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State of California
Department of Transportation
Division of Construction
Office of Transportation Laboratory

EFFECTS OF RECLAIMED WATER ON HIGHWAY PLANTINGS, SOILS, AND IRRIGATION EQUIPMENT

FINAL REPORT

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CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quality	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40 .02540	millimetres (mm) metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2) square feet (ft^2) acres	6.432×10^{-4} .09290 .4047	square metres (m^2) square metres (m^2) hectares (ha)
Volume	gallons (gal) cubic feet (ft^3) cubic years (yd^3)	3.785 .02832 .7646	litre (l) cubic metres (m^3) cubic metres (m^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s	28.317	litres per second 1/s)
	gallons per minute (gal/min)	.06309	litres per second (1/s)
	pounds (lb)	.4536	kilograms (kg)
	miles per hour (mph) feet per second (fps)	.4470 .3048	metres per second (m/s) metres per second (m/s)
Acc	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity (G) (ft/s^2)	9.807	metres per second squared (m/s^2)
Density	(lb/ft^3)	16.02	kilograms per cubic metre (kg/m^3)
Force	pounds (lbs) (1000 lbs) kips	4.448 4448	newtons (N) newtons (N)
Thermal Energy	British termal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds (ft-lb) foot-kips (ft-k)	1.356 1356	joules (J) joules (J)
Bending Moment or Torque	inch-pounds (in-lbs) foot-pounds (ft-lbs)	.1130 1.356	newton-metres (Nm) newton-metres (Nm)
Pressure	pounds per square inch (psi) pounds per square foot (psf)	6895 47.88	pascals (Pa) pascals (Pa)
Stress Intensity	kips per square inch square root inch (ksi$\sqrt{in}$)	1.0988	mega pascals$\sqrt{metre}$ (MPa$\sqrt{m}$)
	pounds per square inch square root inch (psi$\sqrt{in}$)	1.0988	kilo pascals$\sqrt{metre}$ (KPa$\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{+F - 32}{1.8} = +C$	degrees celsius (°C)

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GLOSSARY

Biochemical Oxygen Demand- The amount of oxygen required for microorganisms to oxidatively decompose a material in wastewater, expressed in milligrams per liter (mg/l).

Chemical Oxygen Demand- The amount of oxygen required to oxidize carbonaceous material in wastewater using dichromate or permanganate salts as oxidants expressed in milligrams per liter (mg/l).

Drip Irrigation System- An irrigation system which continuously supplies small amounts of water through small tubes and emitters to the plants being irrigated.

Electrical Conductivity- A measure of the salinity of water made by determining the resistance of the water to the flow of an electrical current, expressed in millimohs per centimeter (mmho/cm), or decisiemens per meter (dS/m).

Emitter- The part of a drip irrigation system which distributes the water to the plant being irrigated.

Enterovirus- A virus which lives and reproduces in the human intestinal tract. Some enteroviruses produce disease.

Macronutrients- Seven nutrient elements (N, P, S, K, Ca, Mg, Fe) required by plants in relatively large amounts.

Micronutrients- Nutrient elements (Cu, Mn, Zn, and etc.) required by plants in relatively small amounts.

Pathogen- A disease producing organism.

Phytotoxin- A substance which is toxic to plants.

Potable Water- Water suitable for drinking and other domestic purposes.

Reclaimed Wastewater- Water used for industrial or domestic purposes, treated to remove contaminants and reused.

Salinity- The total solids in water after all the carbonates have been converted to oxides, all bromides and iodides have been replaced by chloride, and all organic matter has been oxidized. Reported as grams per kilogram (g/kg).

Total Dissolved Solids- The sum of all the dissolved solids in a water sample, expressed in milligrams per liter (mg/l).

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1. INTRODUCTION

Potable water is generally used to irrigate ornamental highway landscaping in urban areas where there is insufficient rainfall to properly maintain the the plants. The potable water used is part of the domestic water supply for the community in which the landscaping exists. However, a growing shortage of potable water in parts of California is causing an increase in the price of potable water.

To conserve potable water, Caltrans is considering using reclaimed wastewater to irrigate ornamental freeway landscaping in the drier parts of California. Wastewater is water that has already been used by a community. Community use degrades water by adding materials to the water which prevent its later use.

The purpose of this study is to determine if using reclaimed wastewater to irrigate ornamental freeway landscaping will damage landscape plants, soil, or irrigation systems, or if such use will degrade surface or groundwater quality. Reclaimed wastewater may contain higher concentrations of toxic metals and total dissolved solids (TDS) and may have higher salinity and higher chlorine concentrations than potable water. Additionally, reclaimed wastewater will contain higher nutrient levels than potable water.

At concentrations above safe levels, toxic metals may cause plants to die. At sublethal levels these metals may stunt plant growth. Because different plant species have different tolerances for various toxic metals, the amount of these metals in the soil may limit the species of plants that can be grown at a contaminated site. Toxic metals sometimes accumulate in plant

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tissues. Perennial ornamental landscape plants may have a greater tendency to accumulate toxic metals in their tissues than annual plant species. Soils may also accumulate toxic metals over time. This concerns Caltrans because irrigation with reclaimed wastewater will continue for several years.

Higher total dissolved solids and salinity levels may also negatively affect plant growth (1,2,3,4). As with toxic metals, high salinity levels may limit what plant species may grow at a site. It is well known that irrigation water can be a significant source of salt in a soil. Poor irrigation practices can render some soils too saline for agricultural use. Increased salinity can cause significant changes in soil structure. This concerns Caltrans, because irrigation with reclaimed wastewater will continue for several years, perhaps leading to a buildup of soil salinity, or other toxic ions such as boron ions.

Another concern is that high chlorine disinfectant concentrations in reclaimed wastewater will negatively affect freeway landscape plants. The concern is that the chlorine disinfectant will kill the plants or retard their growth (2,4).

The effect of reclaimed wastewater on the piping and other distribution system elements of irrigation systems is not known. One of the purposes of this research is to determine if the different physical and chemical properties of reclaimed wastewater will adversely affect irrigation systems.

The aesthetic appeal of freeway landscaping must be considered. The public expects freeway landscaping to be aesthetically pleasing. That decisions on aesthetics are subjective does not reduce the importance of this consideration.

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Wastewater treatment is commonly divided into three parts: primary treatment, secondary treatment, and advanced treatment. Primary treatment is the removal of most of the settleable solid materials from the wastewater. Secondary treatment is the oxidation of dissolved and colloidal organic materials in the wastewater. Advanced treatment is the reduction of inorganic minerals resulting from secondary treatment from the wastewater (2,5,6).

Part of this research was performed by A.C. Chang, G.R. Bradford, J.E. Warneke, and R. Shepherd of the University of California at Riverside (herein called the UCR group). The UCR group studied the soil and vegetation aspects of the use of reclaimed wastewater at the test sites. This research was performed under the provisions of a contract between the university and the California Department of Transportation. The rest of the study was performed by Caltrans personnel from the Transportation Laboratory (Translab).

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2. OBJECTIVES

1. To determine the effects of irrigation using reclaimed wastewater on soils located along California highways.

2. To determine the effects of irrigation using reclaimed wastewater on ornamental landscape vegetation located along California highways.

3. To determine the effects of irrigation using reclaimed wastewater on irrigation water distribution systems.

4. To develop guidelines for using reclaimed wastewater as an alternative to using potable water for irrigating ornamental highway landscaping.

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3. CONCLUSIONS

1. The use of tertiary treated reclaimed wastewater at the test sites had no negative impact on the soils of the test sites.

2. The use of tertiary treated reclaimed wastewater at the test sites had no negative impact on the landscape plant species of the test sites.

3. The use of tertiary treated reclaimed wastewater at the test sites had no negative impact on the irrigation equipment at the test sites.

4. The damage to irrigation equipment noted at the test sites was due to vandalism, and the lack of adequate maintenance effort.

5. The damage to the plants noted at the test sites was due to inadequate irrigation.

6. The use of tertiary treated reclaimed wastewater of reasonable quality should not degrade surface or ground water quality.

7. Guidelines were developed for using reclaimed wastewater as an alternative to using potable water.

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4. RECOMMENDATIONS

1. Reclaimed wastewater should be used whenever the criteria in the guidelines developed as part of this project are met.

2. Product research should be undertaken to determine the types of irrigation equipment that require the least amount of maintenance to effectively operate in the highway environment.

3. Guidelines for irrigation management should be developed and implemented. Developing these guidelines was not part of this project.

4. Research should be done to determine the best drought tolerant landscape species for various climate zones in California.

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5. IMPLEMENTATION

1. A copy of this report will be sent to the maintenance staff in each of the districts and in the appropriate headquarters offices.

2. The editors of the Highway Maintenance Manual, Highway Design Manual, and Environmental Handbook will be contacted to insure that the information presented in this report will be placed in the manuals.

3. During district assistance contacts and environmental review, use of reclaimed wastewater for irrigation will be mentioned when appropriate.

4. The results of this study will be presented in classes given by the Water Quality and Solid Waste Unit of the TransLab.

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6. BACKGROUND

In order to minimize the construction of very large water transportation systems, with their associated adverse impacts, reuse of water should be given a greater emphasis. This should be done if water reuse can be accomplished without creating significant detrimental impacts on people, vegetation, animal life, food supplies, etc. Consequently, Caltrans studied the use of reclaimed wastewater for irrigating ornamental highway landscaping.

In selecting the landscape irrigation sites that were used in this study, three factors were considered. They were:

1- The quality of the reclaimed wastewater

2- The reliability of the reclaimed wastewater source

3- The length of time that wastewater has been used at the site.

6.1 Reclaimed Wastewater Quality

Reclaimed wastewater quality was a major determinant in the study site selection process. For convienience, water quality may be broken down into 3 components; physical, chemical and biological (3).

Physical water quality relates to such items as: the amount of suspended solids in the wastewater,the temperature, the color and the odor of the wastewater. The physical water quality is important in determining the types of irrigation equipment which can be used on a project, the impacts of the wastewater on the soil, and the public acceptance of reclaimed water use.

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Of greatest importance is the nature of the solids in the wastewater. The total solids content includes floating, suspended, and dissolved solids. Solid particles in the water may clog orifices in irrigation lines and emitters. The particles may also reduce soil permeability and change soil structure by clogging the soil pores.

