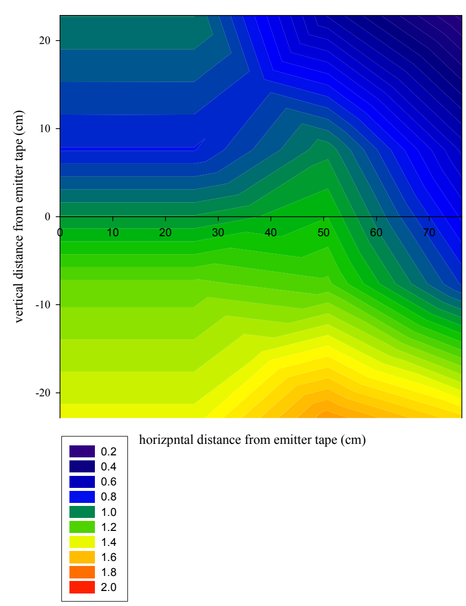
09/26/03 SAR for distal end of Plot 51
after 3.25 cm rainfall



11/10/03 SAR for distal end of Plot 51
after effluent application

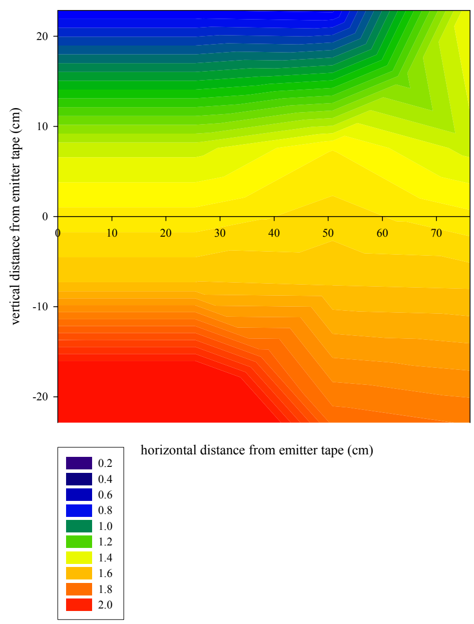


11/21/03 SAR for distal end of Plot 51
after 3.96 cm rainfall

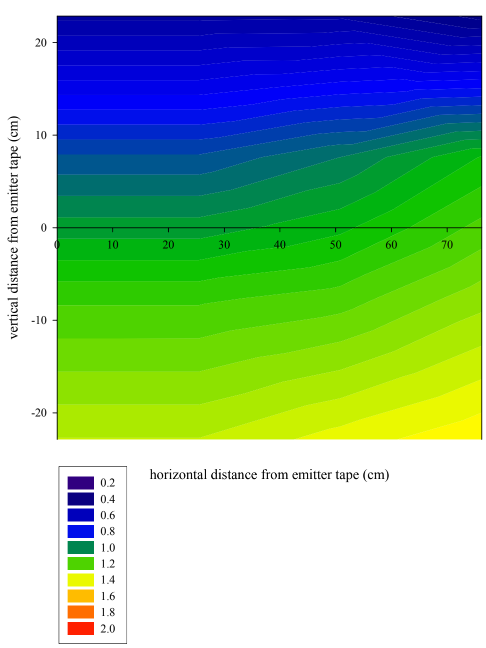


Appendix H: SAR Results for the Inlet End of Plot 51

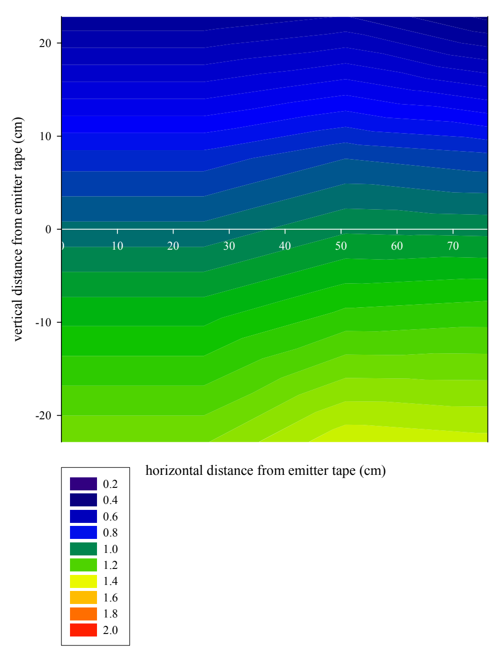
Background SAR for inlet end of Plot 51



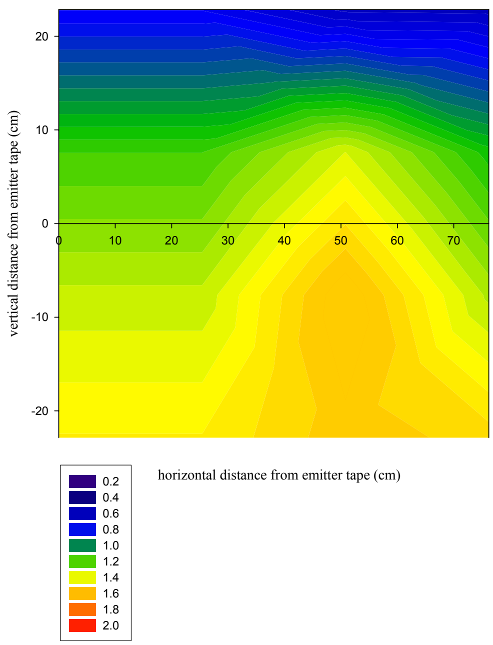
07/23/03 SAR for inlet end of Plot 51
after effluent application



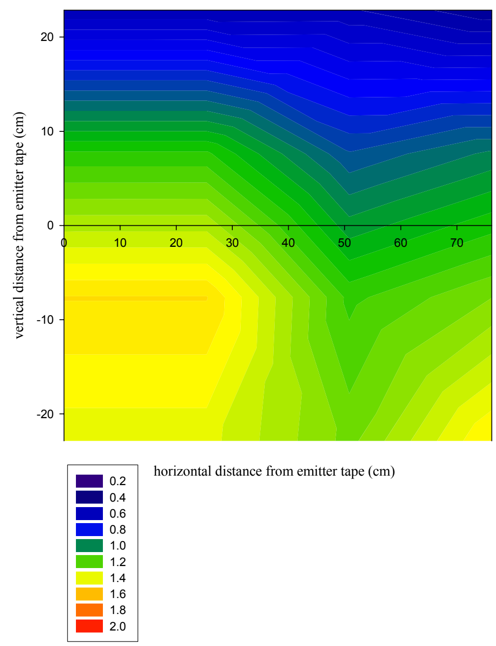
08/05/03 SAR for inlet end of Plot 51
after 4.01 cm rainfall



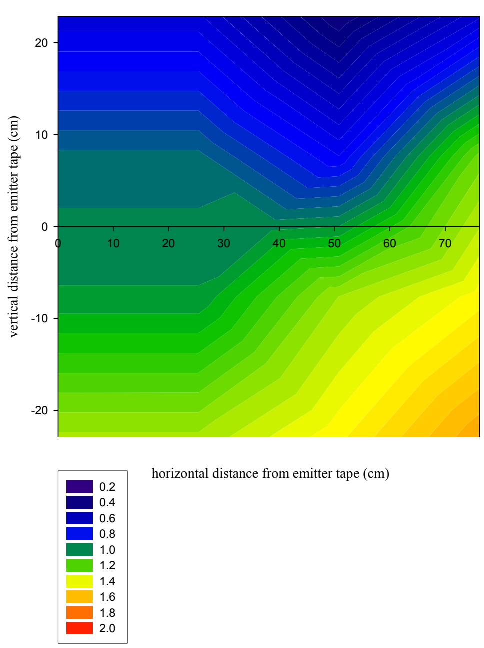
09/09/03 SAR for inlet end of Plot 51
after effluent application



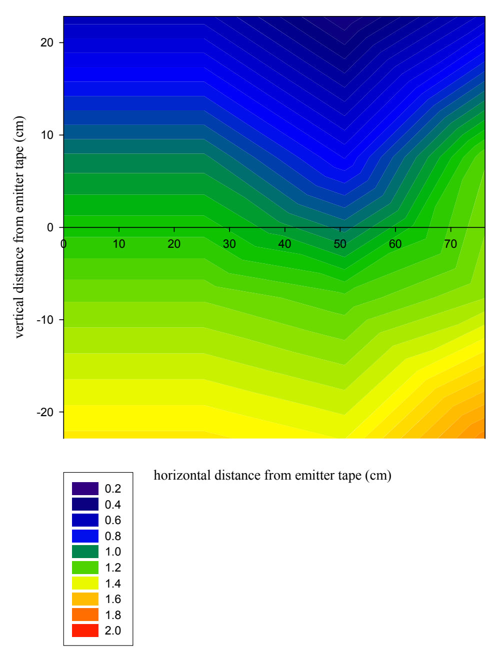
09/26/03 SAR for inlet end of Plot 51
after 3.25 cm rainfall



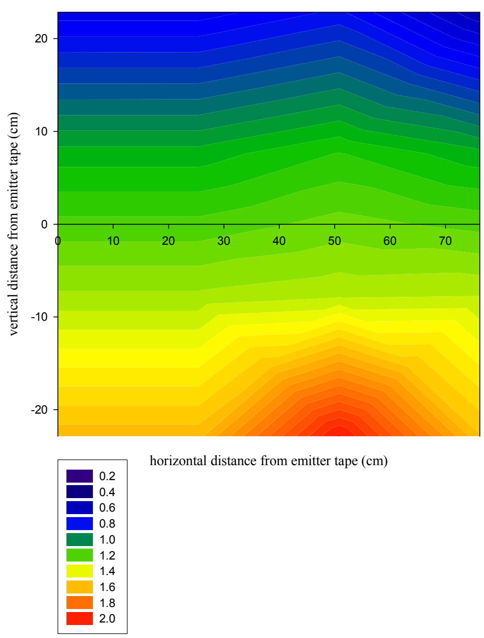
11/10/03 SAR for inlet end of Plot 51
after effluent application



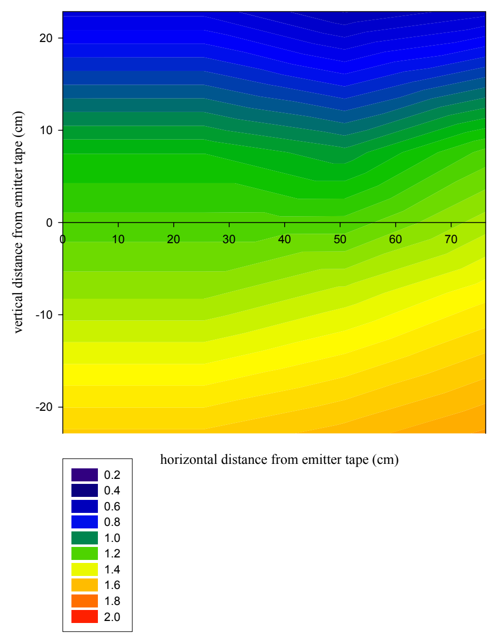
11/21/03 SAR for inlet end of Plot 51
after 3.96 cm rainfall



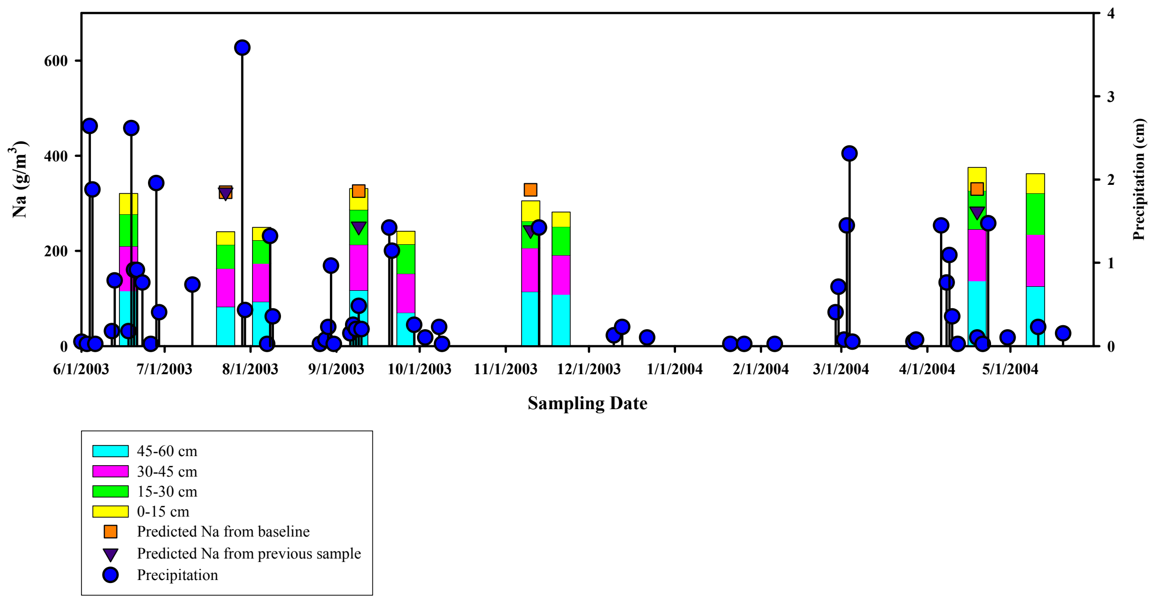
04/19/04 SAR for inlet end of Plot 51
after effluent application



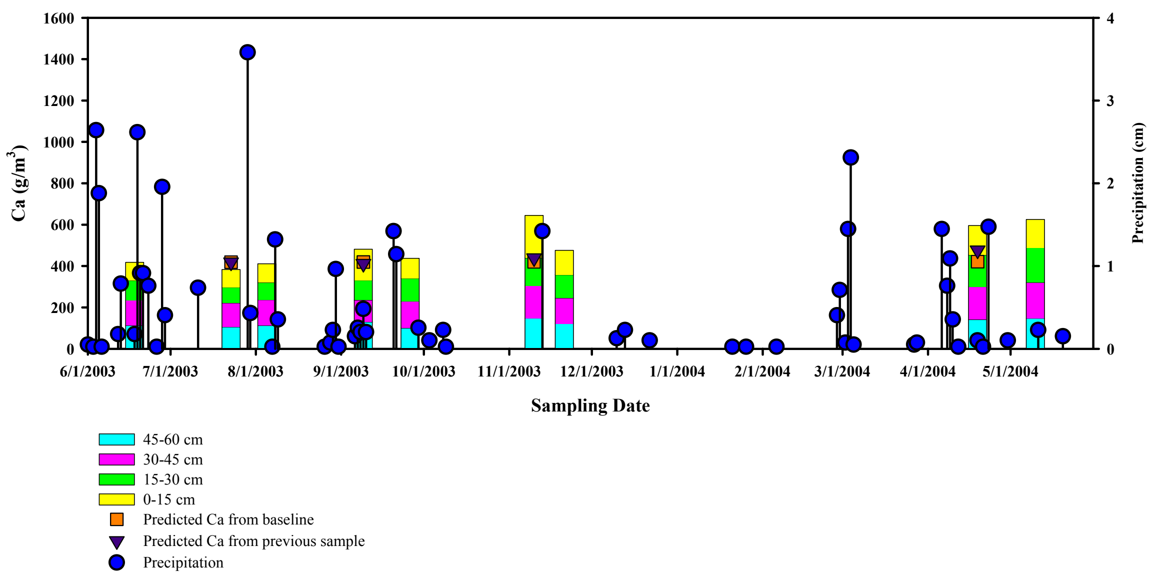
05/10/04 SAR for inlet end of Plot 51
after 1.70 cm rainfall



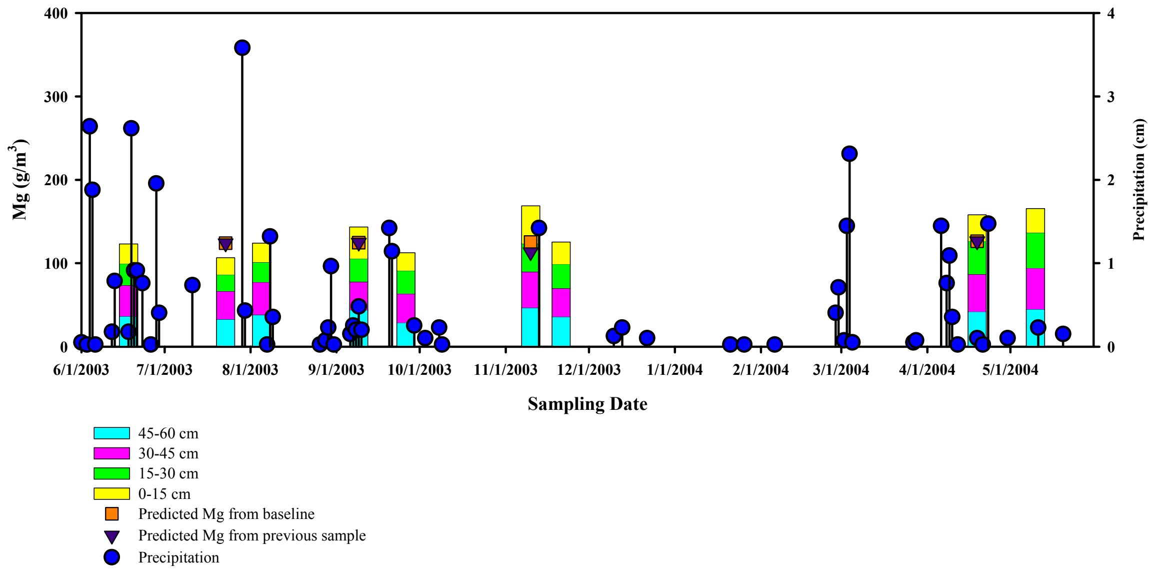
Appendix I: Na Concentrations for the Inlet End of Plot 51