The odors found in reclaimed wastewater are due to the aromatic products of the anaerobic decomposition of the organic materials in the wastewater. The color of the reclaimed wastewater depends on the level of water treatment, the age of the wastewater, and the organic content of the wastewater. The public will, generally, not accept irrigation water that looks dirty or smells bad. Consequently, the physical water quality of reclaimed irrigation wastewater must be good.

The chemical components of reclaimed wastewater can be divided into three units: gases, inorganic matter and organic matter. The gases found in reclaimed wastewater, aside from those gases which cause foul odors, are relatively unimportant for irrigation. A number of inorganic compounds are commonly found in reclaimed wastewater. Some of these compounds, particularly those containing nitrogen, phosphorus, and potassium are plant nutrients. Other compounds particularly those containing toxic metals and boron may be toxic to plants above threshold concentrations. Generally the aggregate of the dissolved compounds, the total dissolved solids, is more important than the concentrations of individual ions. Total dissolved solids levels above 750 mg/l can cause adverse salinity changes in soils. The ratio of calcium, sodium, magnesium and potassium ions to each other is important. If enough sodium ions are present in the wastewater sodium ions will replace the calcium and magnesium ions on clay particles in the soil and negatively affect soil structure (1,4).

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Biological water quality is concerned with the type and quantity of living organisms that are found in the water, eg. does the water contain any pathogenic organisms. A wastewater may contain a wide variety of organisms that may affect its use for irrigation. For instance, pathogenic bacteria and viruses in reclaimed wastewater may infect highway workers and the public, thus spreading disease. Plant pathogens may spread plant disease and damage the landscaping. Algae and bacteria which may clog irrigation systems may occur in wastewater. Public health agencies have regulations establishing acceptable levels of pathogenic organisms in reclaimed wastewater to protect the public and the highway workers from disease. The organisms commonly found in wastewater were considered in this study.

Reclaimed wastewater quality depends on the quality of the potable water source and the degree of treatment given to the wastewater in the reclamation process. Generally, if a potable municipal water supply is suitable for landscape irrigation, then properly treated reclaimed municipal wastewater will also be suitable for use in landscape irrigation. Exceptions to this generalization might be when salty groundwater infiltrates into a sewer system and/or when significant quantities of untreated industrial wastes are discharged into a sewer syatem before wastewater treatment. The problems created by the use of reclaimed wastewater that contains high concentrations of salts and/or toxic materials for landscape irrigation are difficult to evaluate because several years may pass before problems develop.

Wastewater being considered for use in landscape irrigation must be analyzed for the presence of toxic materials, pathogens and total dissolved solids concentrations using standard techniques prescribed by local and state health and water quality control agencies, prior to use. In California the use of reclaimed

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wastewater is controlled by the Department of Health Services (DOHS), the Water Resources Control Board (WRCB) and the Regional Water Quality Control Boards (RWQCB). Selected study sites were supplied with good quality reclaimed wastewater.

6.2 Reclaimed Wastewater Source Reliability

Reclaimed wastewater must be available for landscape irrigation, whenever watering is necessary, to insure that there is sufficient water for the plants. If the source of reclaimed wastewater is not reliable, then another reliable source of water must be available for use. This is normally a potable water source, such as a municipal water supply or a private well. Sites selected for this study had reliable supplies of reclaimed wastewater. One location that was considered as a potential study site was rejected because it lacked a reliable source of reclaimed wastewater. This site was located in Glendale and was to receive water from the Glendale wastewater treatment facility. The supply of wastewater was not reliable because water was not available for irrigation at critical times.

6.3 Reclaimed Wastewater and Potable Water Costs

Potable water costs have increased over the last 20 years due primarily to increasing energy costs and to increasing water demand. Reclaimed wastewater costs have also been rising due, also, to rising energy costs and, to some extent, the increases in water demand.

The cost of reclaimed wastewater has historically been lower than the cost of potable water. The cost difference between reclaimed wastewater and potable water depends mainly upon two factors. First, the cost of tertiary wastewater treatment required to

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prepare the wastewater for its intended use and second, the cost of the wastewater distribution system. In most cases, reclaimed wastewater must be pumped from the wastewater treatment plant to the irrigation site. Pumping reclaimed wastewater for long distances and/or against high heads increases its cost. Thus, if an irrigation site is located a long distance from the wastewater treatment plant, the cost of irrigating with reclaimed wastewater may be equal to, or greater than, the cost of irrigating with potable water. The study sites selected for this project were chosen so that the cost of using reclaimed wastewater was less than the cost of using potable water.

6.4 Long-Term Use of Reclaimed Wastewater for Irrigation

To help determine the long-term impacts of using reclaimed wastewater on plants and soils, sites where reclaimed wastewater has been used for several years were selected for study. Table 1 shows how long each site has been irrigated with reclaimed wastewater.

TABLE 1. The Length of Time That the Study Sites Have Been Irrigated With Reclaimed Wastewater (1986).

Site	Period of Wastewater Irrigation.
1	11 years
2	9 years
3	7 years
4	3 years
5	3 years

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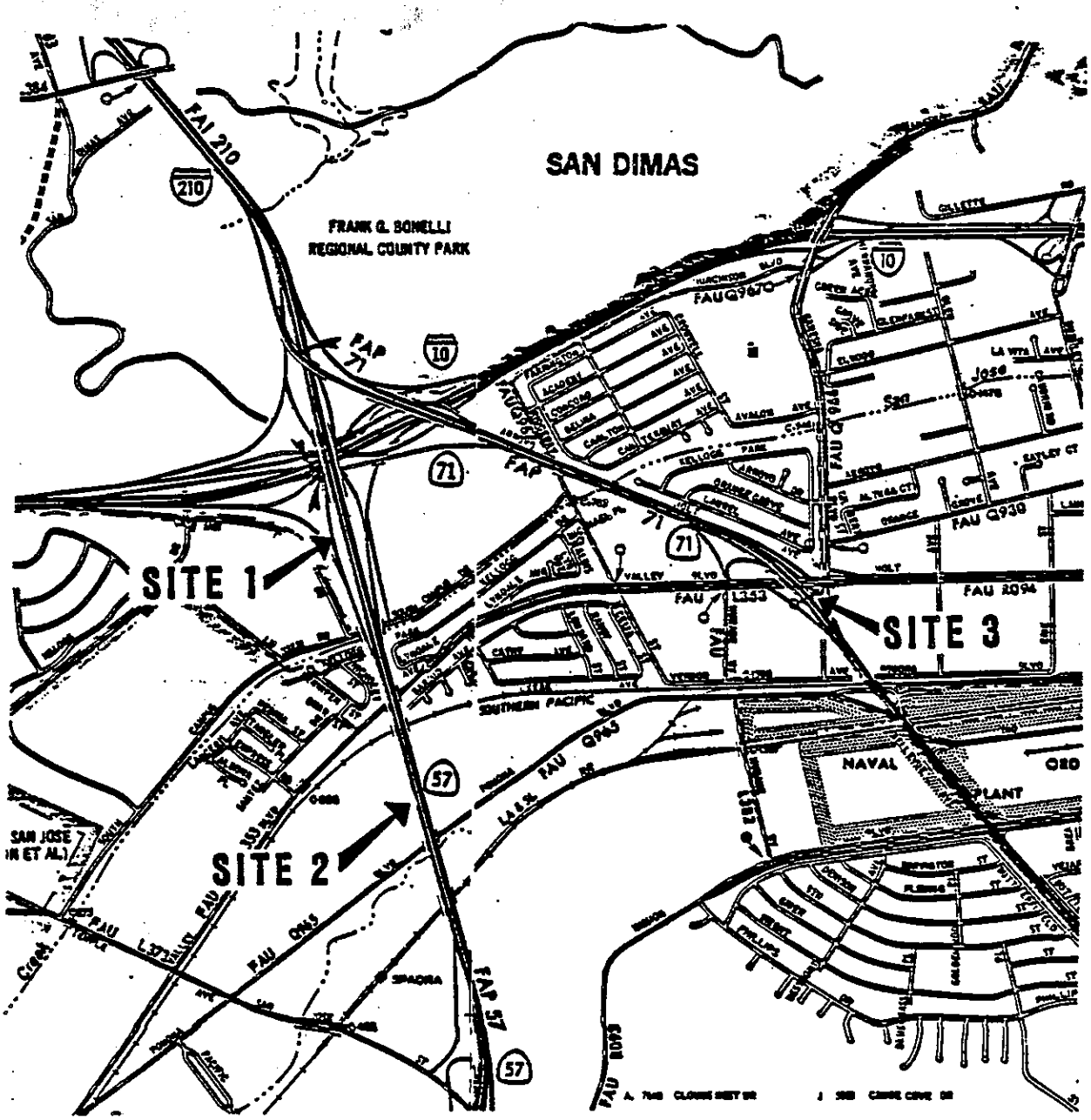

Figure 1, LOCATION OF STUDY SITES 1,2, AND 3

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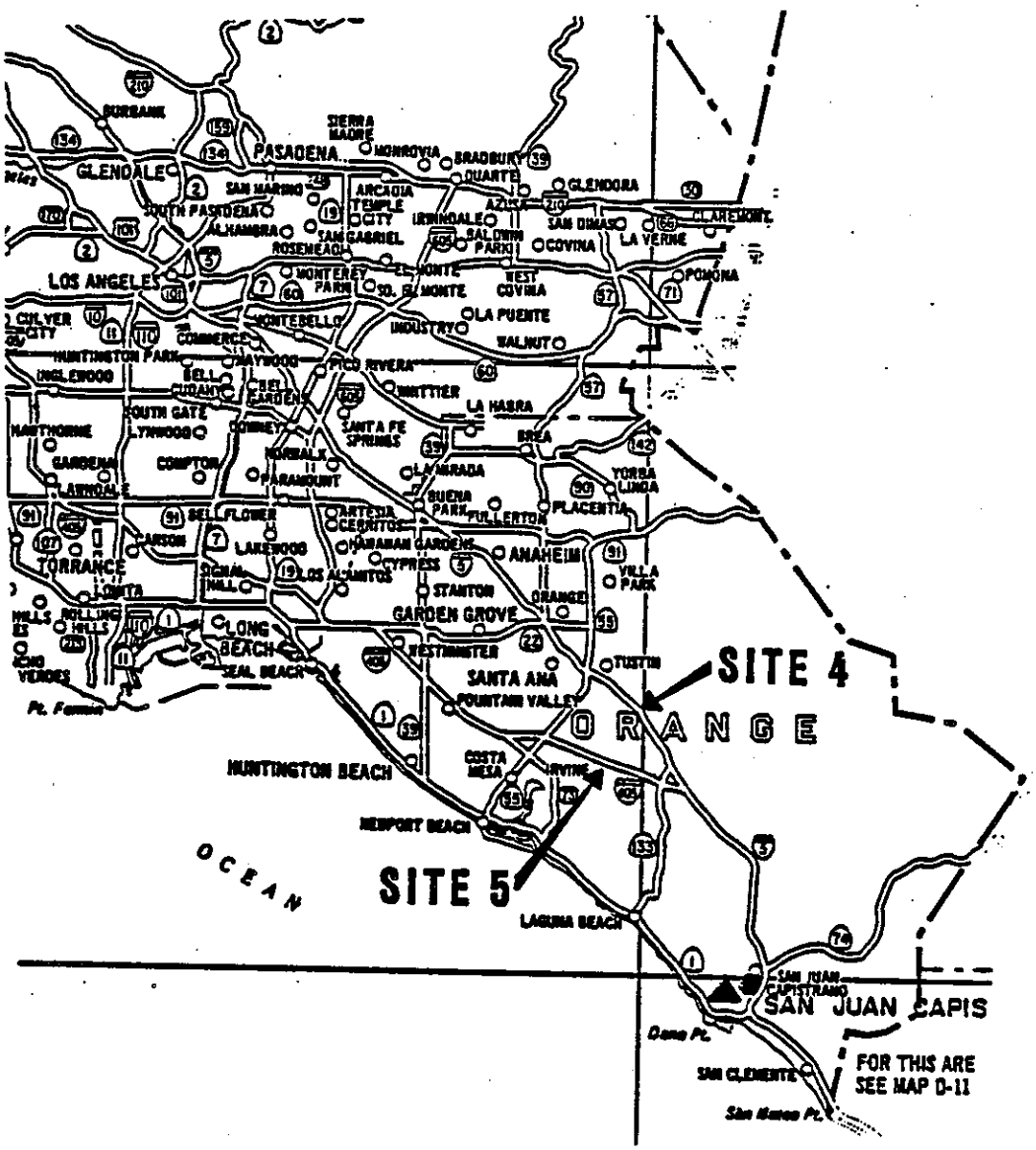

Figure 2, LOCATION OF STUDY SITES 4 AND 5

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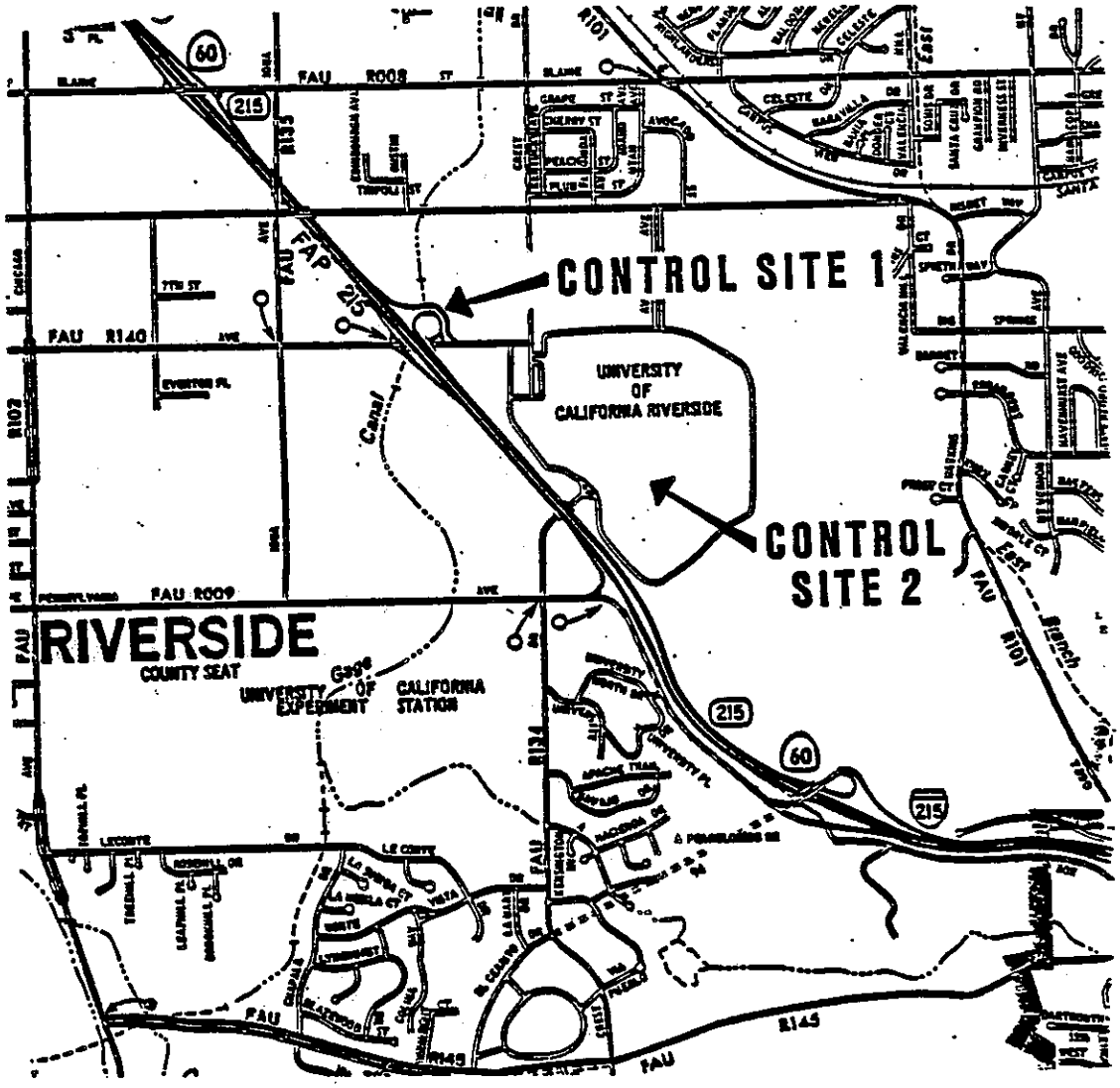

Figure 3, LOCATION OF THE CONTROL SITES

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made according to the methods of the US Soil Salinity Laboratory (9). The concentrations of trace metals was determined using spectrophotometery (7).

The results of the soil constituent testing were compared among the various sites and over time for each individual site. The data were statistically analyzed by using the Student T test to make the comparisons.

7.4 Other Factors

The other factors considered in this study, such as the possibility of reclaimed wastewater damaging irrigation equipment, were studied via a literature search, site visits, and contacts with irrigation specialists. These aspects were subjectively evaluated by Caltrans personnel.

7.5 Aesthetics

The study of aesthetics is very subjective. The idea of what constitutes beauty (which is what aesthetics is concerned about) differs from culture to culture and, within a culture, from person to person. In a pluralistic society such as we have in the United States, defining what is beautiful can be treacherous.

However, some general aesthetic standards related to freeway landscaping can be developed, and must be developed, to judge the impact of using reclaimed wastewater on highway landscaping. The following criteria were used to evaluate the aesthetic appeal of the test sites:

1. The vegetation should appear alive during the proper season.

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2. The vegetation should not appear to be discolored.

3. The vegetation should appear to be the proper size and shape for its age.

4. The number of unsightly weeds visible at a site should be kept to a minimum.

5. The amount of bare ground visible at a site should be kept to a minimum.

6. The reclaimed wastewater should not have an unpleasant odor.

7. The reclaimed wastewater should not appear to be dirty.

8. The irrigation lines should not appear obtrusive.

The aim of these criteria is to describe a "natural looking" clean stand of vegetation. All of these criteria are subjective and individuals may disagree about the condition of the same vegetation stand.

Each test site was evaluated using these criteria, and an overall impression of the site was developed. The following overall categories were used to describe the test sites, Poor, Fair, Good. A literature search and a limited inspection of other sites where reclaimed wastewater was used to irrigate landscaping were performed to determine if reclaimed wastewater was being used with good aesthetic results.

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8. RESULTS AND DISCUSSION

8.1 Reclaimed Wastewater Quality

Two different sources of reclaimed wastewater were used for irrigation during this study. Sites 1,2, and 3 in Pomona received their reclaimed wastewater from the Pomona Water Reclamation Plant. Sites 4 and 5 in Irvine received their reclaimed wastewater from the Irvine Ranch Water District. The control sites both received their potable irrigation water from the city of Riverside's municipal water system. Water quality data for these water systems are included in Tables 1,2, and 3 of the appendix. Historical data indicate that the chemical composition of the reclaimed wastewater has not changed much over the years.

Both of the reclaimed wastewaters contain plant nutrients. There are enough plant nutrients in the two reclaimed wastewaters to supply adequate fertilizer for ornamental landscape plants. The potable water used to irrigate the control sites contained insignificant amounts of plant nutrients.

Reclaimed wastewaters are usually higher in total dissolved solids than potable water (10). In this study, the total dissolved solids concentrations of both the reclaimed wastewaters was higher than the potable water control. The two reclaimed wastewaters also differed from one another. The total dissolved solids concentration of the Pomona wastewater was 559 to 581 mg/l. That of the Irvine wastewater was 767 to 909 mg/l. The total dissolved solids concentration of the potable control water averaged 278 mg/l.

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Looking at total dissolved solids alone, even sensitive plants might be irrigated with the two wastewaters tested without experiencing any injuries, if proper irrigation management is used. Because Caltrans planted only tolerant plants at the test sites, no damage caused by the total dissolved solids concentration was expected, and none was found.