Appendix J: Ca Concentrations for the Inlet End of Plot 51

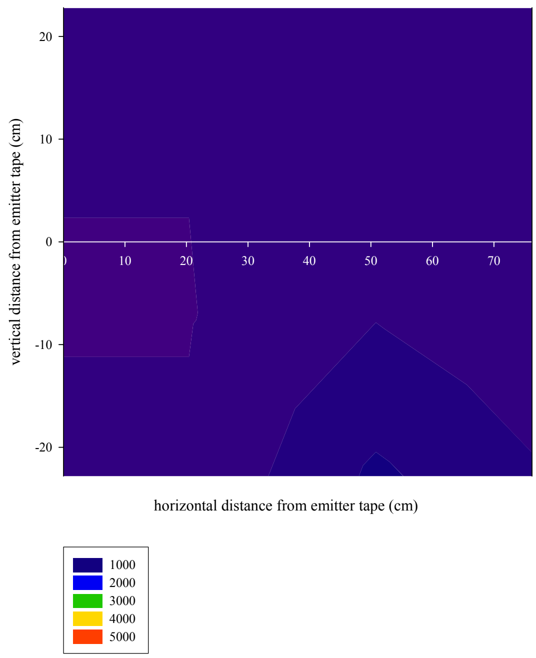


Appendix K: Mg Concentrations for the Inlet End of Plot 51

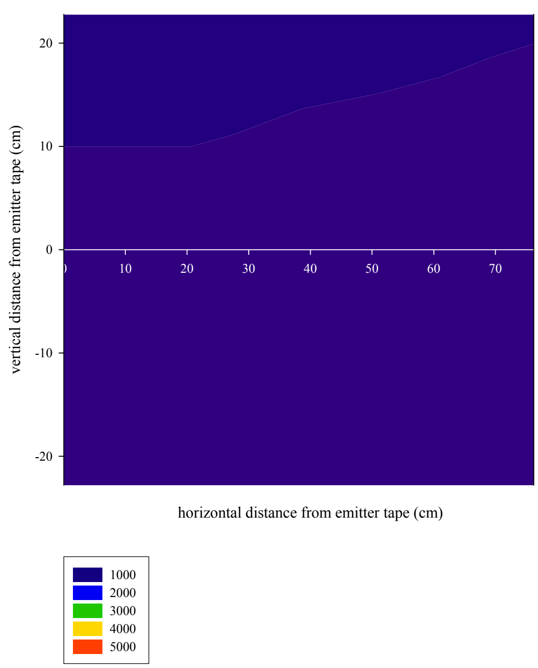


Appendix L: EC Results for the Inlet End of Plot 49-50

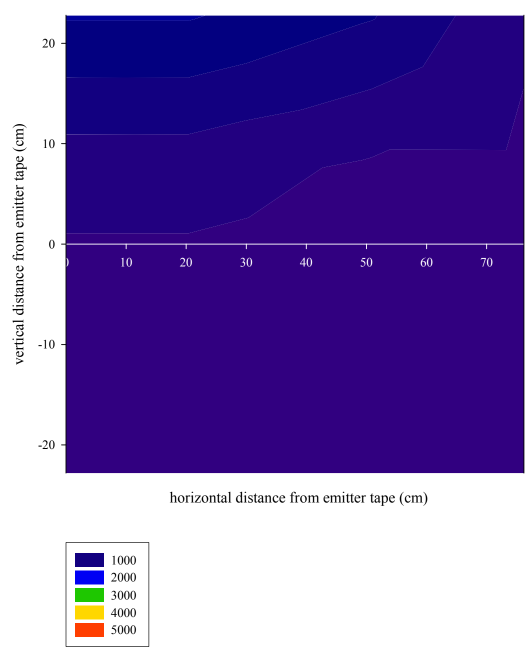
Background EC (uS/cm) for inlet end of Plot 49-50



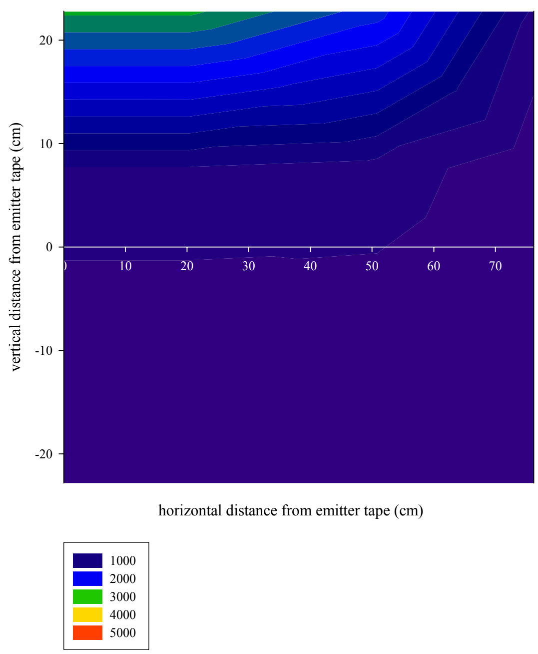
07/23/03 EC (uS/cm) for inlet end of Plot 49-50
after effluent application



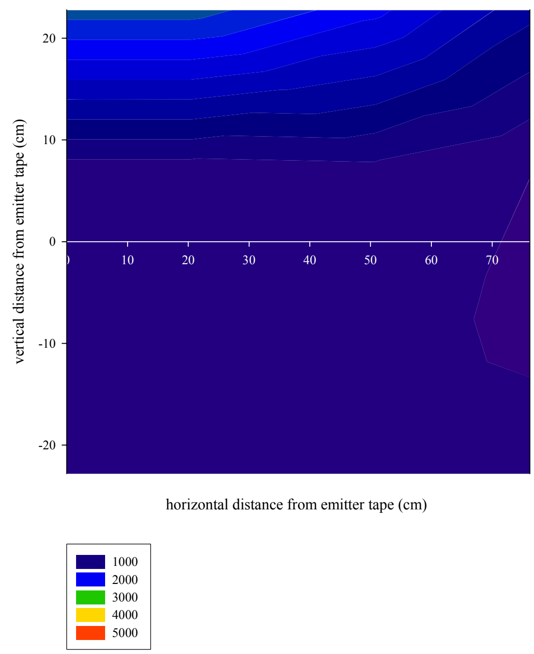
08/05/03 EC (uS/cm) for inlet end of Plot 49-50
after 4.01 cm rainfall



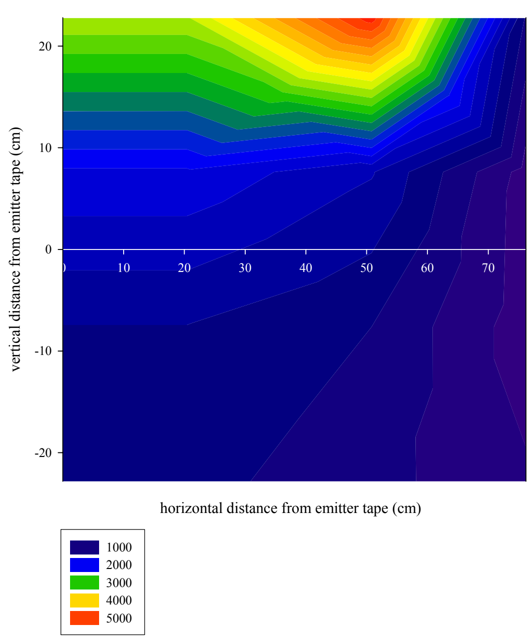
09/09/03 EC (uS/cm) for inlet end of Plot 49-50
after effluent application



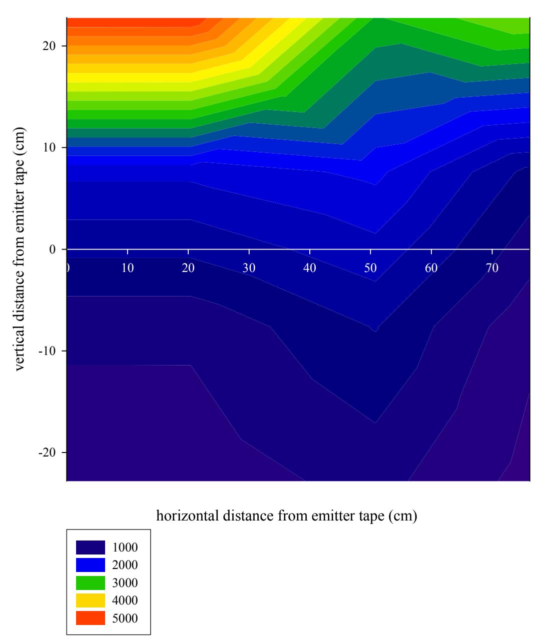
09/26/03 EC (uS/cm) for inlet end of Plot 49-50
after 3.25 cm rainfall



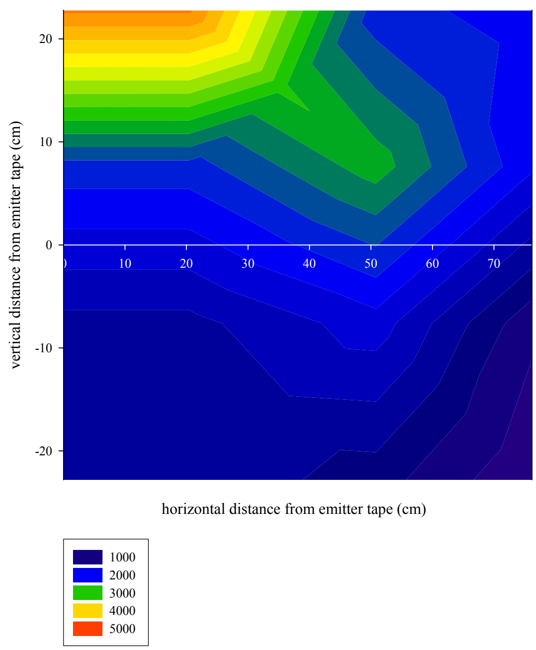
11/10/03 EC (uS/cm) for inlet end of Plot 49-50
after effluent application



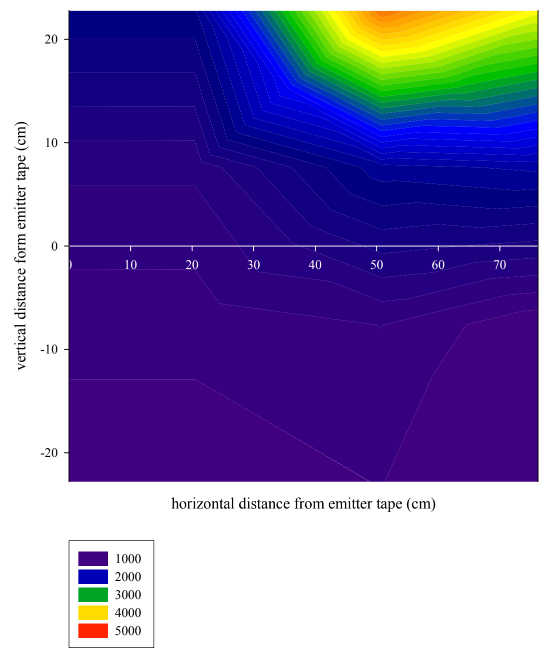
11/21/03 EC (uS/cm) for inlet end of Plot 49-50
after 3.96 cm rainfall



04/19/04 EC (uS/cm) for inlet end of Plot 49-50
after effluent application

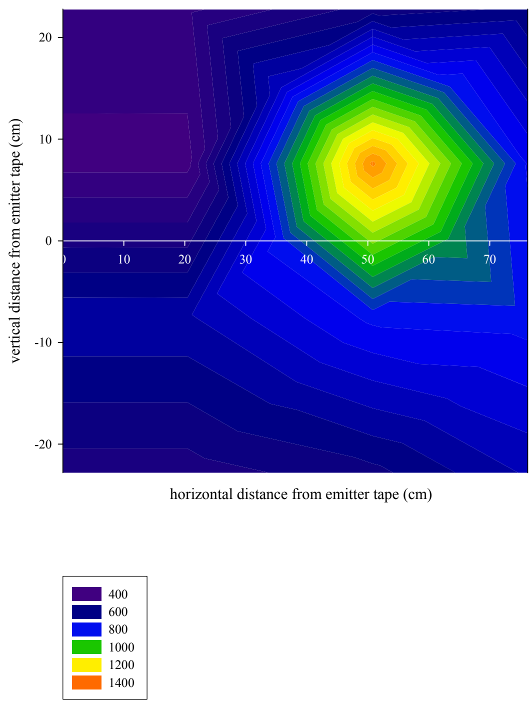


05/10/04 EC (uS/cm) for inlet end of Plot 49-50
after 1.70 cm rainfall

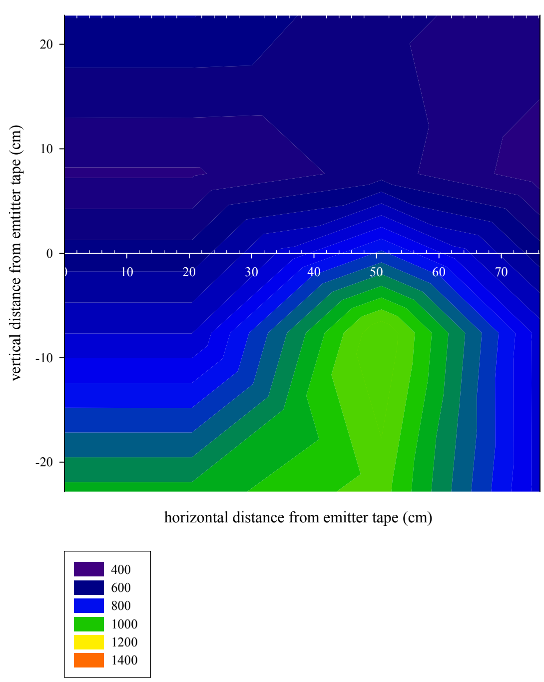


Appendix M: EC Results for the Distal End of Plot 49-50

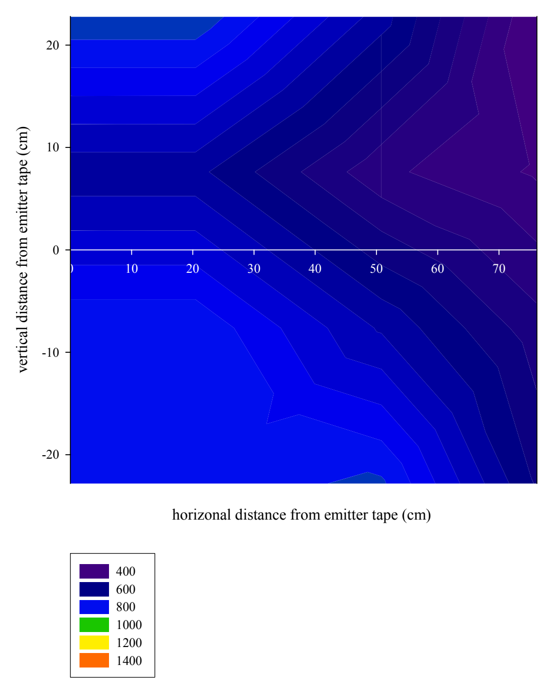
Background EC (uS/cm) for distal end of Plot 49-50



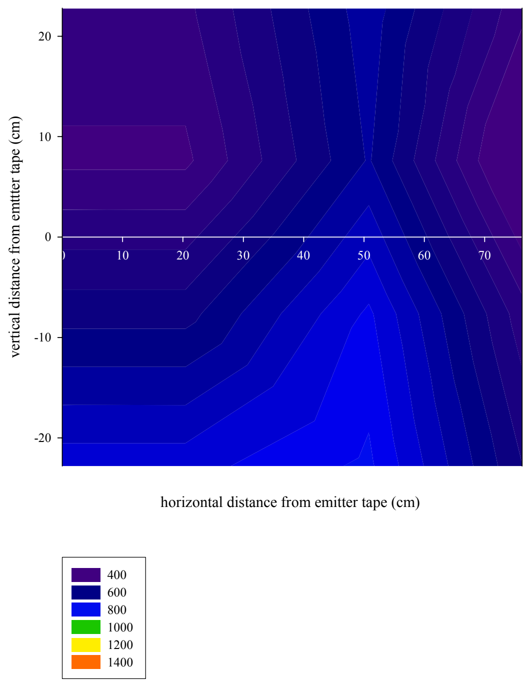
07/23/03 EC (uS/cm) for distal end of Plot 49-50
after effluent application