The two reclaimed wastewaters contained two potentially harmful common ions. Sodium ions and chlorine ions existed in high enough concentrations to warrant attention. The range of the sodium ion concentration in the two reclaimed wastewaters was 104 to 171 mg/l. Sensitive plant species may be harmed when the concentration exceeds 115 mg/l. The chlorine ion concentration in the two reclaimed wastewaters was 90 to 159 mg/l. Sensitive plant species may be harmed when the chlorine ion concentration exceeds 178 mg/l. The chlorine ion concentration was close enough to the level at which sensitive plant species may be damaged to warrant care in species selection. This is because chlorine ion may become concentrated in the soil, if improper irrigation practices are used. Because only tolerant plant species were planted at the test site, no damage from sodium ions or chlorine ions was expected and none occurred.

The potentially harmful trace element boron existed in the two reclaimed wastewaters. The boron concentration of the two reclaimed wastewaters was 0.35 to 0.80 mg/l. A few sensitive plant species may be harmed by boron at these concentrations. Because only tolerant plant species were planted at the test sites, no damage from boron was expected and none occurred.

The reclaimed wastewater used at the Pomona test sites was analyzed to determine the trace element content of the water. Tables.1,2, and 3 of the appendix show the results of this

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analysis. The trace metal concentrations in this reclaimed wastewater were less than the trace metal concentrations recommended by the National Academy of Science (1).

8.2 Soil Assessment

The soils at the test sites consisted of fills of unknown origins which, due to lack of adequate time, have not developed soil horizons. The soils were gravelly and compacted.

The constituents present in soil saturation extracts are usually used to determine soil salinity. Tables 4 through 10 of the appendix show the chemical composition at the various test and control sites.

Statistical analysis using the Student T-test indicated that soil salinity levels at sites irrigated with water from the same source were not significantly different. This is probably because, the same irrigation management protocol was followed for all sites used in the same community. The soil salinity at each site varied widely over time. This is probably because the irrigation protocols for the various sites were not consistently followed.

Nevertheless, the soil salinities at the wastewater irrigation sites in both Pomona and Irvine were suited for all ornamental landscape species, except for those species which are the most salt sensitive. No damage was done to the soils at the test sites by the salinity of the wastewater.

Roadside soils are often contaminated by metallic pollutants generated by automobiles. The metals are products of tire wear, automobile wear, and combustion. Elevated concentrations of zinc

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and lead were found in the soils of all the freeway sites sampled. The freeway reference site exhibited elevated concentrations of these metals along with the test sites. The lead and zinc concentrations exhibited typical patterns for metal contamination in roadside soils (11). That is, the lead and zinc concentrations at the surface of the soil were several times higher than those deeper in the soil profile. Tables 11 through 17 of the appendix show the heavy metal concentrations of the soils sampled.

The soil samples taken at the reference site on Route 57 in Pomona also exhibited elevated heavy metal concentrations despite being unlandscaped and unirrigated. The toxic metal concentrations at this site were the same as those of the nearby Pomona test sites, which were irrigated with reclaimed wastewater. The second reference site on the California Polytechnic University Pomona Campus, which was irrigated with reclaimed wastewater for more than 10 years prior to the sampling, exhibited considerably lower heavy metal contents than did the freeway sites. Consequently, it was concluded that the reclaimed wastewater was less important in determining the toxic metal content of the soil than other factors.

8.3 Elemental Contents of Leaf Tissue

The elemental contents of leaf tissue are frequently used to diagnose nutrient deficiency and elemental phytotoxicity (toxicity to plants) in plants. A low concentration of a nutrient element in leaf tissue is an indicator of a deficiency of that element. Similarly, a high concentration of a toxic element is an indicator of a phytotoxicity problem.

The leaves analyzed in this study exhibited a wide variation in elemental concentrations. The results of the analyses are

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presented in Tables 18 through 39 of the appendix. For the most part, the elemental concentrations obtained from leaves at the test sites were in the same order of magnitude as those from the control sites.

Because leaves found on eucalyptus trees at the test sites were abnormal, their elemental concentrations are illustrated in figures 1-9 of the appendix. The results indicate little possibility of nutrient deficiency or phytotoxicity due to elements imported to the irrigation site by the reclaimed wastewater. The leaf concentrations of some potentially toxic elements in the tested leaves from the control sites versus test sites were not significantly different .

The elemental concentrations of damaged leaves versus healthy leaves were compared at Sites 1, 3 and 4, to determine if any significant differences in elemental concentrations could be found. The results are in tables 40 and 41 of the appendix. The results indicate little clear-cut evidence that phytotoxicity was occurring.

During the course of the study the rate of application of water to the test sites was not proper. This was due to equipment problems and/or faulty irrrigation management. There were long periods of time when no irrigation water was applied. At times the water was applied in limited quantities so that only the uppermost layer of soil was moistened. Consequently, the landscape plants at the test sites were stressed by drought. The drought stress is the most likely cause of damage to the landscape plants at the test sites. It is not likely that the damage to landscape plants was caused by using reclaimed wastewater. The California Polytechnic University at Pomona has used reclaimed wastewater from the Pomona Water Reclamation Plant for over ten years without causing damage to landscape plants.

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8.4 Public Health Concerns

It has long been known that municipal wastewater carries pathogenic (i.e. disease producing) organisms. The sources of the pathogens in the wastewater are the population served by the sewage system, and the wild and domestic animals whose waste enters the sewage system. Many illnesses are known to be transmitted by wastewater. Table 2 lists selected organisms that may be present in wastewater from American communities (12).

Pathogenic bacteria may survive from one day to several months in the soil. The variability of survival time depends on such factors as the soil temperature, moisture, pH, and the nature of the soil biota. (4, 13, 14). Enteroviruses (viruses of the human intestinal tract) may survive up to 170 days in soils (4, 13,14). Again, the length of time that enteroviruses survive in the soil depends on the conditions of the soil environment. Some resting stages of parasites may remain viable in soil for several months. The spread of these parasites occurs when a person comes into contact with the resting stage in the soil (4, 13, 13). Hookworms are particularly adapted to be spread in this way.

Long-term application of pathogen laden wastewater at a site may lead to an accumulation of pathogens at the soil surface. The pathogens usually will not enter the groundwater unless the soil contains large cracks or channels. The soil usually acts as a filter preventing their downward movement. Although, under some circumstances, they may travel some distance down through the soil (15).

Pathogens in the soil may be transported from a site by a variety of means. Birds, insects and other animals may transport

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pathogens from the site. Storm runoff from a pathogen-contaminated site may also transport pathogens from the site. Of course, if pathogen-laden irrigation water is sprayed onto roadways,sidewalks or yards, pathogens may be directly spread. Human or domestic animal consumption of pathogen-laden irrigation water may directly cause disease. Workers who deal with pathogen-laden wastewater may also contract disease from the wastewater (4,15).

There are several measures which can be taken to protect public health and the health of the maintenance workers. The primary method of protecting the public health is to obtain reclaimed wastewater which is as pathogen-free as possible.

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Table 2. Selected Pathogenic Organisms That May Be Present In Wastewater. (after Clark, 12)

Organisms	Disease
Enteroviruses	Gastroenteritis, heart anamolies meningitis, and others
Rotaviruses	Gastroenteritis
Parovirus-like agents	Gastroenteritis
Hepatitis A	Infectious hepatitis
Adenoviruses	Respiratory disease, conjunctivitis, and others
Escherichia coli	Gastroenteritis
Salmonella	Typhoid fever, salmonellosis
Shigella	Shigellosis
Balantidium coli	Balantidiasis
Entamoeba histolytica	Amebic dysentery
Giardia lamblia	Giardiasis
Ascaris lubricoides	Ascaris worm infection
Ancylostoma duodenale	Hookworm infection
Necator americanus	Hookworm infection
Ancylostoma braziliense	Cutaneous larva migrans
Ancylostoma caninum	Cutaneous larva migrans
Strongyloides stercoralis	Threadworm infection
Toxocara spp.	Viscaral larval migrans
Trichuris trichiura	Trichuriasis
Taenia spp.	Tapeworm infection
Enterobius vermicularis	Pinworm infection
Hymenolepis nana	Tapeworm infection
Echinococcus granulosus (dog tapeworm)	Unilocular echinococcosis
Echinococcus multilocularis	Alveolar hydatid disease

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Wastewater treatment reduces the concentration of pathogens in the wastewater. Primary treatment will not effectively remove bacteria or viruses from sewage. Good secondary treatment will remove more than 90% from the wastewater (4). However, after secondary treatment the wastewater may still contain enough viruses, parasites and bacteria to pose a health risk. Consequently, the wastewater used in Caltrans projects should receive tertiary treatment and be disinfected.

The design of the irrigation system itself can limit the possibility of infection due to wastewater contact. Human and animal contact with wastewater may be minimized by taking the following steps. The irrigation system should be designed so that wastewater used for irrigation does not leave the irrigation site. The spray patterns of the sprinklers used in the system should be known. The sprinklers should be located so that the wastewater is only sprayed on the ground being irrigated, and not on nearby sidewalks, roadways, yards or buildings. Additionally, the landscaping should be designed so that the wastewater will not flow off the irrigation site, but will stay on the ground being irrigated. Each of the irrigation system components should be distinctively painted, and the irrigation site fenced to reduce the possibility of entry. Signs warning the public that unpotable water is being used for irrigation should be posted. If there is a significant non-English speaking population in the vicinity of the wastewater irrigation site, signs in the appropriate language should be posted.

The irrigation program itself may be designed to reduce the possibility of infection due to wastewater contact. Pathogens usually do best in soil that is wet. Irrigation should be done in such a fashion that the soil surface dries out after irrigation episodes. The amount of wastewater applied should be controlled so that the water reaches the root zones of the plants, but will not run off the site.

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8.5 Aesthetics

None of the test sites was subjectively evaluated as good. Sites 1,2,and 3 were rated as fair. Sites 4 and 5 were rated as poor.

Site 1 contained damaged ivy. The plants appeared dry and stunted. Site 1 also contained a relatively large proportion of bare ground and weedy species coverage.

Site 2 contained some damaged trees. The damaged trees had dry leaves and looked spindly. There was also a relatively large proportion of bare ground.

Site 3 contained some dead iceplant. Some of the rest of the iceplant appeared spindly and unhealthy. There was also a high proportion of bare ground.

Despite the damage at the first three sites the sites were rated fair because passing motorists would be presented with a generally pleasing view. The damage was minor and localized.

Sites 4 and 5 were rated poor. Both sites had discolored and damaged eucalyptus trees, misshapen pine trees, and large amounts of bare ground. Both sites had a dry unhealthy appearance.

Although none of the test sites received a good rating, reclaimed wastewater can be used for irrigation and produce aesthetically pleasing landscapes. Reclaimed wastewater is used in many places in California for landscaping. Wastewater from the Pomona Water Reclamation Plant is used to irrigate landscaping at the Pomona Campus of California Polytechnic University. Inspection of the campus revealed that the landscape is aesthetically pleasing. Wastewater from the Irvine water reclamation plant is used in the Irvine area with a pleasing aesthetic effect.

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To insure a pleasing aesthetic effect the landscaping must be properly maintained. The fair to poor results that occurred in this project are likely to have been produced by poor irrigation management. It appears that the watering interval was too infrequent or the amount of water applied was too small to properly maintain the plants.

8.6 Effects of Reclaimed Wastewater on Irrigation Equipment

During the course of the study, researchers noted that there were problems with the irrigation equipment at the test sites. However, the problems were not the result of the reclaimed water damaging the irrigation equipment. Rather, the problems appear to be related to a lack of maintenance effort and vandalism.

Among the problems noted were: sprinklers and irrigation lines broken and/or stolen by vandals; irrigation lines destroyed by rodents; improper installation of irrigation equipment; improper types of equipment used; and lack of maintenance due to a shortage of maintenance personnel. In no case was there any damage noted that could be attributed to the use of reclaimed wastewater.

The literature indicates that using reclaimed wastewater may cause clogging problems in some irrigation systems (16). Drip irrigation systems are more particularly prone to clogging problems. The clogging may be caused by two different conditions. First, particulate matter may fill holes in the emitter and plug it up. Wastewater which has received tertiary treatment contains less particulate matter than wastewater which has only undergone secondary treatment. Second, clogging may be caused by bacterial slimes which form in irrigation lines and emitters. These slimes form when bacteria grow in irrigation systems by utilizing the nutrients in the irrigation water. The slimes can plug the

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orifices of emitters and clog them. Slimes can also grow densely enough in irrigation lines to reduce water flow or even completely clog the irrigation line.

The California Polytechnic University at Pomona Campus has irrigated landscaping with reclaimed wastewater from the Pomona Water Reclamation Plant for ten years. This is the same wastewater source that was used at the Pomona test sites for this project. The Pomona plant produces wastewater with low levels of particulate matter because of tertiary treatment. Therefore, this wastewater has a reduced probability to clog irrigation equipment. The university also has a preventive maintenance program staffed with full time irrigation specialists. Because of the good quality wastewater, preventive maintenance program, and trained staff, the university has had no significant problems with equipment damage due to using reclaimed wastewater. If Caltrans were to make a similar effort to maintain irrigation equipment, no significant problems would be expected.

Experiments performed by the University of Hawaii at Manoa using secondary treated wastewater from the Mililani wastewater treatment plant showed that wastewater containing high levels of particulates can be used in drip irrigation systems. The effluent used in the Hawaiian experiments was of generally lower quality than the wastewater used in this study. To prevent clogging due to the high levels of particulates, the Hawaiian workers found that they had to use larger sized emitter orifices and properly designed irrigation systems (16).

8.7 Impacts of Reclaimed Wastewater Irrigation on Water Quality

During the course of the study, the question of the impacts of wastewater on water quality was raised. Because there is a wide

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variance in the quality of reclaimed wastewater, no single answer can be provided. The reclaimed wastewaters used in this study were of good quality. No degrading of water quality was noted during the study. The reclaimed wastewater produced by the Irvine wastewater plant is used to provide recreational water in the Irvine area.

The reclaimed wastewaters used at the test sites contain enough nutrients that fertilization is not necessary to maintain the landscape plants. If fertilizer would be added to the plantations, then the fertilizer might run off the site during storm events. The nutrient rich runoff could pollute surface waters, or seep into groundwater.

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9. GUIDELINES FOR THE USE OF RECLAIMED WASTEWATER FOR HIGHWAY LANDSCAPE IRRIGATION

The following guidelines are provided to assist Caltrans maintenance personnel in determining when irrigation may be done with reclaimed wastewater, and how reclaimed wastewater systems should be established. These guidelines are not designed to be a checklist. They are designed to be intelligently applied according to the specific conditions of the proposed site.

9.1 Choice of Vegetation

The choice of vegetation is important when reclaimed wastewater is being considered for irrigation. If improper plant species are chosen, then the plantation may either grow poorly, or fail completely.

Because reclaimed wastewater tends to have a higher total dissolved solids than potable water, plants should be selected that are not highly sensitive to salinity. Table 42 of the appendix is a list of landscape plant species that are salt-tolerant.

Similarly, reclaimed wastewater may have a higher concentration of boron than potable water. Consequently, boron-sensitive plants should not be used in plantations irrigated with reclaimed wastewater. Table 43 of the appendix is a list of landscape plants that are boron-tolerant.

The amount of water used for irrigation may be significantly reduced by using landscape plants that are able to grow well with little or no irrigation required. The plant species that are drought-resistant differ with the different areas of California.

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The differences are due to the differing amounts of rainfall in the different parts of the state. Species that require little or no irrigation should be used whenever possible.

9.2 Cost of Irrigation Water

Reasonable use of reclaimed wastewater requires that the cost of using reclaimed wastewater for landscape irrigation be cheaper than using potable water for landscape irrigation. The costs of delivering water to the plants should be compared. These costs include the initial price of the water, the cost of transporting the water to the irrigation site, the cost of the equipment (which includes the cost of signs and etc., which notify the public that reclaimed wastewater is being used), and the cost of maintenance. If the total cost of using wastewater is higher than the cost of using potable water, then potable water should be used.

9.3 Reclaimed Wastewater Quality

The reclaimed wastewater used should be of high quality. Low quality reclaimed wastewater should not be used. The use of low quality reclaimed wastewater can cause plugging problems in equipment, and can create a public health hazard by carrying pathogens. All reclaimed wastewater used for irrigation should meet the standards of Title 22 Environmental Health of the Social Security Code. The intent of Title 22 is to provide standards for the quality of reclaimed wastewater so as to protect public health.

Only reclaimed wastewater that has undergone advanced treatment should be used for irrigating freeway landscaping. Tertiary treatment of reclaimed wastewater reduces the amount of

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particulates in the wastewater, and can, by disinfecting the water, reduce the number of pathogens in the wastewater. Thus, tertiary treatment reduces the probability of clogging problems occurring in irrigation systems, and reduces the possibility of disease being spread via the reclaimed wastewater.

Prior to being considered for use in irrigating highway landscaping, all reclaimed wastewater supplies should be analyzed. The total dissolved solids content, the pH, the odor, the color, the contents of nutrient and toxic elements, and the level of pathogenic viruses and bacteria should be checked. The levels of pathogens should meet the requirements of Title 22. The reclaimed wastewater should not have a strong odor or color. The reclaimed wastewater will likely be used in an urban area, and may be used near businesses or homes. Odiferous or dirty looking water is not acceptable in this environment. The total dissolved solids, pH, nutrient, and toxic elemental contents should all be within the acceptable range for the landscape species used.

9.4 Stability of Reclaimed Wastewater Supply

All reclaimed wastewater supplies considered for use should be reliable. That is, there should be sufficient quantities of water available to adquately irrigate the landscape plants whenever irrigation is necessary. If the supply of irrigation water is not stable, then the landscape plantation may be damaged by lack of reclaimed wastewater.

9.5 Measures to Protect Public Health

All raw domestic sewage contains considerable quantities of pathogens. For the use of reclaimed wastewater to be safe, the water must be disinfected, and the public must be kept away from the water.

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All reclaimed wastewater lines, sprinkler heads, valves, and emitters should be distinctly marked, so that the public will know that the water being used is not potable. All areas where reclaimed wastewater is used should be clearly signed to notify the public that reclaimed wastewater is being used and that the water is not potable. Care should be taken to erect signs in languages other than English, where a significant portion of the population does not read in English.

Where reclaimed wastewater is used, fencing should be used to segregate the plantation from public thoroughfares. Fencing will reduce the likelihood that people will enter the site and drink the water. Fencing is also likely to reduce the amount of vandalism by reducing the number of people who access the plantation.

9.6 Equipment

The equipment for irrigating with good quality reclaimed wastewater does not significantly differ from the irrigation equipment required to irrigate with potable water systems. The major difference between irrigating with potable water and irrigating with reclaimed wastewater that relates to irrigation equipment is that the pressure of the wastewater may be significantly lower than the pressure of potable water. Consequently, pumps may be necessary to increase the pressure, or the irrigation system may be designed to operate with low pressure.

Because the level of nutrients in the reclaimed wastewater is higher than the level of nutrients that is found in potable water, there may be an increased possibility for drip irrigation systems to clog due to bacterial growth.

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Chlorination or some other method to retard bacterial growth may be necessary to prevent clogging. If the reclaimed wastewater is disinfected for public health purposes, there may be enough residual disinfectant in the reclaimed wastewater to prevent bacterial growth in the irrigation system.

The type and amount of disinfectant used to disinfect the reclaimed wastewater should be determined during the initial study of the wastewater source. The residual of the disinfectant in the reclaimed wastewater at the irrigation site should be determined when the system is installed. At that point, it should be determined if there is enough disinfectant in the water to retard bacterial growth. The level of the disinfectant required to retard bacterial growth differs with the type of disinfectant used. Therefore, each reclaimed wastewater system must be examined separately. Another point that should be considered, is the effect of the disinfectant on the vegetetion that will be irrigated.

Drip irrigation systems that use reclaimed wastewater and develop clogging problems may be aided by installing 80 mesh filter srceens (which have 175 micron openings) prior to use. The filters prevent larger particles from travelling into the irrigation lines and clogging them. Emitters that are designed to be cleared by flushing, at higher pressure may aid in eliminating clogging problems.