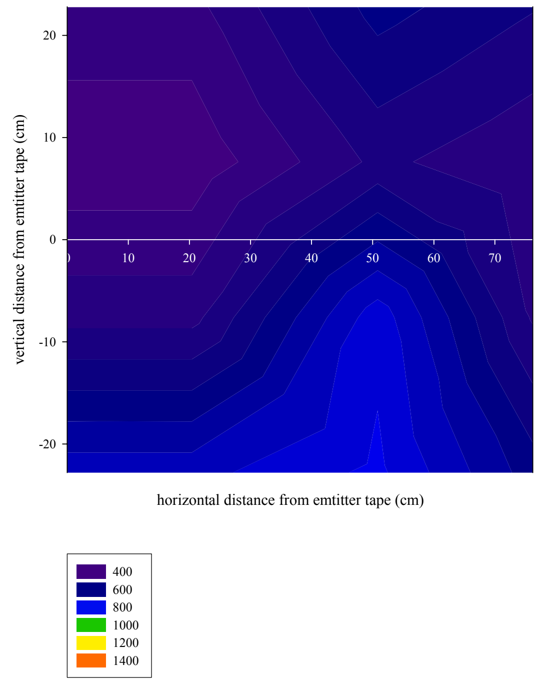
08/05/03 EC (uS/cm) for distal end of Plot 49-50
after 1.5 inch rainfall



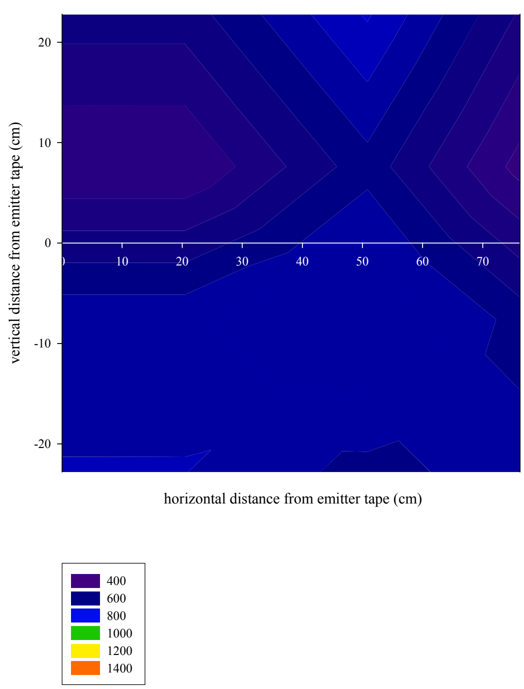
09/09/03 EC (uS/cm) for distal end of Plot 49-50
after effluent application



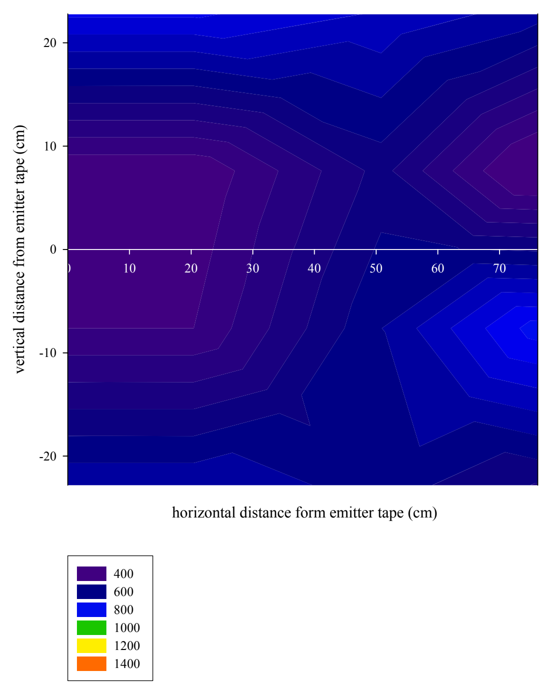
09/26/03 EC (uS/cm) for distal end of Plot 49-50
after 1.25 inch rainfall



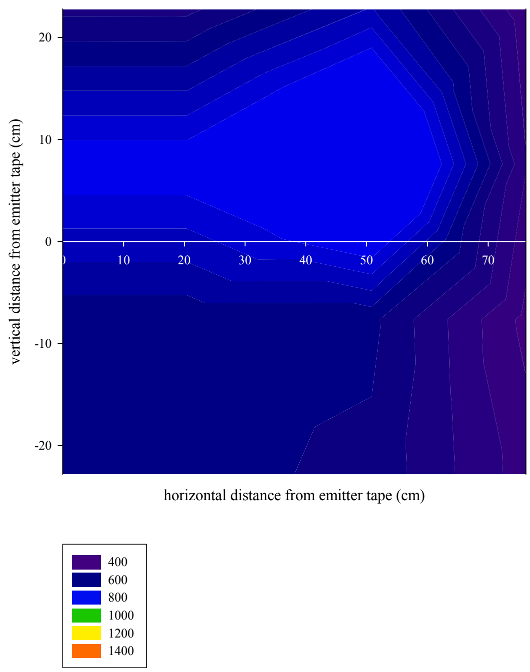
11/10/03 EC (uS/cm) for distal end of Plot 49-50
after effluent application



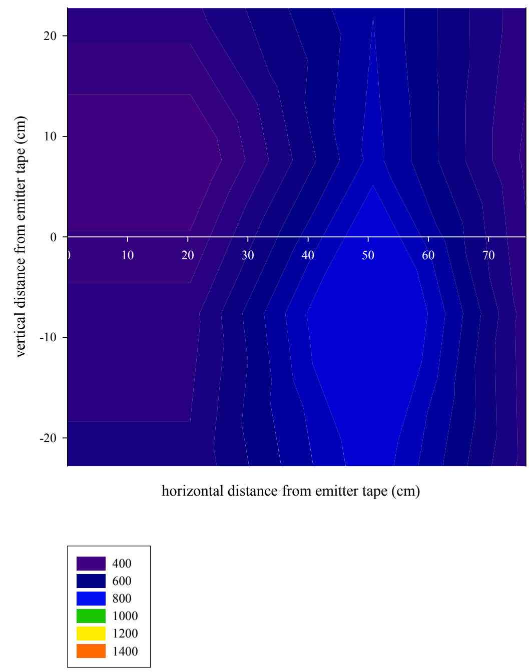
11/21/03 EC (uS/cm) for distal end of Plot 49-50
after 1.0 inch rainfall



04/19/04 EC (uS/cm) for distal end of Plot 49-50
after effluent application

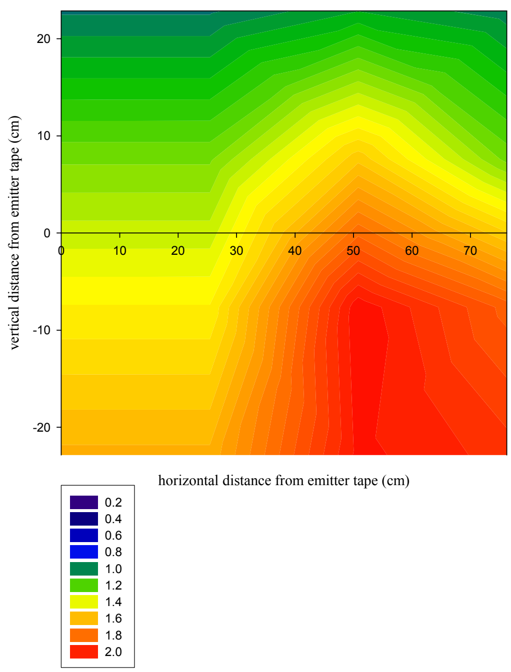


05/10/04 EC (uS/cm) for distal end of Plot 49-50
after 0.6 inch rainfall

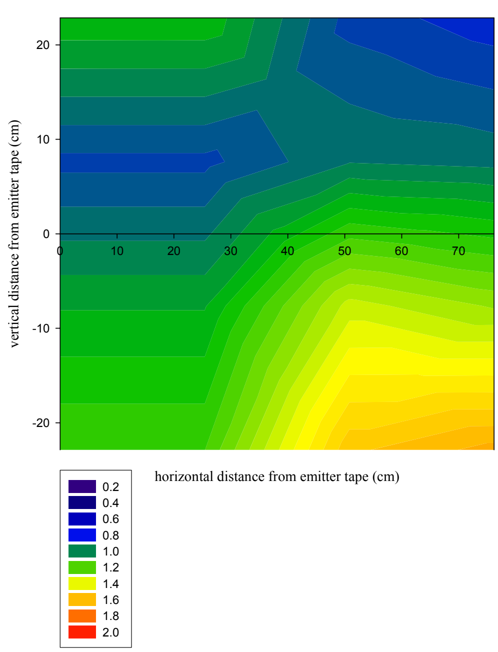


Appendix N: SAR Results for the Inlet End of Plot 49-50

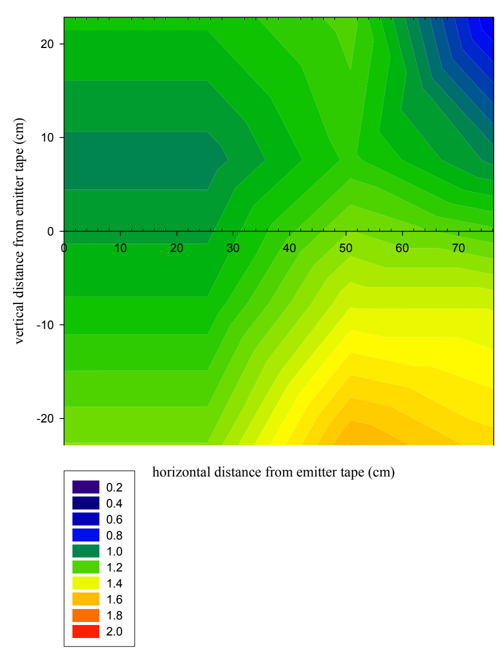
Background SAR for inlet end of Plot 49-50



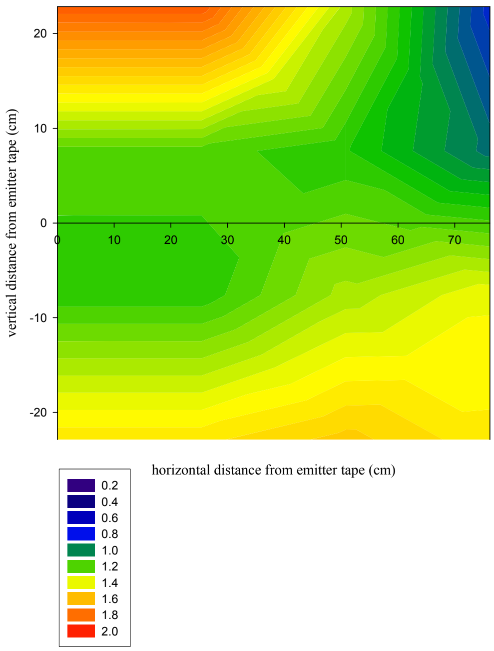
07/23/03 SAR for inlet end of Plot 49-50
after effluent application



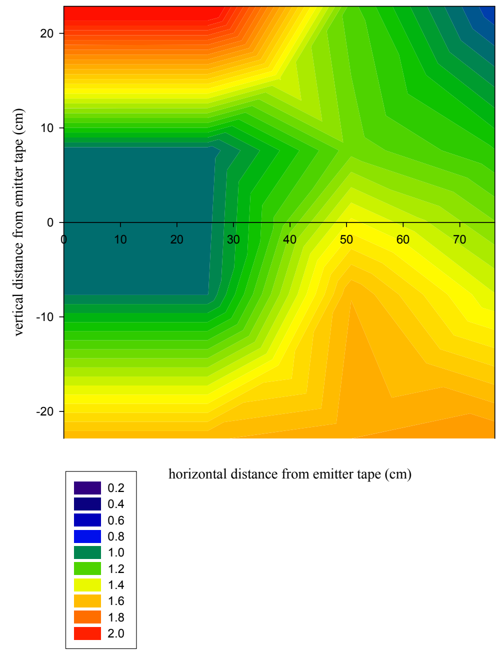
08/05/03 SAR for inlet end of Plot 49-50
after 4.01 cm rainfall



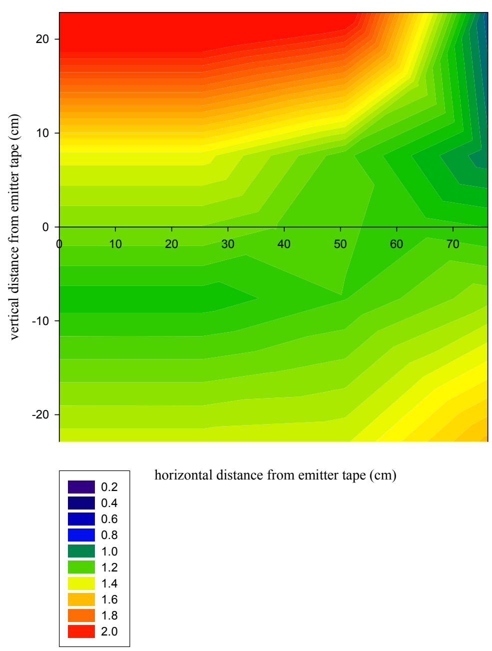
09/09/03 SAR for inlet end of Plot 49-50
after effluent application



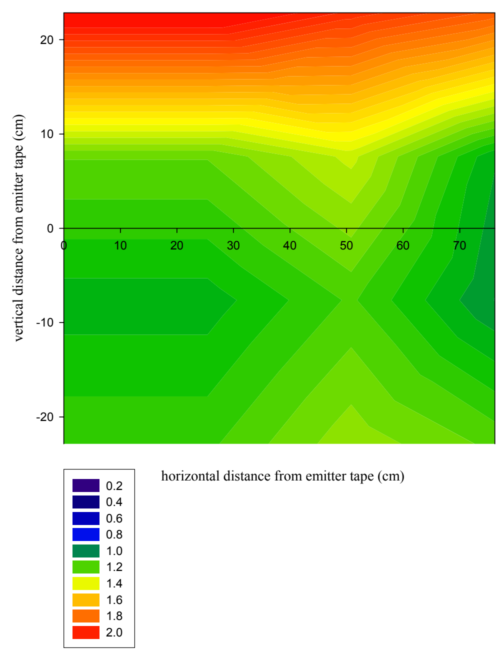
09/26/03 SAR for inlet end of Plot 49-50
after 3.25 cm rainfall



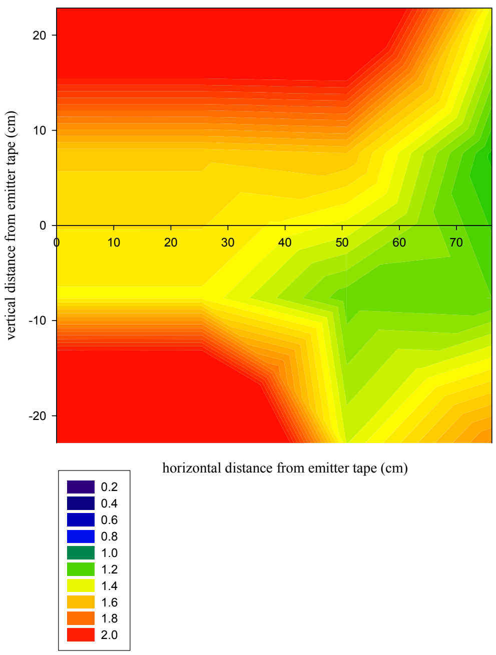
11/10/03 SAR for inlet end of Plot 49-50
after effluent application



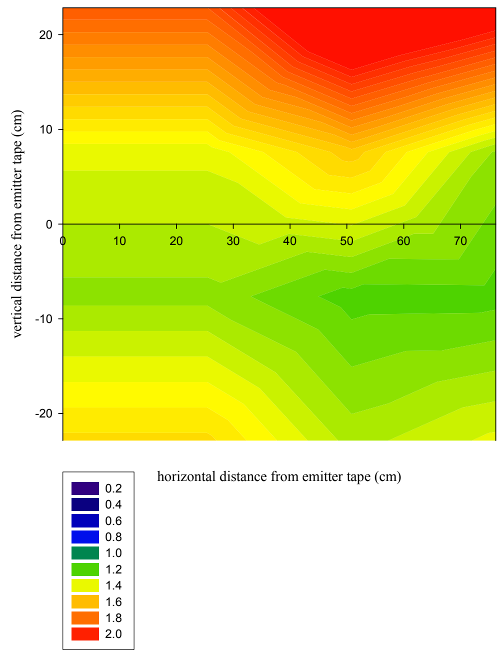
11/21/03 SAR for inlet end of Plot 49-50
after 3.96 cm rainfall