9.7 Key of the Stages to Follow When Considering the Use of Reclaimed Wastewater for Irrigating Highway Landscaping

1a. Cost of reclaimed wastewater at the source is higher than potable water ----------Use potable water

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1b. Cost of reclaimed wastewater at the source is less than potable water.---------- Go To 2

2a Cost of transporting the reclaimed wastewater raises the cost of using wastewater higher than using potable water.----------Use Potable Water

2b. Cost of transporting the reclaimed wastewater does not raise the cost of using wastewater higher than using potable water----------Go To 3

3a. The reclaimed wastewater has tertiary treatment----Go to 4

3b. The reclaimed wastewater has not undergone tertiary treatment----------Use Potable Water

4a. The reclaimed wastewater meets Title 22 standards--Go To 5

4b. The reclaimed wastewater does not meet Title 22 standards----------Use Potable Water

5a. The source of the reclaimed wastewater is reliable----Go To 6

5b. The source of reclaimed wastewater is not reliable --------Use Potable Water

6. Perform physical and chemical analysis on ---------Go To 7 the reclaimed wastewater, or obtain analysis.

7a. Physical analysis indicates that the reclaimed wastewater has no distinct color. ----------Go to 8

7b. Physical analysis indicates that the reclaimed wastewater has a distinct color.----------Use Potable Water

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8a. Physical analysis indicates that the reclaimed wastewater has no distinct odor. ----------Go to 9

8b. The wastewater stinks.----------Use Potable Water

9. Select landscape plant species that can thrive in the wastewater with its various constituents.------- Go To 10

10. Design the irrigation system paying special attention to: the operating pressure of the system, the possibility of emitter clogging, and the necessity of segregating the system from the public. Insure that any site-specific factors that would influence the design of the system are considered.---Go To 11

11. Insure that the contract correctly conveys the contract design to the prospective contractors.----------Go To 12

12. Insure that the Resident Engineer understands the special features of irrigation system.----------Go To 13

13. Install the irrigation system.----------Go To 14

14. Plant the landscape plants.----------Go To 15

15. Properly maintain the irrigation system.

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APPENDIX

UCR GROUP TEST RESULTS

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Effluent Quality of Pomona Water Reclamation Plant - Table 1

Constituent	Unit	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
pH		7.1	7.1	7.0	7.1	7.0	7.1	-	7.2	7.3	7.1
TDS	mg/L	559	567	570	564	547	561	566	562	581	567
As	g/L	47	3	4	4	4	<2	1.8	<1	0.8	<2.1
B	mg/L	0.8	0.8	0.7	0.6	0.6	0.6	0.53	0.43	0.40	0.35
Cd	g/L	2	3	3	2	<2	<2	1	<1	<1	<1
Cr	mg/L	0.03	0.01	<0.01	<0.01	0.02	0.01	0.01	0.01	0.01	<0.01
Cu	mg/L	0.02	0.02	<0.02	<0.01	0.01	0.02	0.01	0.02	0.02	0.02
Pb	mg/L	0.03	0.02	<0.02	0.03	<0.02	<0.01	0.1	<0.02	<0.01	<0.01
Hg	g/L	<2	<1	<0.2	<0.1	<0.1	<0.2	0.2	<0.1	<0.1	<0.1
Ni	mg/L	0.04	0.04	0.04	0.06	0.05	0.06	0.04	0.04	0.04	0.02
Se	g/L	<4	<3	<3	4	2	<2	3.2	<2	<2	<4
Ag	g/L	<2	<1	<3	<1	<2	<1	1	<2	2	<2
Zn	mg/L	0.06	0.08	0.11	0.11	0.06	0.07	0.05	0.06	0.06	0.07
F^-	mg/L	0.63	0.55	0.57	0.57	0.58	0.57	0.61	0.52	0.50	0.64
CN^-	mg/L	<0.02	0.02	0.02	0.02	<0.01	<0.01	0.32	<0.01	<0.01	<0.1
Phenols	mg/L	0.009	0.005	0.006	0.006	0.004	<0.001	0.004	0.006	0.003	<0.002
Cl^-	mg/L	102	106	105	103	101	104	108	90	92	96
$SO_4^=$	mg/L	113	112	123	118	106	134	113	129	127	116
N (Total)	mg/L	17.7	17.5	16.5	15.7	14.7	12.6	17.4	14.0	13.6	15.8
PO_4	mg/L	-	-	-	-	-	-	6.4	4.9	4.6	4.3
Ca^{++}	mg/L	-	-	-	-	-	-	62	64	66	67
Mg^{++}	mg/L	-	-	-	-	-	-	48	45	51	52
Na^+	mg/L	-	-	-	-	-	-	106	105	105	104
K^+	mg/L	-	-	-	-	-	-	12	11	11	13
SAR†	-	-	-	-	-	-	-	3.1	3.03	2.99	2.98

†Sodium Adsorption Ratio (SAR) = $Na/\sqrt{(Ca+Mg)/2}$ where Na, Ca, and Mg are respectively concentrations of sodium, calcium and magnesium ions of the water in milliequivalence per liter.

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Table 2
Quality of Reclaimed Wastewater — Irvine Ranch Water District

Constituent[1]	1981		1982		1983		1984		1985	
	Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
pH	6.3 -7.4	6.9	6.6 -7.2	6.8	6.8 -7.4	7.2	6.9 -7.6	7.3	6.8 -7.5	7.2
TDS	682 -902	767	743 -1050	884	679 -1042	909	825 -1001	907	735 -876	810
Ca	58 -76	64	42 -92	67	40 -101	80	74 -93	84	61 -89	72
Mg	22 -41	29	25 -43	32	23 -44	35	32 -39	36	30 -39	34
Na	68 -168	138	132 -201	171	123 -196	165	153 -185	166	134 -158	149
K	7 -24	14	8 -29	13	5 -16	12	12 -17	14	13 -16	14
Cl^-	129 -183	151	119 -183	159	124 -185	157	141 -174	152	122 -151	137
$SO_4^=$	108 -331	259	214 -472	324	208 -402	330	312 -356	325	225 -334	285
PO_4	0.20-0.62	0.35	0.26-0.54	0.42	0.31-0.50	0.47	0.90-0.68	0.52	0.31-0.52	0.42
N (total)	1 -17	11	1 -25	16	9 -17	13	9 -19	15	11 -22	16
B	0.56-0.76	0.65	0.49-0.81	0.63	1.44-0.58	0.49	0.40-0.50	0.47	0.20-0.54	0.39

[1]All measurements are in mg/L except pH

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Table 3
Quality of Irrigation Water at Riverside and UCR† - 1986

Constituent	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
pH	7.4	7.5	7.5	7.5	7.6	7.6	7.5	7.5	7.7	7.4	7.4	7.2
TDS	256	242	324	279	296	266	269	264	238	280	247	377
Ca	49	44	61	55	54	46	48	45	37	52	42	78
Mg	7	7	10	8	8	7	7	7	4	7	5	10
Na	23	25	40	27	40	40	39	42	43	35	37	37
K	3	2	2	3	2	2	2	2	2	3	3	3
Cl^-	15	11	32	17	29	26	25	27	21	20	17	35
$SO_4^=$	46	39	60	57	54	43	44	42	38	53	52	73
PO_4	-	-	-	-	-	-	-	-	-	-	-	-
N (total)												
B	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.2	0.3	0.1	0.1	0.1

†All measurements were in mg/L except pH, source of the information: City of Riverside - Water Department.

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Table 4
Chemical Composition of Reclaimed Wastewater Irrigation Soil at Site 1

Date	Depth (cm)	pH	EC (mmho/cm)	Cations (meq/L)				Anions (meq/L)			
				Ca^{++}	Mg^{++}	K^{+}	Na^{+}	Cl^{-}	NO_3^{-}	HCO_3^{-}	$SO_4^{=}$
August, 1985	0-5	7.3	1.2	4.9	1.5	1.0	4.8	1.9	3.2	3.3	2.6
	5-15	7.2	1.2	4.4	1.3	1.0	5.2	2.7	2.0	2.8	3.7
	15-30	7.3	0.9	3.3	0.7	0.6	4.0	1.7	0.9	2.6	2.9
March, 1986	0-5	7.2	0.7	3.1	0.7	1.0	1.9	0.4	0.8	3.5	1.1
	5-15	7.1	0.6	2.0	0.6	0.8	2.5	0.3	0.8	3.2	1.1
	15-30	7.2	0.6	2.1	0.5	0.4	3.4	0.4	0.8	2.9	1.3
June, 1986	0-5	7.4	0.7	3.1	1.3	0.9	3.4	1.6	1.6	3.6	0.7
	5-15	7.4	0.6	2.2	0.9	0.6	3.1	1.1	1.4	2.6	0.7
	15-30	7.3	0.5	1.2	0.5	0.4	3.3	0.9	0.8	2.2	0.5
September, 1986	0-5	7.5	1.5	5.9	2.5	0.7	7.2	4.6	1.5	3.8	3.0
	5-15	7.3	1.7	6.4	2.8	0.6	7.5	5.5	2.5	3.8	3.0
	15-30	7.3	4.7	3.2	14.3	1.2	16.2	23.8	0.2	3.3	7.9
December, 1986	0-5	7.4	0.7	3.2	0.7	0.4	5.2	1.4	0.7	2.9	1.0
	5-15	7.5	1.0	4.2	1.4	0.7	6.5	2.5	0.4	4.5	1.4
	15-30	7.3	1.1	4.2	1.5	0.7	6.6	2.9	0.3	3.7	1.6
March, 1987	0-5	6.7	0.8	1.9	1.1	0.5	4.8	1.3	1.7	2.4	1.0
	5-15	6.9	0.9	2.4	1.2	0.7	4.7	1.0	0.5	3.1	1.2
	15-30	7.0	0.8	2.3	1.1	0.6	5.2	1.4	0.1	3.0	1.4
June, 1987	0-5	7.2	1.5	4.5	1.7	0.6	7.1	5.3	0.5	2.1	3.6
	5-15	7.3	1.2	3.7	1.6	0.9	5.3	2.3	1.8	4.2	1.5
	15-30	7.3	1.9	5.4	2.5	0.8	9.3	9.3	0.1	3.5	3.3

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Table 5
Chemical Composition of Reclaimed Wastewater Irrigation Soil at Site 2

Date	Depth (cm)	pH	EC (dS/m)	Cations (meq/L)				Anions (meq/L)			
				Ca^{++}	Mg^{++}	K^{+}	Na^{+}	Cl^{-}	NO_3^{-}	HCO_3^{-}	$SO_4^{=}$
August, 1986	0.5	7.5	1.9	15.6	5.3	1.0	4.0	1.4	0.8	3.8	16.1
	5-15	7.4	1.4	9.0	5.3	0.5	2.2	0.6	0.5	3.0	12.2
	15-30	7.4	2.0	11.5	7.7	0.5	4.3	1.6	0.3	2.7	15.9
March, 1986	0-5	7.4	0.6	5.1	1.6	0.4	9.7	0.3	0.7	4.4	0.9
	5-15	7.5	0.4	1.9	0.7	0.3	9.4	0.3	0.5	3.4	0.6
	15-30	7.6	0.4	2.0	0.6	0.2	8.6	0.2	0.4	2.7	0.5
June, 1986	0-5	7.7	0.5	1.8	1.1	0.7	0.8	0.4	1.2	2.5	0.2
	5-15	7.8	0.4	1.4	1.0	0.3	1.3	0.2	0.4	2.4	0.1
	15-30	7.7	0.8	3.9	3.0	0.3	2.9	0.5	0.2	1.9	3.5

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Table 6
Chemical Composition of Reclaimed Wastewater Irrigation Soil at Site 3

Date	Depth (cm)	pH	EC (dS/m)	Cations (meq/L)				Anions (meq/L)			
				Ca^{++}	Mg^{++}	K^{+}	Na^{+}	Cl^{-}	NO_3^{-}	HCO_3^{-}	$SO_4^{=}$
August, 1985	0-5	6.3	2.6	7.5	5.4	1.1	12.7	17.8	0.9	2.4	6.2
	5-15	6.6	1.6	4.5	2.1	0.6	9.3	6.3	0.5	3.2	6.0
	15-30	6.9	1.5	5.7	1.6	0.4	7.8	7.4	0.5	2.5	5.7
March, 1986	0-5	6.6	0.8	4.6	1.1	0.6	4.9	1.5	0.3	3.3	1.5
	5-15	6.7	0.8	3.1	0.6	0.5	5.7	1.3	0.3	3.4	1.8
	15-30	7.1	0.8	3.6	0.9	0.4	5.2	1.7	0.3	4.3	1.4
June, 1986	0-5	6.4	2.8	12.9	9.7	1.4	10.0	10.5	0.2	2.4	5.5
	5-15	6.6	1.7	6.4	3.8	0.8	8.2	5.7	0.3	2.0	5.8
	15-30	6.8	1.9	6.8	1.9	0.4	8.2	2.5	0.2	1.9	6.6
September, 1986	0-5	6.8	2.7	16.7	6.3	0.7	9.4	9.0	0.2	2.0	6.2
	5-15	6.7	2.7	7.0	4.6	0.6	14.6	20.0	0.2	2.4	4.0
	15-30	6.2	3.3	8.1	5.6	1.0	18.9	26.4	0.1	1.3	3.3
December, 1986	0-5	6.6	4.2	33.1	10.2	0.8	16.5	12.8	0.1	1.5	8.6
	5-15	6.3	4.2	24.9	8.0	0.8	20.3	19.9	0.1	1.5	8.2
	15-30	6.6	2.3	5.7	3.2	0.5	12.8	16.6	0.1	2.3	2.1
March, 1987	0-5	6.5	2.6	13.5	7.8	0.6	11.0	3.6	0.1	2.2	8.4
	5-15	6.6	1.0	2.1	1.4	0.4	6.3	0.8	0.1	2.8	3.0
	15-30	6.8	1.3	2.4	1.6	0.4	9.3	4.0	0.1	3.7	3.2
June, 1987	0-5	6.5	1.5	3.1	2.4	0.4	6.6	3.0	0.1	2.2	4.8
	5-15	6.6	2.1	11.7	3.0	0.6	9.9	2.9	0.1	2.7	5.2
	15-30	6.8	1.5	2.7	1.9	0.5	9.5	5.7	0.2	4.4	2.8

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Table 7
Chemical Composition of Reclaimed Wastewater Irrigation Soil at Site 4

Date	Depth (cm)	pH	EC (dS/m)	Cations (meq/L)				Anions (meq/L)			
				Ca^{++}	Mg^{++}	K^{+}	Na^{+}	Cl^{-}	NO_3^{-}	HCO_3^{-}	$SO_4^{=}$
August, 1985	0.5	7.1	3.8	14.1	10.0	0.7	24.8	20.8	0.7	5.2	18.3
	5-15	7.4	2.8	10.7	6.1	0.5	18.8	14.9	0.6	4.2	11.3
	15-30	7.6	2.2	9.2	6.2	0.4	15.8	10.4	0.4	3.6	9.6
March, 1986	0-5	7.1	0.8	2.1	0.8	0.4	8.4	1.1	0.2	5.1	1.5
	5-15	7.3	0.8	1.2	0.5	0.3	7.8	1.4	0.2	4.4	1.6
	15-30	7.3	0.9	1.1	0.4	0.4	7.2	2.0	0.2	4.0	2.4
June, 1986	0-5	6.7	3.3	13.6	10.0	1.7	17.3	23.4	0.5	3.6	3.2
	5-15	7.5	1.2	2.2	1.3	0.3	8.5	5.0	0.2	4.1	1.1
	15-30	7.9	1.0	1.5	1.0	0.2	7.8	1.3	0.2	3.3	2.4
September, 1986	0-5	7.2	1.7	3.5	2.4	0.6	11.5	7.5	0.1	4.0	2.9
	5-15	7.4	1.4	2.7	2.0	0.6	8.8	5.5	0.9	2.9	2.0
	15-30	7.3	1.2	2.2	1.8	0.4	8.4	3.9	0.5	3.8	1.8
December, 1986	0-5	6.8	1.7	4.4	2.8	0.3	12.3	6.2	0.1	4.0	3.9
	5-15	7.4	1.5	3.9	2.2	0.3	10.5	5.0	0.2	4.7	2.7
	15-30	7.4	1.4	4.0	2.6	0.4	9.7	4.5	0.3	4.7	2.8
March, 1987	0-5	6.9	1.7	3.1	2.7	0.5	11.2	10.7	0.1	2.9	1.8
	5-15	7.0	1.0	1.9	1.6	0.4	7.2	2.4	0.2	3.8	1.0
	15-30	7.0	1.2	2.6	2.2	0.4	8.5	2.5	0.1	3.9	2.9
June, 1987	0-5	7.0	1.8	3.8	3.3	0.5	11.3	11.4	0.5	2.9	3.4
	5-15	7.0	1.6	3.3	3.0	0.4	10.5	7.6	0.2	3.6	3.3
	15-30	7.2	1.0	2.9	2.1	0.6	9.7	4.6	0.1	3.5	3.8

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Table 8
Chemical Composition of Reclaimed Wastewater Irrigation Soil at Site 5

Date	Depth (cm)	pH	EC (mmho/cm)	Cations (meq/L)				Anions (meq/L)			
				Ca^{++}	Mg^{++}	K^{+}	Na^{+}	Cl^{-}	NO_3^{-}	HCO_3^{-}	$SO_4^{=}$
August, 1985	0.5	7.5	4.7	27.6	17.3	0.9	26.8	17.3	14.8	3.0	17.3
	5-15	7.7	2.4	6.6	4.0	0.3	16.0	6.7	7.6	2.7	10.8
	15-30	7.8	2.3	3.4	3.2	0.1	17.0	5.4	5.3	2.2	9.2
March, 1986	0-5	7.6	1.0	5.1	1.8	0.4	9.9	2.3	0.8	5.0	0.9
	5-15	7.6	1.1	1.7	0.6	0.3	9.6	3.2	0.9	4.4	0.8
	15-30	7.6	1.0	1.5	0.6	0.4	8.9	2.3	0.8	3.5	1.0
June, 1986	0-5	7.3	1.3	7.3	6.2	0.6	20.4	13.0	0.2	4.9	4.3
	5-15	7.7	0.9	2.0	1.1	0.2	12.0	5.4	0.3	4.1	3.9
	15-30	7.9	0.7	1.7	1.1	0.1	9.7	1.0	0.2	3.3	4.2
September, 1986	0-5	7.6	1.0	1.5	1.1	0.1	8.0	2.1	0.1	3.8	1.9
	5-15	7.6	1.4	2.2	1.8	0.2	9.8	8.8	0.3	3.1	1.3
	15-30	7.8	1.2	1.3	1.2	0.1	10.0	3.0	0.1	4.9	2.1
December, 1986	0-5	7.3	2.3	7.3	4.4	0.3	12.7	15.6	0.3	3.2	2.1
	5-15	7.7	0.9	2.8	1.4	0.1	6.7	1.1	0.2	3.5	2.0
	15-30	7.8	1.1	2.3	1.2	0.1	9.8	1.8	0.2	4.1	3.0
March, 1987	0-5	7.2	1.1	1.3	1.4	0.1	8.6	1.8	0.1	3.7	2.4
	5-15	7.1	1.1	1.8	1.7	0.1	7.9	2.3	0.1	4.0	2.6
	15-30	7.0	1.2	1.9	1.9	0.1	8.6	5.2	0.1	4.1	1.9
June, 1987	0-5	7.6	1.4	2.8	2.4	0.2	10.1	1.4	0.1	3.4	4.8
	5-15	7.5	1.0	1.7	1.4	0.2	8.1	3.9	0.2	3.2	2.4
	15-30	7.5	2.1	3.0	3.0	0.2	16.0	13.9	0.1	2.6	4.1

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Table 9
Chemical Composition of Irrigated Soil Along Highway Right-of-Ways in Riverside
(University Ave. Off-On Ramp of Hwy. 60)