04/19/04 SAR for inlet end of Plot 49-50
after effluent application

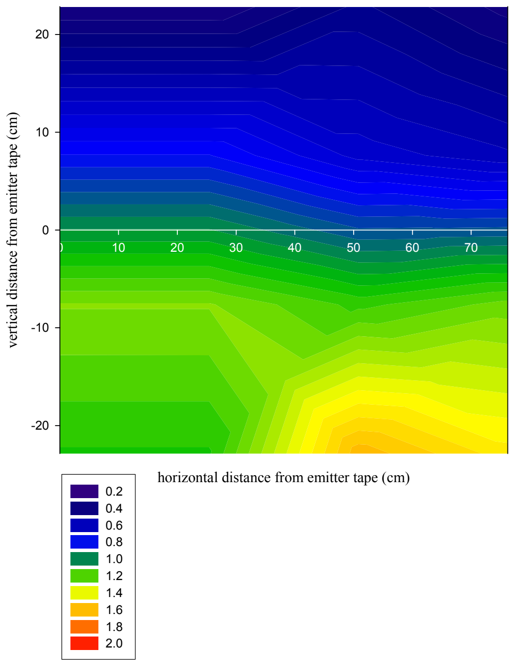


05/10/03 SAR for inlet end of Plot 49-50
after 1.70 cm rainfall

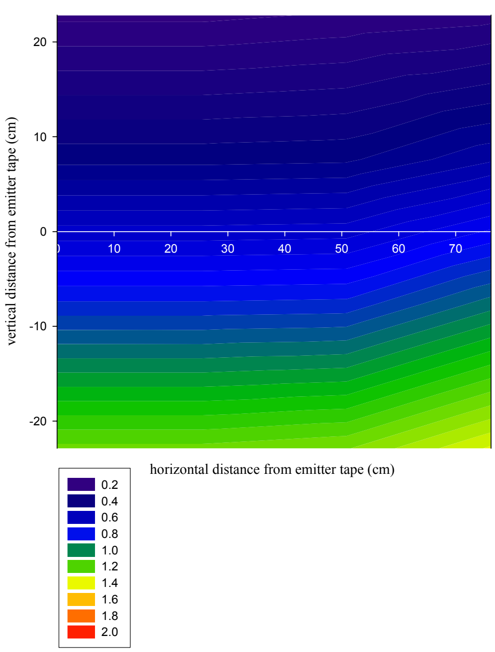


Appendix O: SAR Results for the Distal End of Plot 49-50

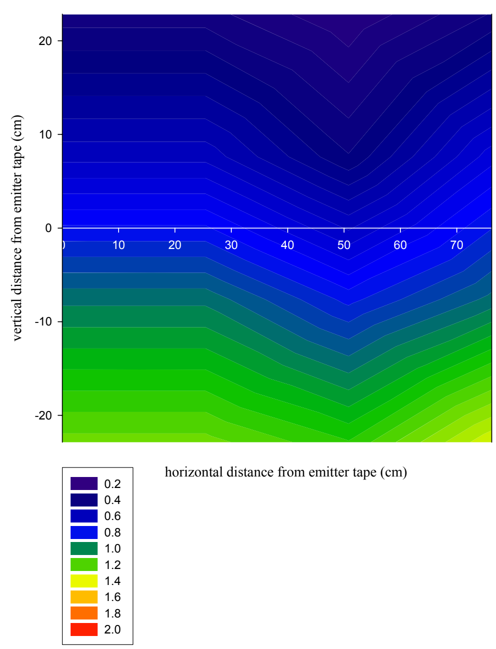
Background SAR for distal end of Plot 49-50



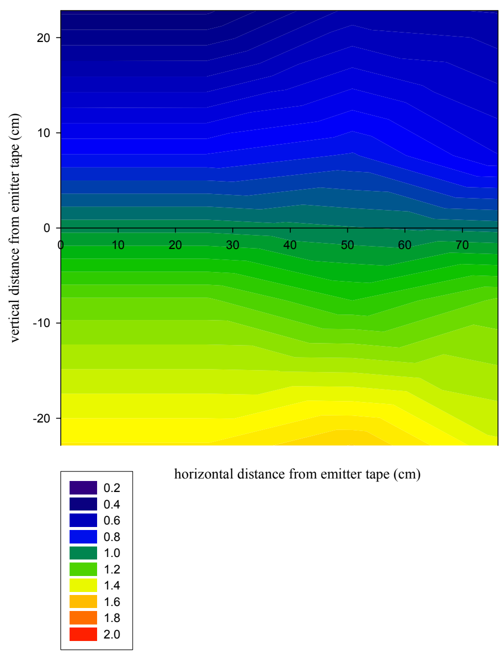
07/23/03 SAR for distal end of Plot 49-50
after effluent application



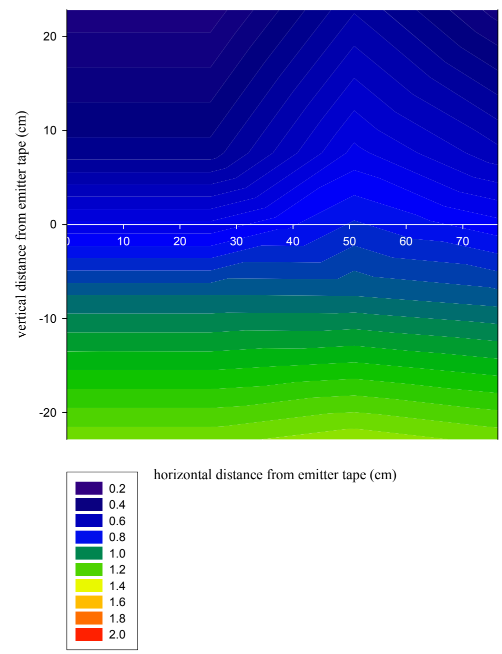
08/05/03 SAR for distal end of Plot 49-50
after 4.01 cm rainfall



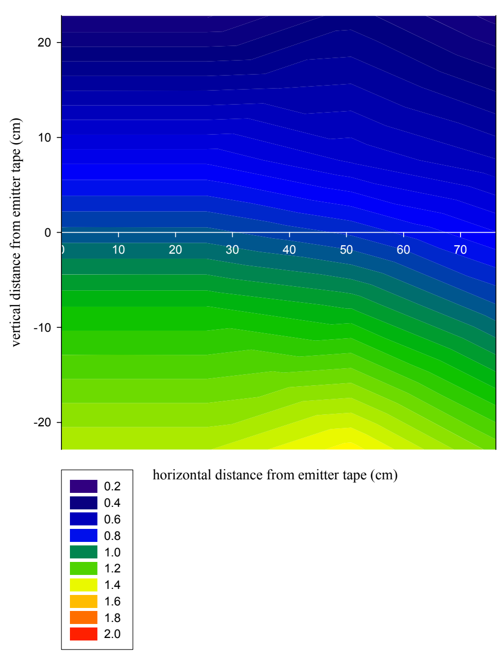
09/09/03 SAR for distal end of Plot 49-50
after effluent application



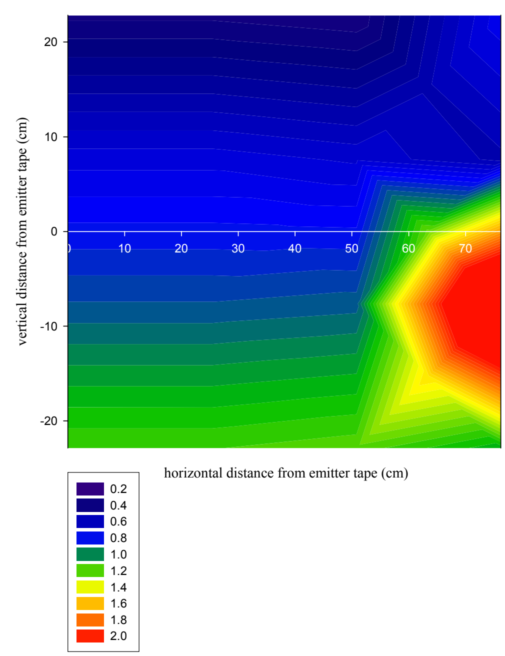
09/26/03 SAR for distal end of Plot 49-50
after 3.25 cm rainfall



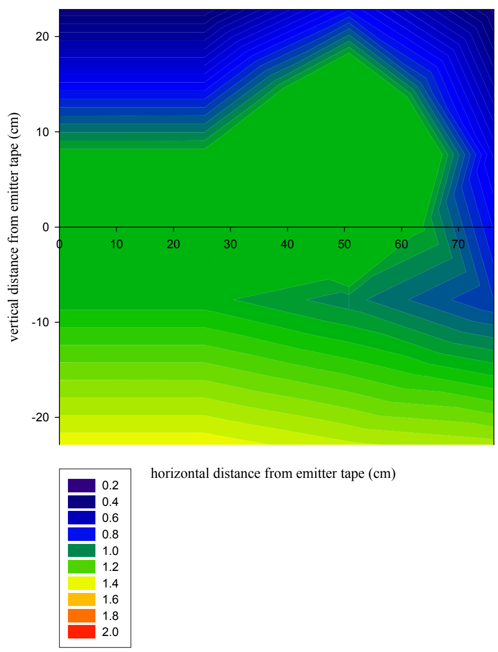
11/10/03 SAR for distal end of Plot 49-50
after effluent application



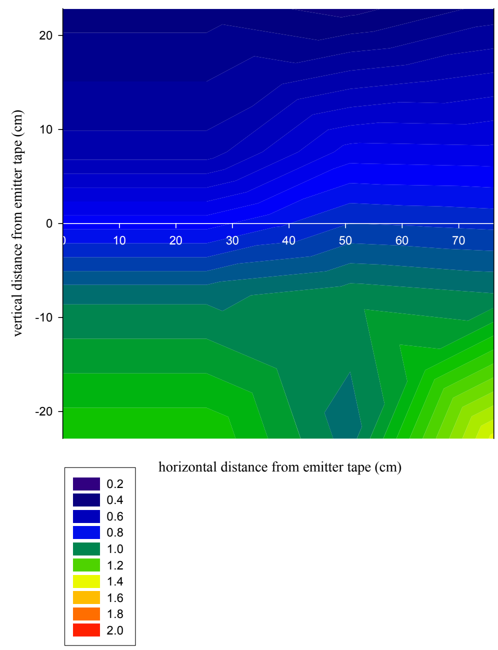
11/21/03 SAR for distal end of Plot 49-50
after 3.96 cm rainfall



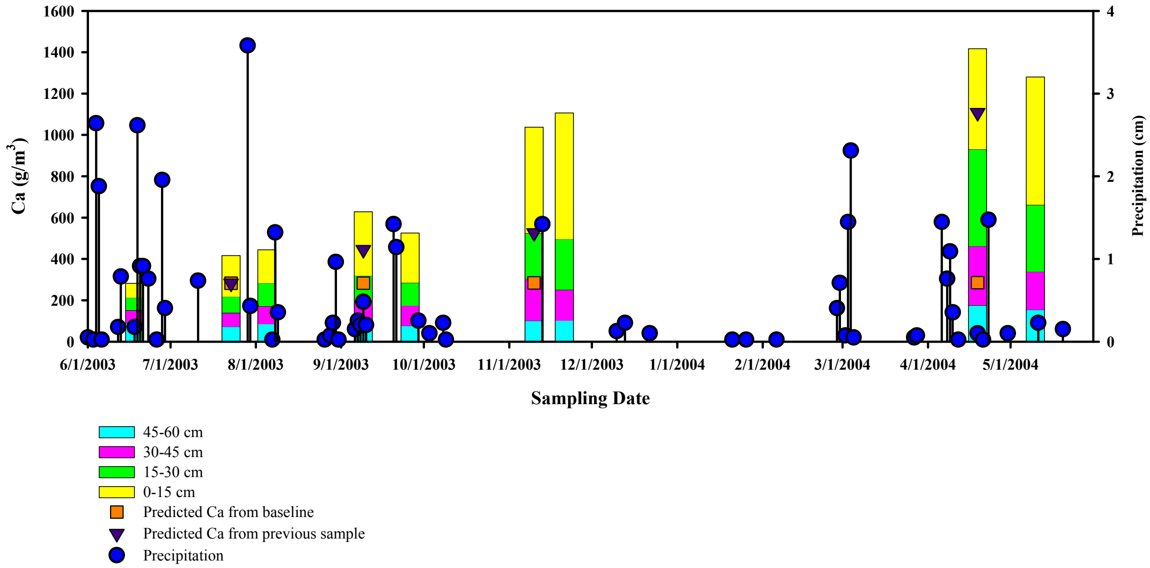
04/19/04 SAR for distal end of Plot 49-50
after effluent application



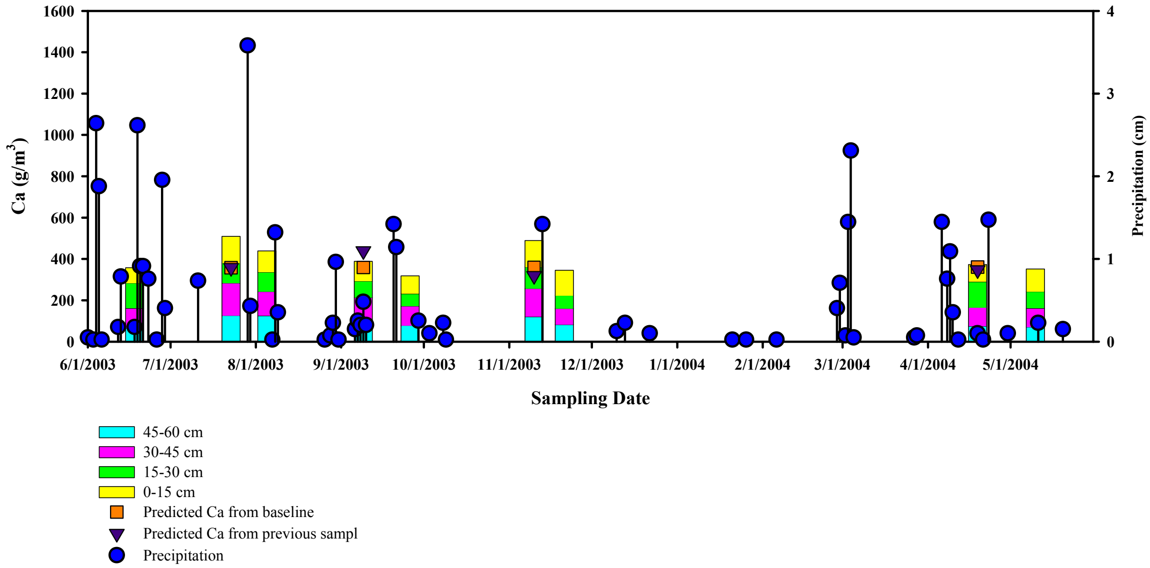
05/10/04 SAR for distal end of Plot 49-50
after 1.70 cm rainfall



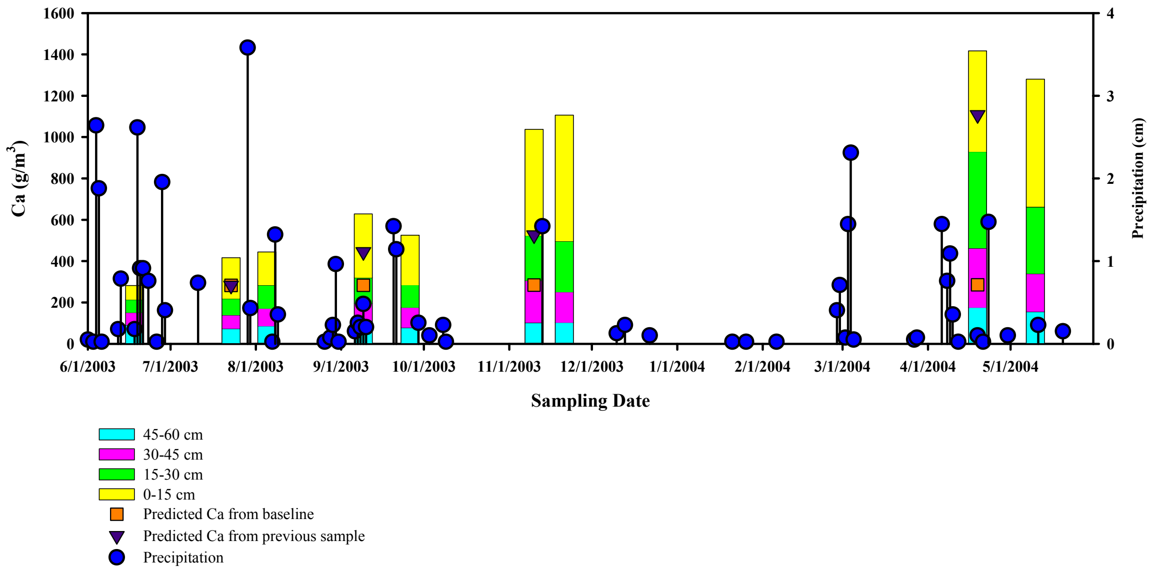
Appendix P: Na Concentrations for the Inlet End of Plot 49-50



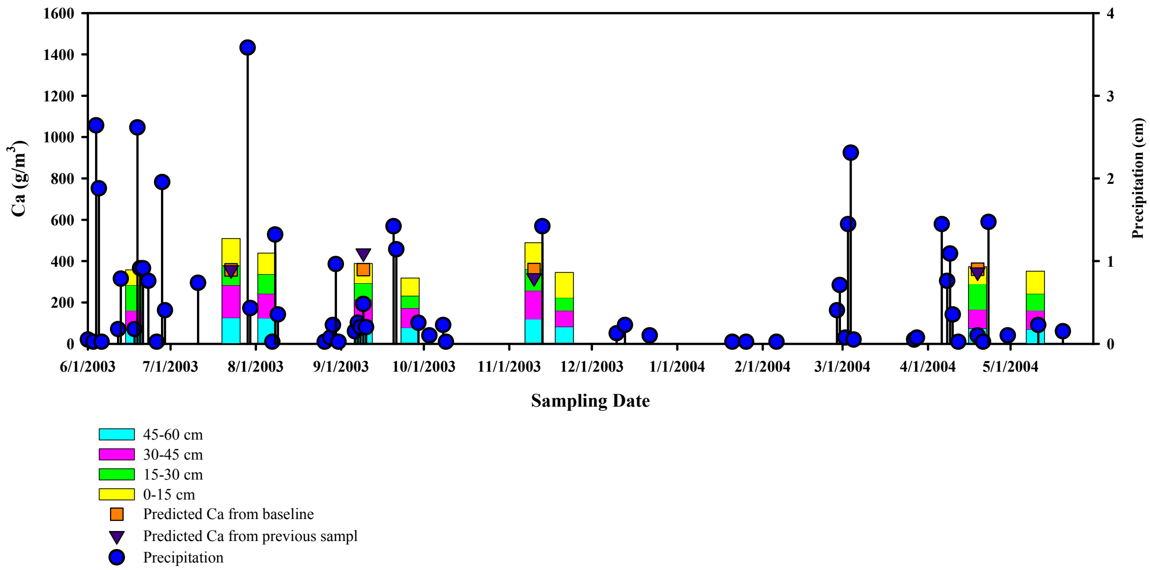
Appendix Q: Na Concentrations for the Distal End of Plot 49-50



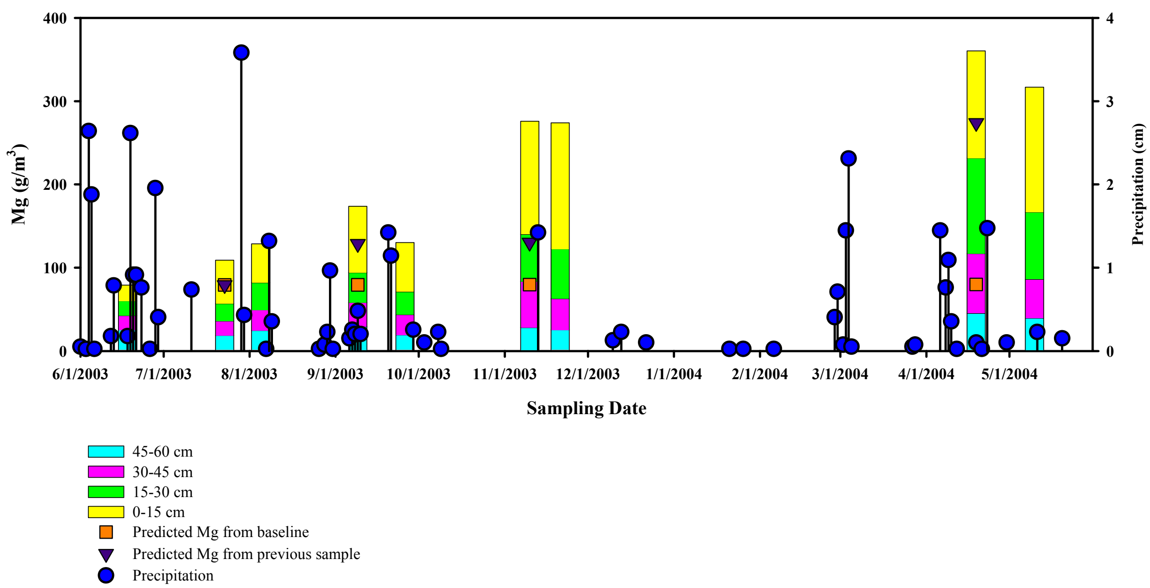
Appendix R: Ca Concentrations for the Inlet End of Plot 49-50



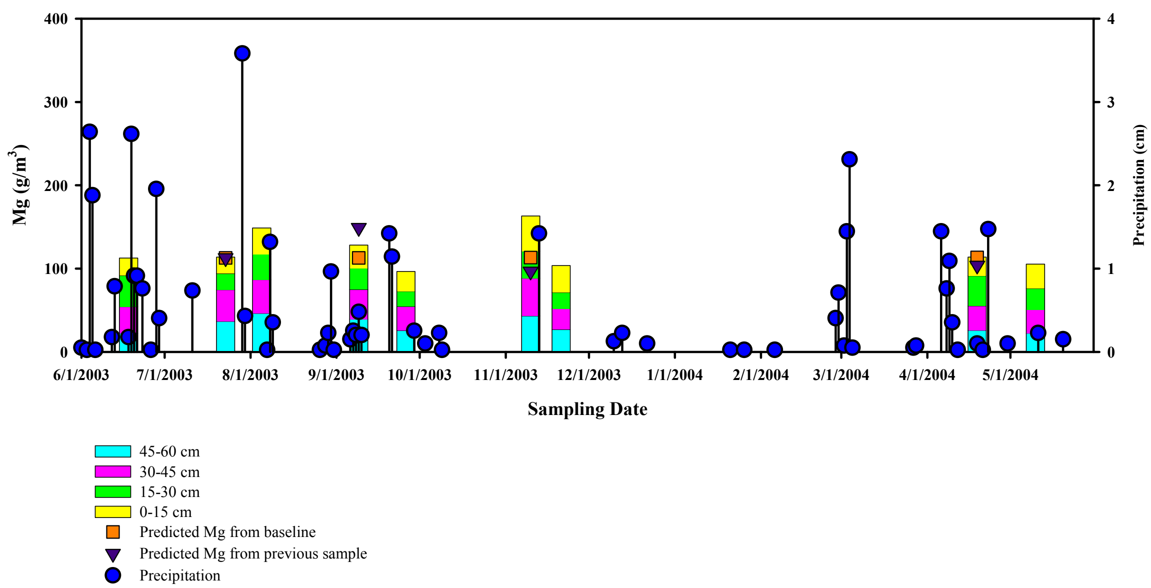
Appendix S: Ca Concentrations for the Distal End of Plot 49-50



Appendix T: Mg Concentrations for the Inlet End of Plot 49-50

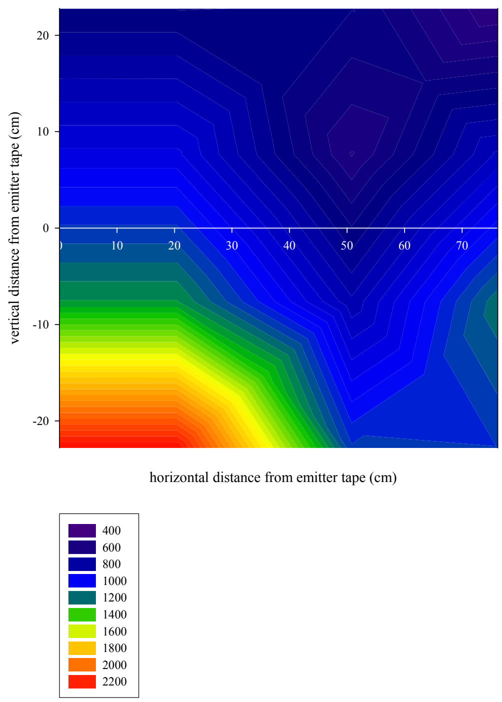


Appendix U: Mg Concentrations for the Distal End of Plot 49-50

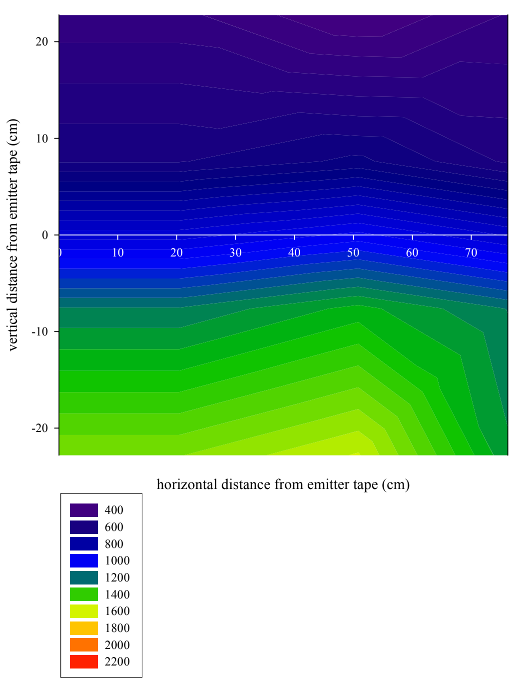


Appendix V: EC Results for the Inlet End of Plot 53

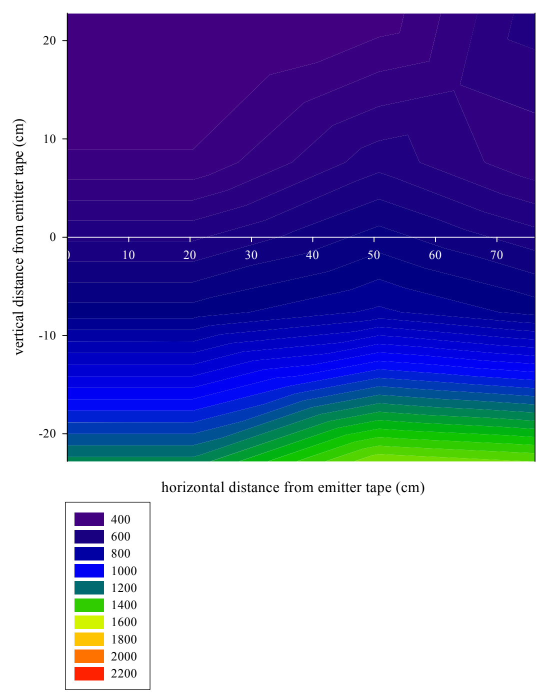
Background EC (uS/cm) for inlet end of Plot 53



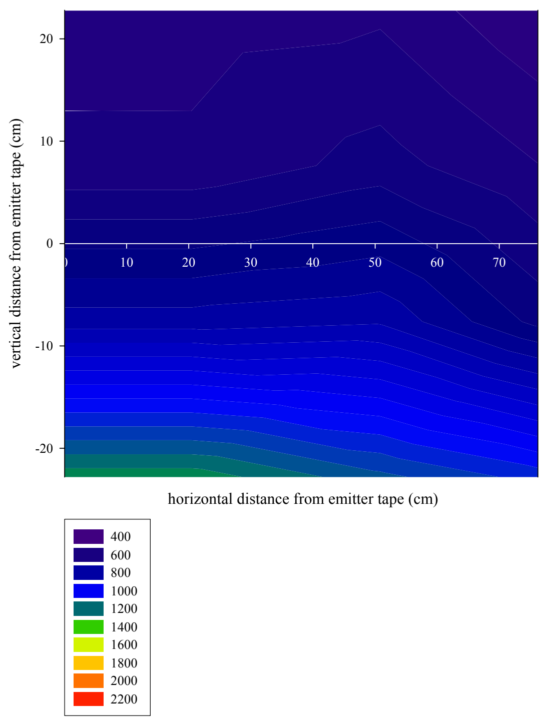
07/23/03 EC (uS/cm) for inlet end of Plot 53
after effluent application



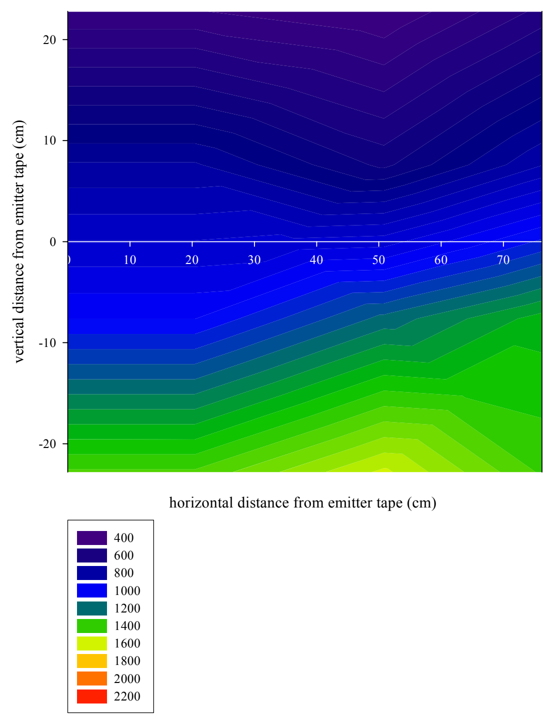
08/05/03 EC (uS/cm) for inlet end of Plot 53
after 4.01 cm rainfall



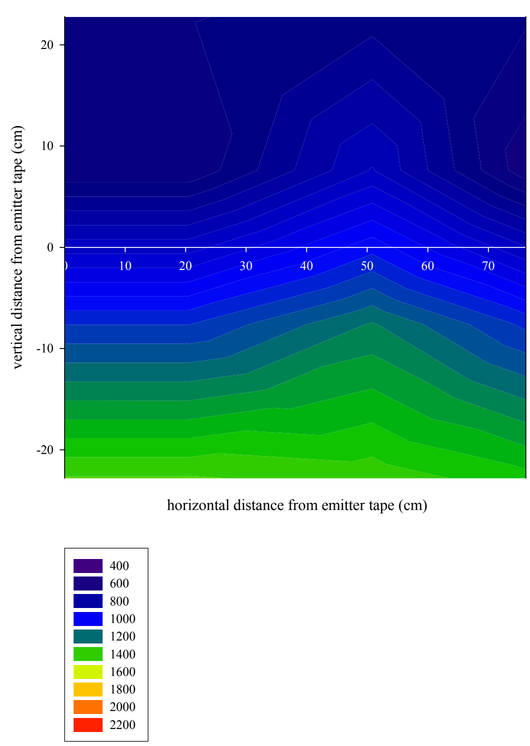
09/09/03 EC (uS/cm) for inlet end of Plot 53
after effluent application



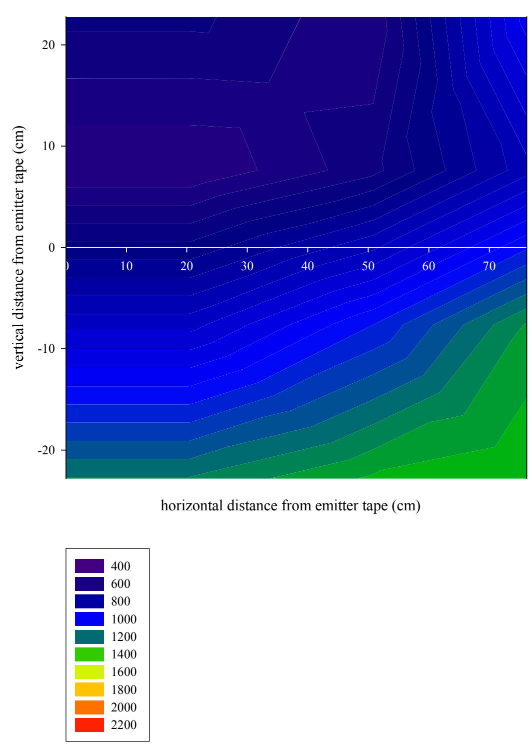
09/26/03 EC (uS/cm) for inlet end of Plot 53
after 3.25 cm rainfall



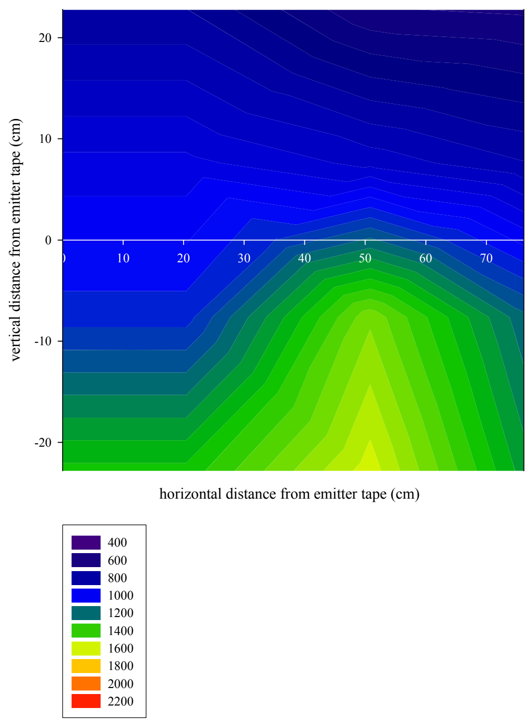
11/10/03 EC (uS/cm) for inlet end of Plot 53
after effluent application



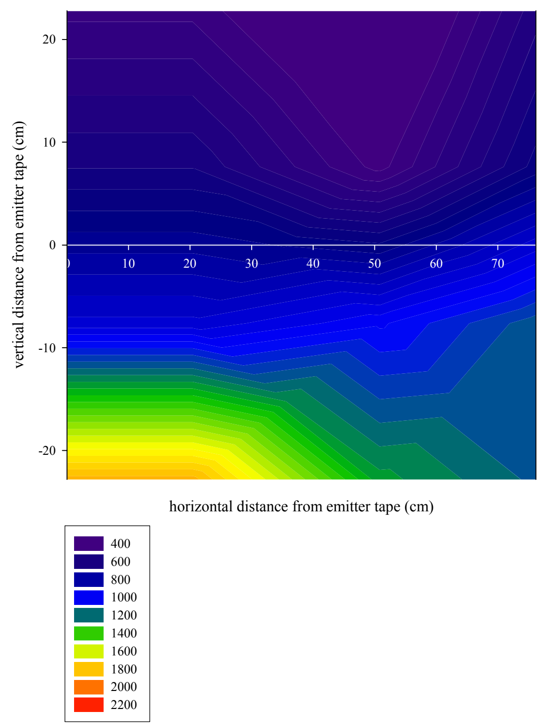
11/21/03 EC (uS/cm) for inlet end of Plot 53
after 3.96 cm rainfall



04/19/04 EC (uS/cm) for inlet end of Plot 53
after effluent application

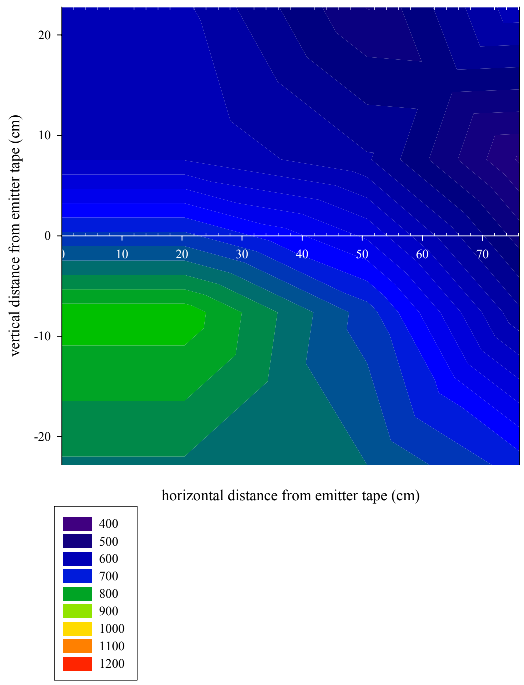


05/10/04 EC (uS/cm) for inlet end of Plot 53
after 1.70 cm rainfall

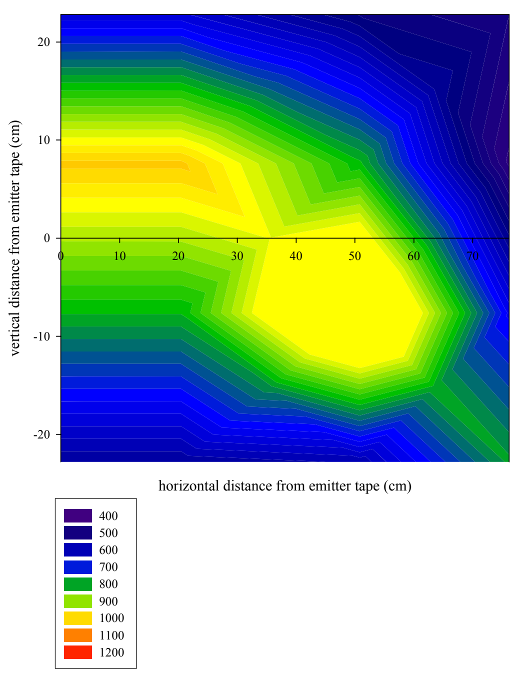


Appendix W: EC Results for the Distal End of Plot 53

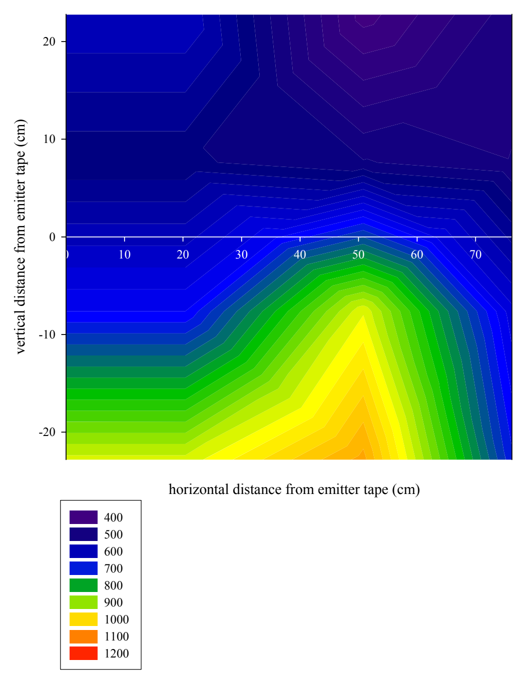
Background EC (uS/cm) for distal end of Plot 53



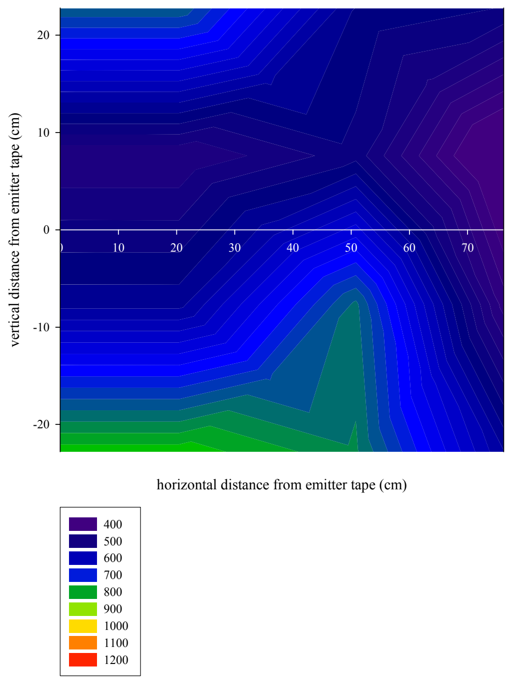
07/23/03 EC (uS/cm) for distal end of Plot 53
after effluent application



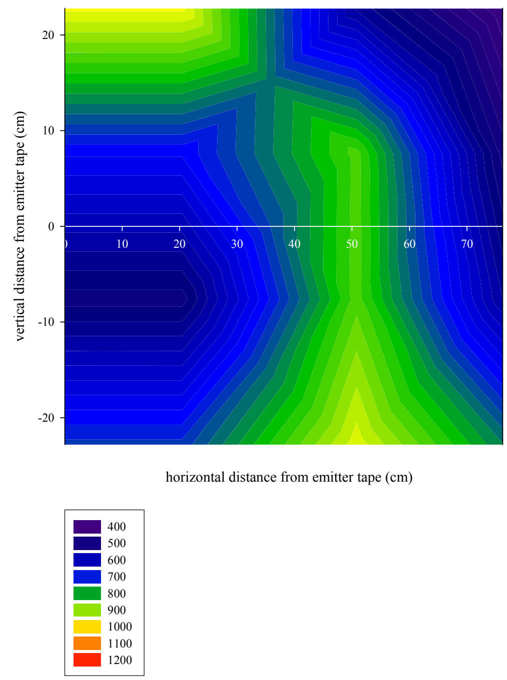
08/05/03 EC (uS/cm) for distal end of Plot 53
after 4.01 cm rain



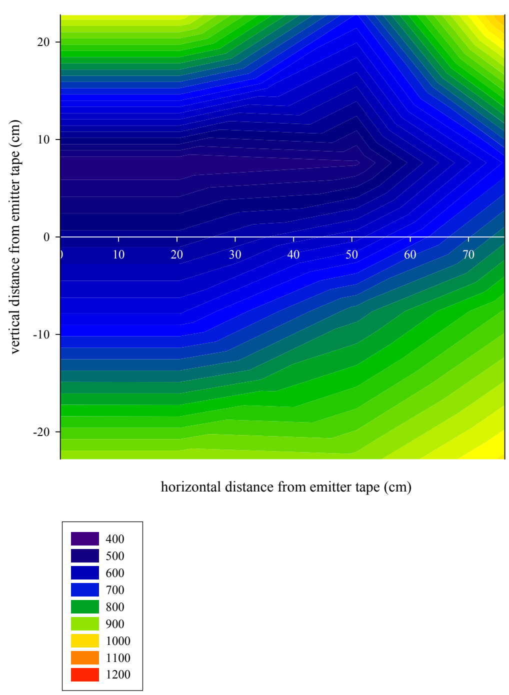
09/09/03 EC (uS/cm) for distal end of Plot 53
after effluent application



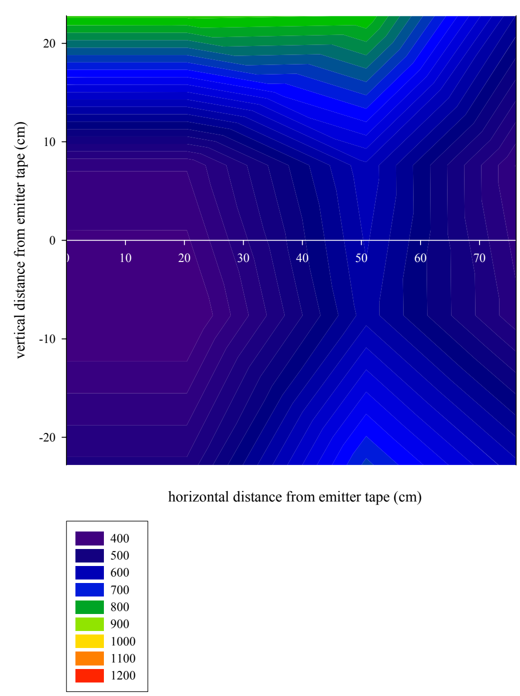
09/26/03 EC (uS/cm) for distal end of Plot 53
after 3.25 cm rainfall



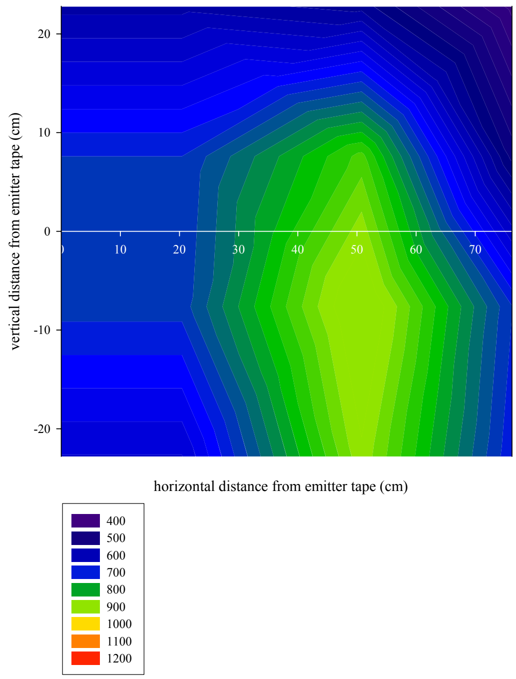
11/10/03 EC (uS/cm) for distal end of Plot 53
after effluent application



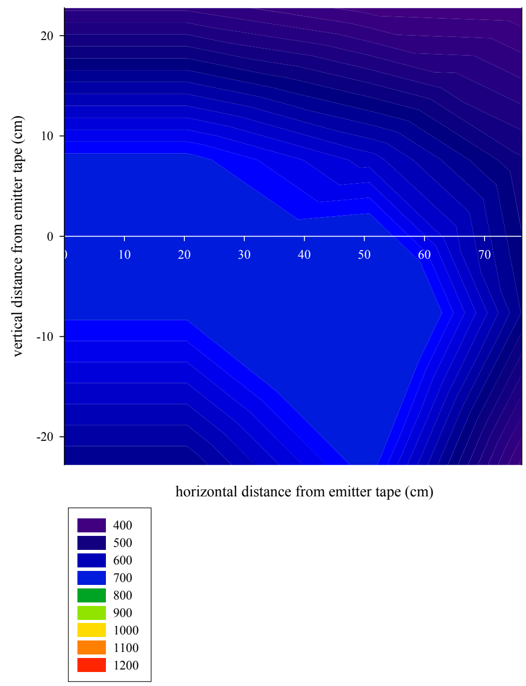
11/21/03 EC (uS/cm) for distal end of Plot 53
after 3.96 cm rainfall



04/19/04 EC (uS/cm) for distal end of Plot 53
after effluent application

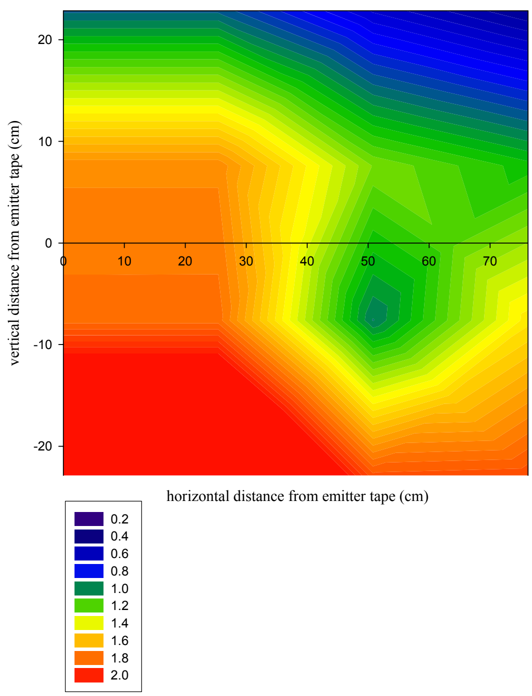


05/10/04 EC (uS/m) for distal end of Plot 53
after 1.70 cm rainfall

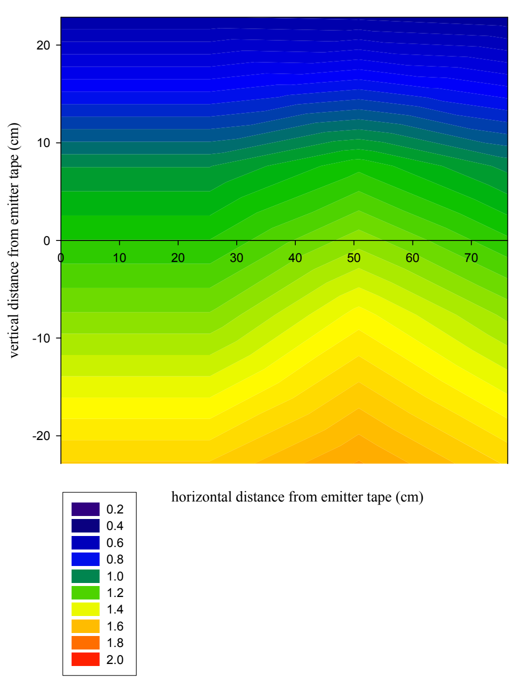


Appendix X: SAR Results for the Inlet End of Plot 53

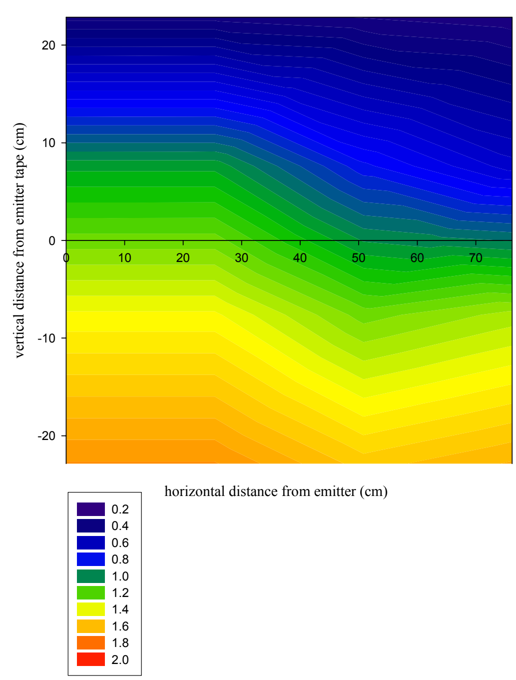
Background SAR for inlet end of Plot 53



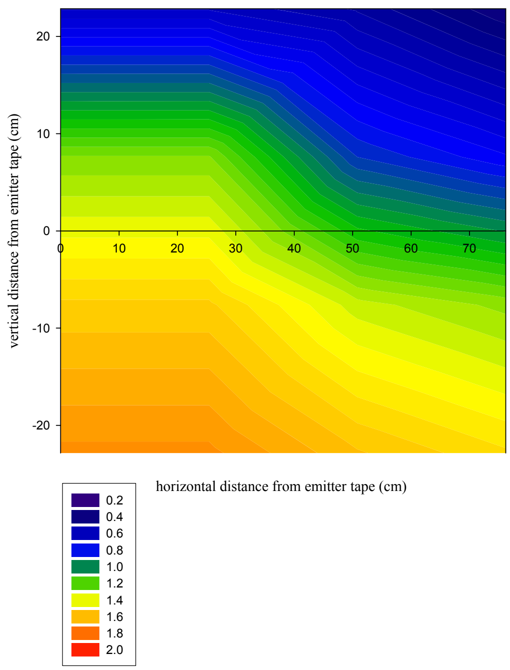
07/23/03 SAR for inlet end of Plot 53
after effluent application



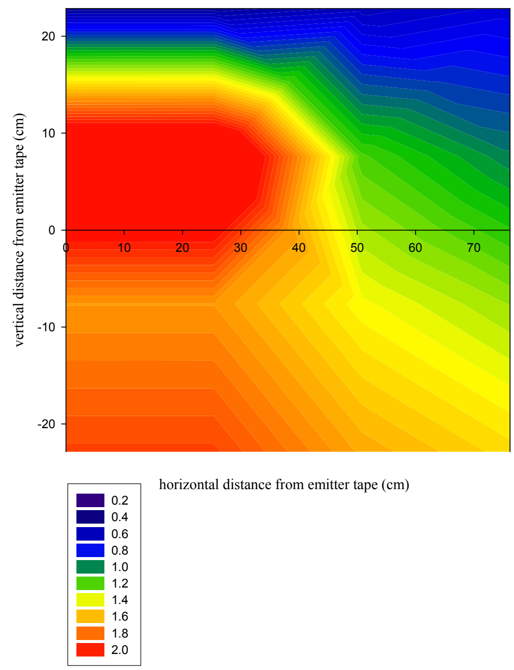
08/05/03 SAR for Plot 53
after 4.01 cm rainfall



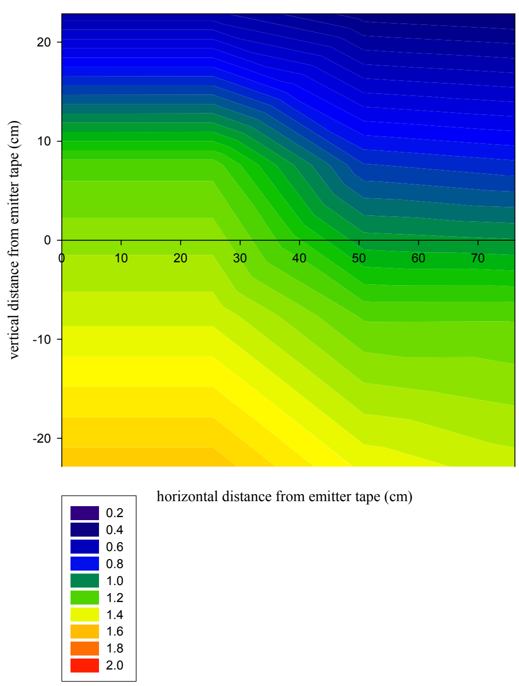
09/09/03 SAR for inlet end of Plot 53
after effluent application



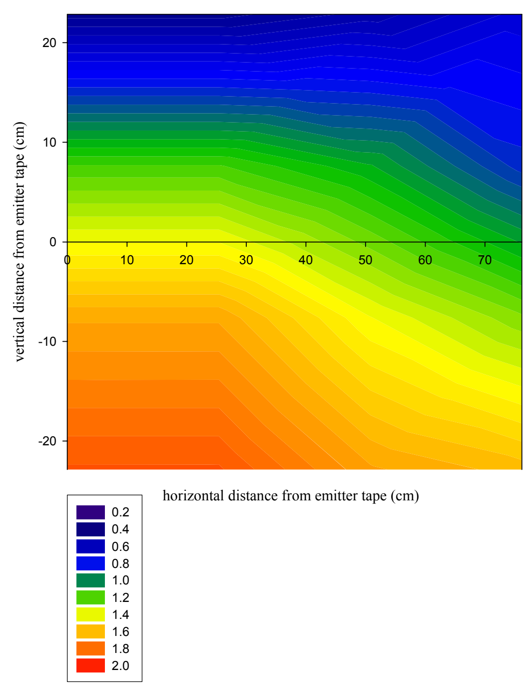
09/26/03 SAR for inlet end of Plot 53
after 3.96 cm rainfall



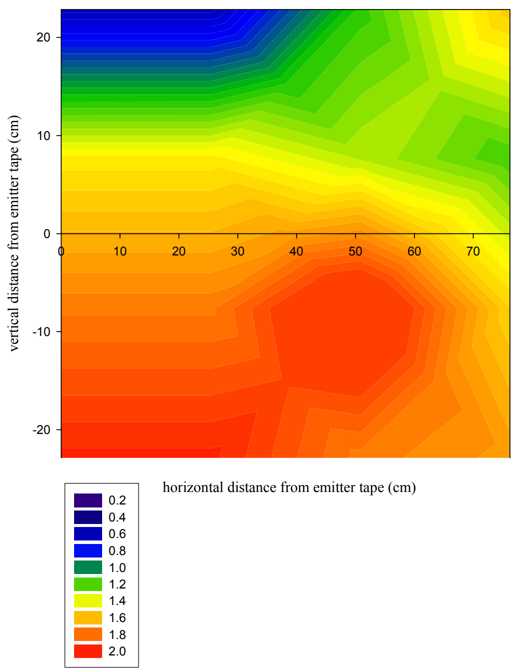
11/10/03 SAR for inlet end of Plot 53
after effluent application



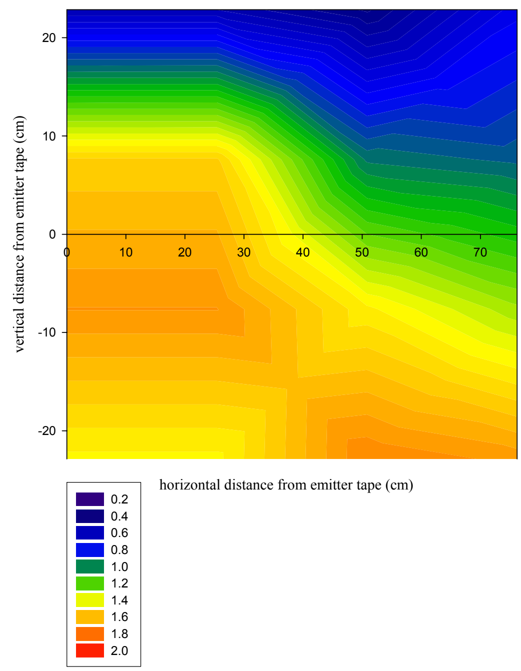
11/21/03 SAR for inlet end of Plot 53
after 3.96 cm rainfall



04/19/04 SAR for inlet end of Plot 53
after effluent application

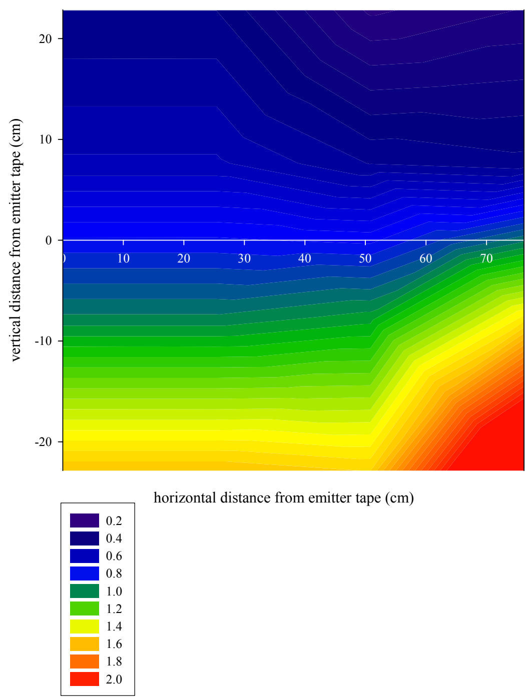


05/10/04 SAR for inlet end of Plot 53
after 1.70 cm rainfall

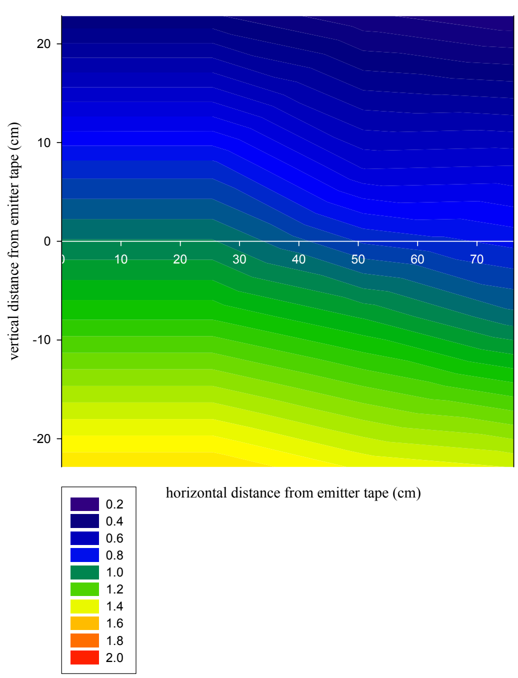


Appendix Y: SAR Results for the Distal End of Plot 53

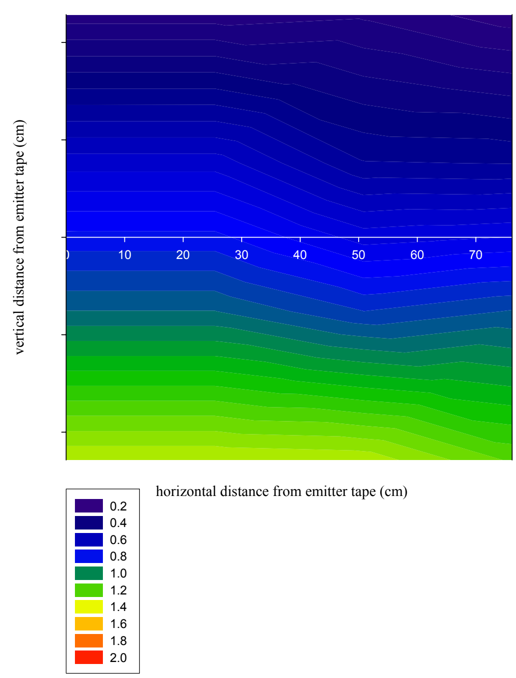
Background SAR for the distal end of Plot 53



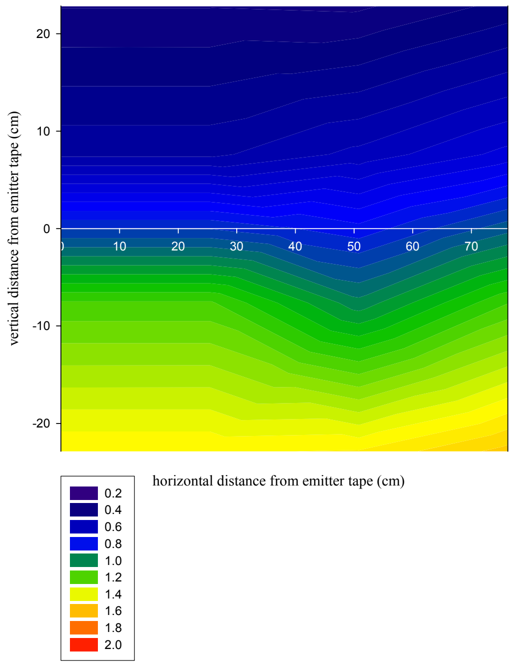
07/23/03 SAR for distal end of Plot 53
after effluent application



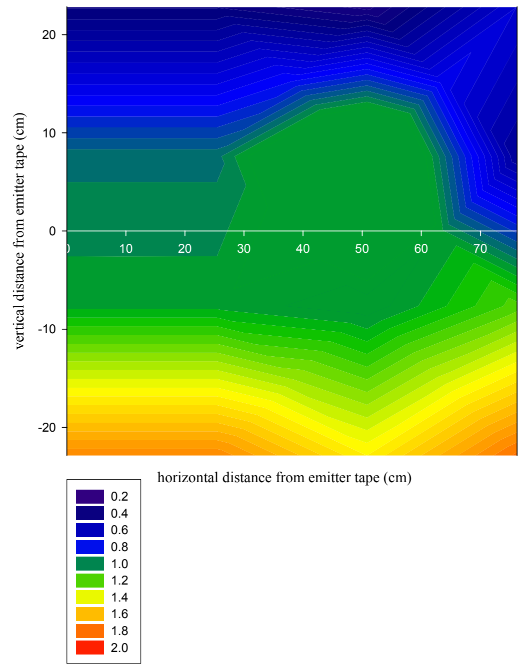
08/05/03 SAR for distal end of Plot 53
after 4.01 cm rainfall



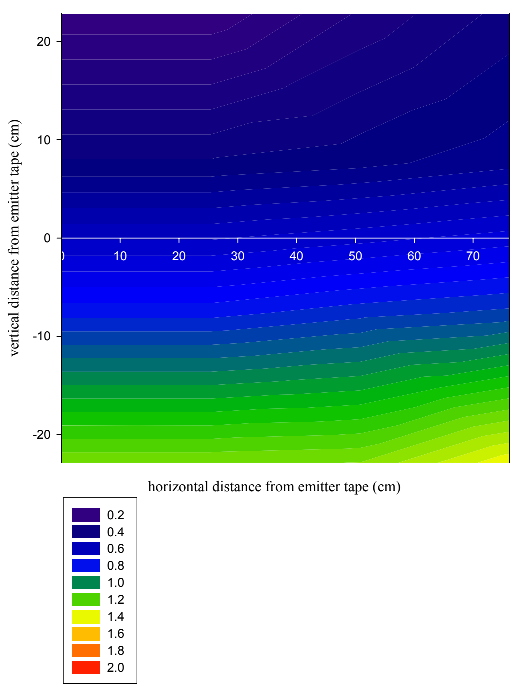
09/09/03 SAR for distal end of Plot 53
after effluent application



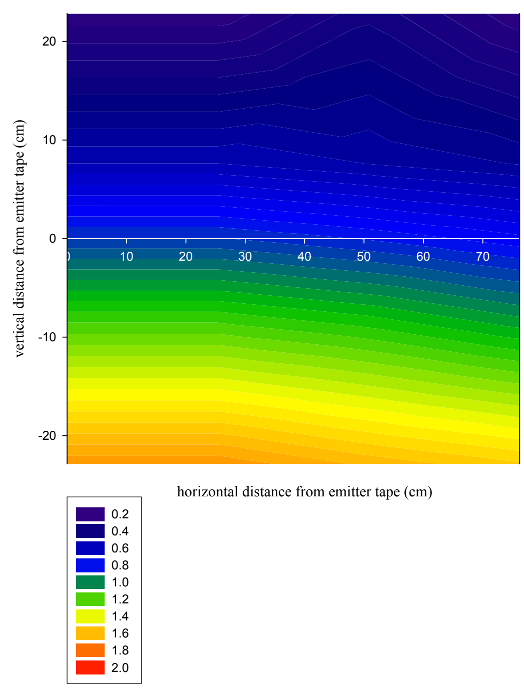
09/26/03 SAR for distal end of Plot 53
after 3.25 cm of rainfall



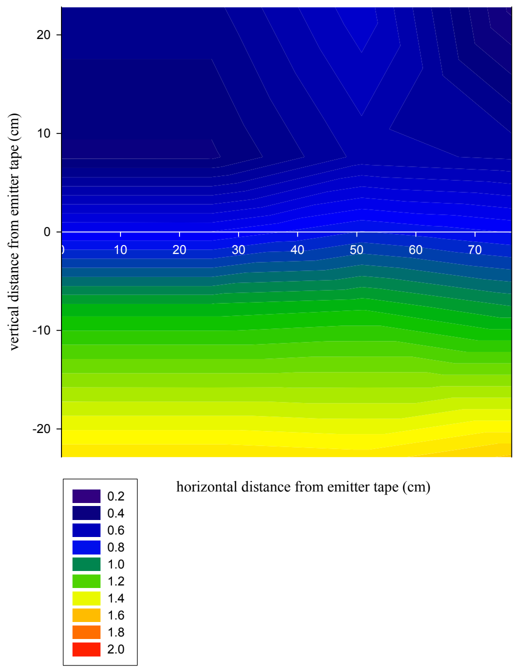
11/10/03 SAR for distal end of Plot 53
after effluent application



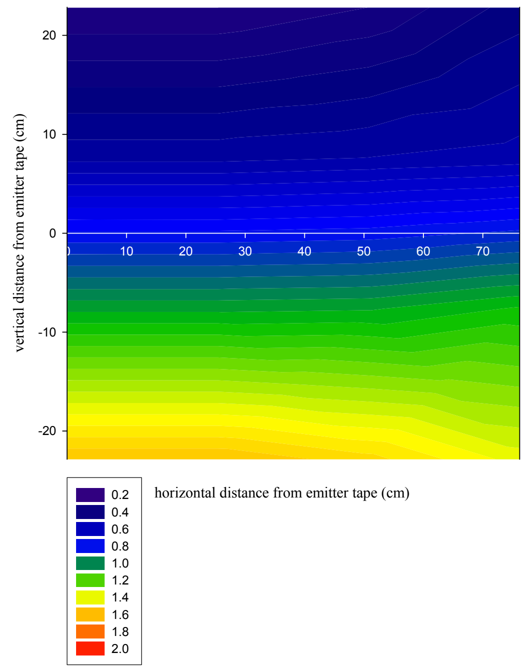
11/21/03 SAR for distal end of Plot 53
after 3.96 cm rainfall



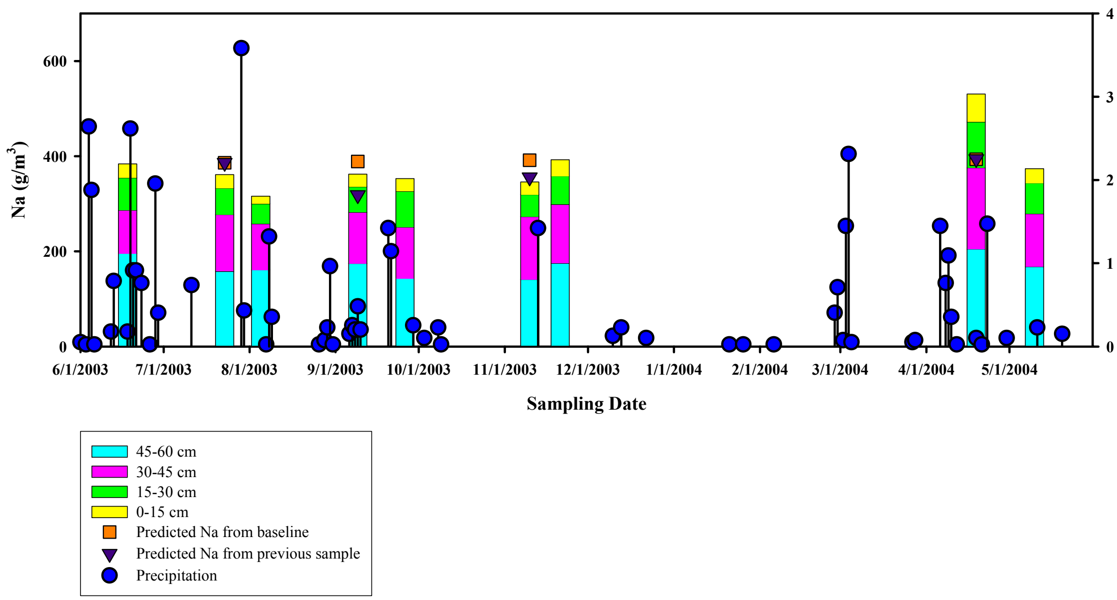
04/19/04 SAR for distal end of Plot 53
after effluent application



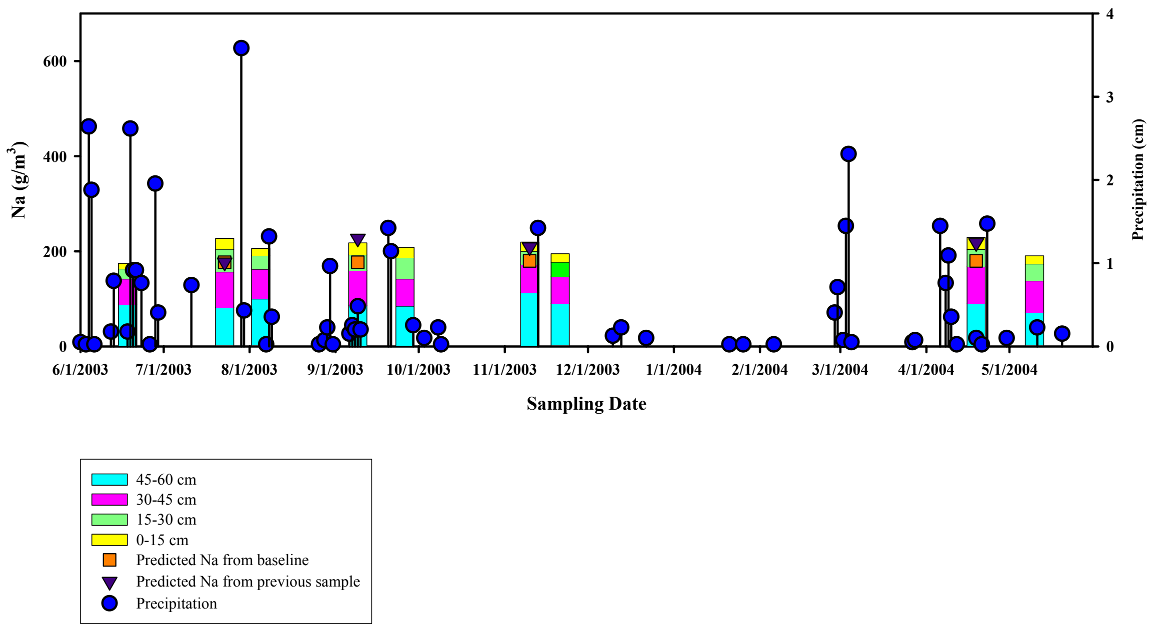
05/10/03 SAR for distal end of Plot 53
after 1.70 cm rainfall



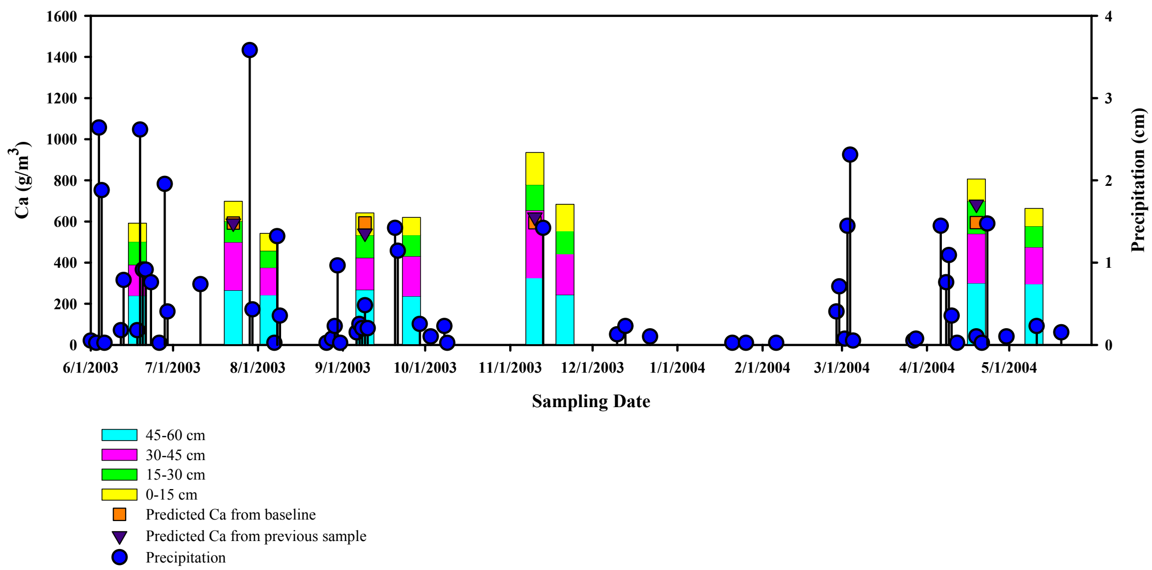
Appendix Z: Na Concentrations for the Inlet End of Plot 53



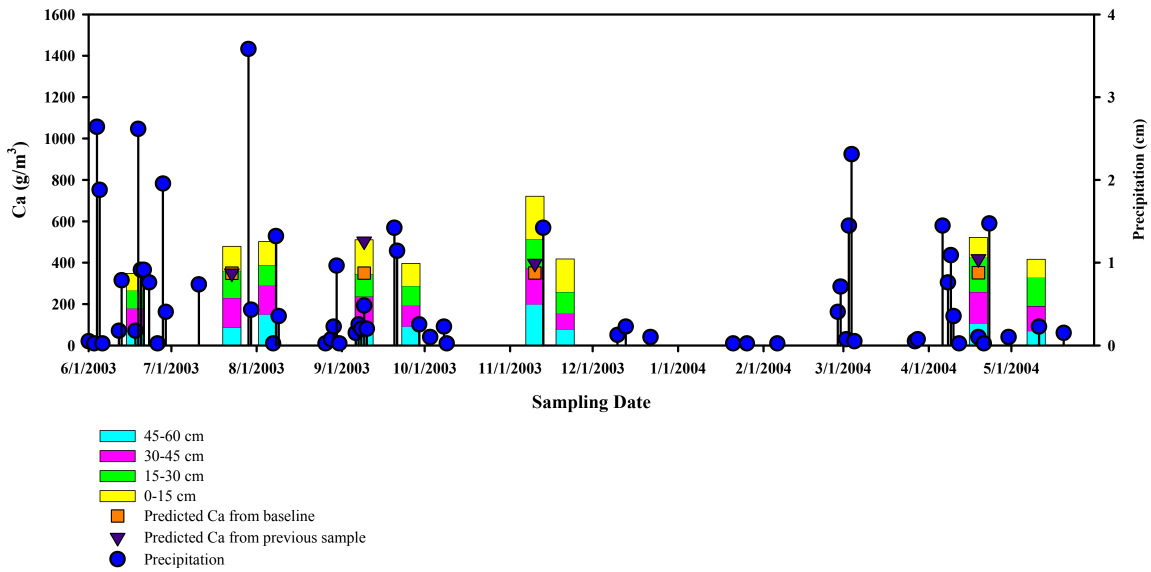
Appendix AA: Na Concentrations for the Distal End of Plot 53



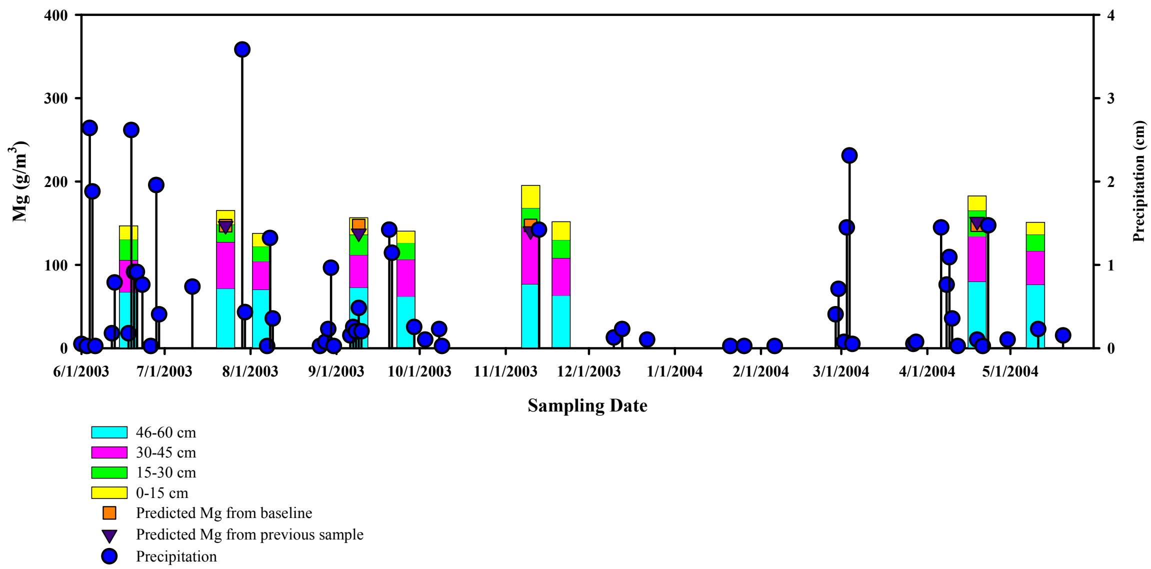
Appendix BB: Ca Concentrations for the Inlet End of Plot 53



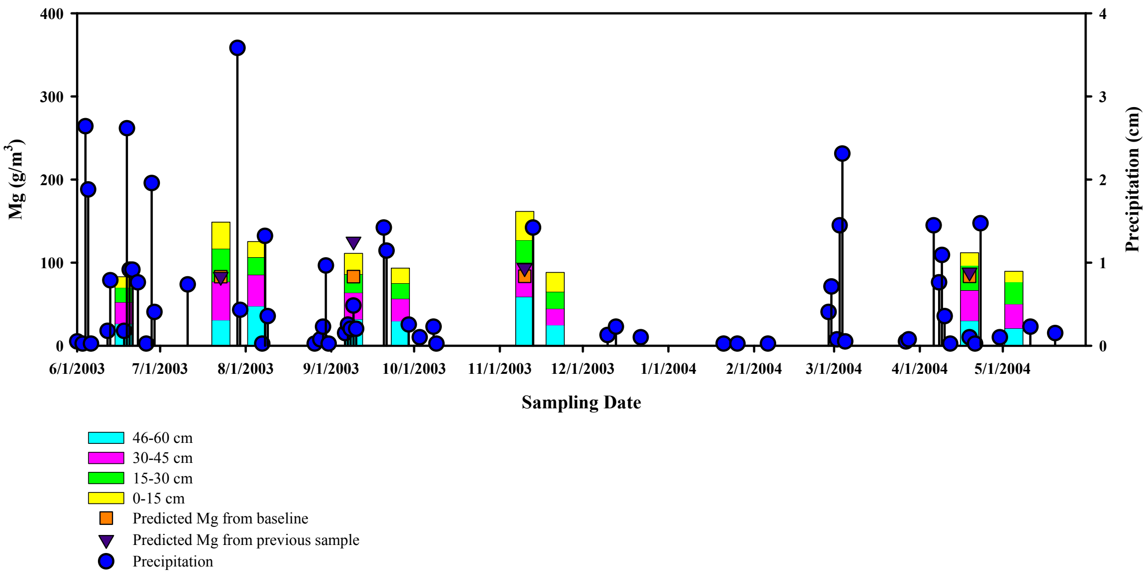
Appendix CC: Ca Concentrations for the Distal End of Plot 53



Appendix DD: Mg Concentrations for the Inlet End of Plot 53



Appendix EE: Mg Concentrations for the Distal End of Plot 53



VITA

Kimberly Anne Hornbuckle

Candidate for the Degree of

Master of Science

Thesis: TRANSPORT OF SWINE EFFLUENT SALTS WHEN LAND-APPLIED IN A SEMI-ARID REGION THROUGH A SUBSURFACE DRIP IRRIGATION SYSTEM

Major Field: Biosystems Engineering

Biographical:

Personal Data: Born in Norman, Oklahoma, on July 1, 1974. The daughter of Paul and Betty Lewis. Married Bobby Hornbuckle on September 29, 2001.

Education: Graduated from Noble High School, Noble, Oklahoma in June 1992; received Associate of Applied Science degree in Drafting and Design from Connors State College, Warner, Oklahoma in May 1994; received Bachelor of Science degree in Biosystems Engineering from Oklahoma State University, Stillwater, Oklahoma in May 1998. Completed the requirements for the Master of Science degree with a major in Biosystems Engineering at Oklahoma State University in December 2004.

Experience: Employed by Oklahoma State University, Department of Biosystems and Agricultural Engineering as an Undergraduate Research Assistant, 1995 to 1998; employed by Oklahoma Department of Agriculture, Food and Forestry, Agricultural Environmental Management Services as an Environmental Consultant, 1998 to 2003; employed by Oklahoma State University, Department of Biosystems and Agricultural Engineering as a Research Engineer, 2001 to present.

Professional Memberships: American Society of Agricultural Engineers, Soil and Water Conservation Society, Phi Kappa Phi.

Certifications: 40-hour WAZWOPER certification.

Name: Kimberly Anne Hornbuckle Date of Degree: December, 2004

Institution: Oklahoma State University Location: Stillwater, Oklahoma

Title of Thesis: TRANSPORT OF SWINE EFFLUENT SALTS WHEN LAND-APPLIED IN A SEMI-ARID REGION THROUGH A SUBSURFACE DRIP IRRIGATION SYSTEM

Pages in Study: 149 Candidate for Degree of Master of Science

Major Field: Biosystems Engineering

Scope of Study: This thesis concerns the salt transport around a subsurface drip irrigation (SDI) system land-applying swine effluent in the panhandle of Oklahoma. Three plots equipped with different emitter sizes are utilized. Soil samples are taken at different stages and locations. Rhoades saturated paste extraction method is utilized to remove the liquid from the soil samples and various analyses are completed. The electrical conductivity, sodium adsorption ratio, sodium, calcium, and magnesium profiles for the different plots are compared to determine the best emitter size for the use of swine effluent, in order to minimize salt concentration in the root zone.

Findings and Conclusions: It does not appear from this single year of data that the application of swine effluent by SDI will significantly alter the buildup of salts in the crop root zone for the soil conditions within any of the three plots at this experimental site.

ADVISER'S APPROVAL: Michael Kizer