Date	Depth (cm)	pH	EC (dS/m)	Cations (meq/L)				Anions (meq/L)			
				Ca^{++}	Mg^{++}	K^{+}	Na^{+}	Cl^{-}	NO_3^{-}	HCO_3^{-}	$SO_4^{=}$
August, 1985	0.5	7.1	1.6	8.4	2.8	1.1	13.2	10.1	1.6	5.0	4.2
	5-15	7.1	1.3	5.3	1.6	0.6	10.8	6.7	1.2	3.5	3.6
	15-30	7.0	1.2	4.1	1.2	0.4	9.7	4.7	0.9	3.2	3.2
March, 1986	0-5	7.3	0.9	6.7	1.4	0.7	6.9	2.0	0.3	5.2	1.6
	5-15	7.2	0.7	1.7	0.5	0.4	5.6	2.2	0.3	3.3	1.3
	15-30	7.1	0.7	1.2	0.4	0.3	5.5	3.1	0.3	2.3	1.0
June, 1986	0-5	7.4	0.9	4.6	1.7	0.4	7.4	2.1	1.1	4.8	0.8
	5-15	7.4	0.6	3.6	1.3	0.5	7.4	2.3	0.8	4.1	0.9
	15-30	7.5	0.7	2.7	1.0	0.3	6.6	2.0	0.6	3.5	0.5
September, 1986	0-5	7.5	1.3	4.9	2.9	0.7	8.5	3.1	2.7	4.6	1.7
	5-15	7.5	0.8	4.0	1.6	0.3	5.6	0.3	0.1	3.4	1.3
	15-30	7.4	0.9	5.4	1.9	0.4	4.7	1.8	0.5	2.9	0.9
December, 1986	0-5	7.4	1.1	3.8	1.3	0.2	10.2	1.4	0.1	5.9	1.5
	5-15	7.3	1.1	5.1	1.6	0.5	6.5	2.8	0.1	3.5	1.5
	15-30	7.4	1.8	5.5	2.1	0.9	11.3	8.5	0.5	3.4	2.6
March, 1987	0-5	6.9	1.0	3.3	1.8	0.3	6.4	2.7	0.1	3.7	2.2
	5-15	7.1	2.2	6.1	2.8	0.5	12.7	13.7	0.1	4.5	1.8
	15-30	7.0	2.8	5.8	3.2	2.6	14.7	10.8	1.0	2.8	0.9
June, 1987	0-5	7.1	2.2	5.0	3.0	0.5	13.2	12.3	0.6	3.8	2.7
	5-15	7.1	1.7	5.1	2.2	0.4	8.5	7.2	0.1	3.9	2.8
	15-30	7.1	2.0	4.8	2.5	1.1	10.0	11.0	2.1	3.0	2.2

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Table 10
Chemical Composition of Irrigated Soil at UCR Campus

Date	Depth (cm)	pH	EC (dS/m)	Cations (meq/L)				Anions (meq/L)			
				Ca^{++}	Mg^{++}	K^{+}	Na^{+}	Cl^{-}	NO_3^{-}	HCO_3^{-}	$SO_4^{=}$
August, 1985	0-5	7.3	0.7	4.4	1.1	0.5	2.7	1.1	0.9	3.7	1.3
	5-15	7.2	0.5	2.9	0.6	0.4	2.2	0.9	0.4	2.4	0.9
	15-30	7.2	0.5	2.1	0.4	0.2	1.8	0.8	0.1	2.1	0.8
March, 1986	0-5	7.3	0.6	8.3	1.1	0.6	1.2	0.5	0.4	3.1	1.0
	5-15	7.3	0.4	2.6	0.5	0.3	1.5	0.4	0.4	1.8	0.9
	15-30	7.3	0.3	1.6	0.3	0.3	1.2	0.2	0.2	1.6	0.6
June, 1986	0-5	7.4	0.7	4.9	1.3	0.6	3.0	1.9	0.6	3.0	1.2
	5-15	7.3	0.5	4.2	0.8	0.3	2.1	1.2	0.3	2.0	0.6
	15-30	7.4	0.3	3.9	0.5	0.1	1.8	0.6	0.2	1.7	0.3
September, 1986	0-5	7.6	0.9	5.9	1.6	0.3	4.5	2.1	0.1	2.7	1.5
	5-15	7.6	0.7	4.1	1.0	0.4	4.3	0.7	0.1	3.2	0.7
	15-30	7.5	0.6	3.7	0.8	0.4	3.6	0.8	0.1	3.1	0.5
December, 1986	0-5	7.5	0.5	3.3	0.9	0.4	3.1	0.6	0.1	3.0	0.8
	5-15	7.5	0.5	2.9	0.7	0.5	3.7	0.5	0.2	3.0	0.8
	15-30	7.5	0.5	2.6	0.7	0.5	4.4	0.7	0.1	3.4	1.0
March, 1987	0-5	7.4	0.5	1.9	0.7	0.3	2.8	0.7	0.1	3.4	0.4
	5-15	7.4	0.6	2.3	0.8	0.6	2.9	0.8	0.1	3.3	0.4
	15-30	7.2	0.5	2.0	0.8	0.5	2.7	0.7	0.1	2.5	0.4
June, 1987	0-5	7.3	0.7	2.4	0.8	0.4	3.5	1.3	0.1	2.8	1.0
	5-15	7.2	0.7	2.4	0.8	0.4	3.6	1.4	0.3	2.4	0.9
	15-30	7.3	0.7	2.5	0.9	0.3	3.8	1.4	0.1	2.6	1.2

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Table 11
Heavy Metal Contents of Soils at Site 1

Date	Depth	Cd	Cr	Cu	Ni	Pb	Zn
	(cm)	(mg/kg)					
August, 1985	0-5	3.4	39	29	42	42	83
	5-15	3.4	40	29	45	22	75
	15-30	3.0	36	23	42	11	67
March, 1986	0-5	2.2	32	25	37	33	91
	5-15	2.1	32	24	36	25	84
	15-30	2.0	32	23	34	10	76
June, 1986	0-5	1.8	35	20	41	30	88
	5-15	2.6	43	25	44	35	105
	15-30	3.2	33	25	36	17	104
September, 1986	0-5	3.2	33	29	33	56	95
	5-15	2.5	29	25	25	35	76
	15-30	1.0	28	24	23	29	73
December, 1986	0-5	2.1	32	29	43	45	92
	5-15	2.0	32	28	44	17	82
	15-30	2.3	37	27	49	9	77
March, 1987	0-5	2.0	40	29	43	45	92
	5-15	1.7	38	28	38	18	80
	15-30	1.6	44	26	33	14	73
June, 1987	0-5	2.0	38	30	62	43	108
	5-15	1.6	38	30	64	23	99
	15-30	1.6	35	30	62	13	89

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Table 12
Heavy Metal Contents of Soils at Site 2

Date	Depth	Cd	Cr	Cu	Ni	Pb	Zn
	(cm)	(mg/kg)					
August, 1985	0-5	7.4	50	38	49	38	91
	5-15	7.7	52	38	51	24	102
	15-30	6.3	52	36	50	15	100
March, 1986	0-5	6.6	43	32	41	45	133
	5-15	6.4	43	30	43	32	128
	15-30	6.4	43	29	43	15	129
June, 1986	0-5	7.2	53	31	48	33	134
	5-15	6.6	49	30	44	26	131
	15-30	5.8	52	34	44	16	126

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Table 13
Heavy Metal Contents of Soils at Site 3

Date	Depth	Cd	Cr	Cu	Ni	Pb	Zn
	(cm)	(mg/kg)					
August, 1985	0-5	4.1	47	34	39	122	114
	5-15	3.0	40	24	40	74	74
	15-30	2.2	30	23	36	35	70
March, 1986	0-5	4.7	33	28	34	232	148
	5-15	4.9	35	28	39	54	128
	15-30	1.9	30	23	29	40	85
June, 1986	0-5	5.4	38	28	34	218	157
	5-15	5.6	36	25	38	81	134
	15-30	2.1	28	18	29	14	78
September, 1986	0-5	5.8	39	31	40	149	205
	5-15	3.8	29	23	31	57	87
	15-30	2.4	25	19	28	33	70
December, 1986	0-5	6.0	55	31	56	145	175
	5-15	2.6	45	24	43	28	88
	15-30	1.2	31	19	29	16	66
March, 1987	0-5	4.5	44	30	36	176	166
	5-15	4.4	51	28	46	45	99
	15-30	3.8	46	29	43	24	92
June, 1987	0-5	5.7	46	32	44	228	182
	5-15	3.0	41	25	36	46	113
	15-30	1.8	37	23	32	24	94

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Table 14
Heavy Metal Contents of Soils at Site 4

Date	Depth	Cd	Cr	Cu	Ni	Pb	Zn
	(cm)	(mg/kg)					
August, 1985	0-5	1.8	18	12	15	31	59
	5-15	1.7	18	11	16	22	56
	15-30	1.7	18	10	18	22	46
March, 1986	0-5	2.1	20	18	14	35	103
	5-15	1.5	16	13	10	20	64
	15-30	1.4	14	12	9	15	54
June, 1986	0-5	2.2	35	21	18	41	139
	5-15	1.3	27	14	14	21	77
	15-30	1.1	26	12	12	18	57
September, 1986	0-5	2.6	25	22	15	53	128
	5-15	2.0	23	18	11	36	90
	15-30	2.0	20	14	9	34	65
December, 1986	0-5	1.6	26	23	17	35	101
	5-15	1.2	21	17	12	20	73
	15-30	1.1	19	15	11	15	65
March, 1987	0-5	1.8	30	23	17	45	107
	5-15	1.0	23	16	12	20	72
	15-30	1.0	20	14	9	18	64
June, 1987	0-5	1.7	30	23	18	42	130
	5-15	0.9	25	18	14	24	89
	15-30	0.8	21	13	12	14	63

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Table 15
Heavy Metal Contents of Soils at Site 5

Date	Depth	Cd	Cr	Cu	Ni	Pb	Zn
	(cm)	(mg/kg)					
August, 1985	0-5	0.9	18	9	13	101	47
	5-15	0.8	18	9	14	34	38
	15-30	0.7	19	9	16	11	37
March, 1986	0-5	0.6	16	13	9	395	110
	5-15	0.3	14	11	9	156	66
	15-30	0.3	14	10	8	57	44
June, 1986	0-5	0.7	29	13	12	406	132
	5-15	0.5	27	10	12	266	81
	15-30	0.3	28	9	12	28	38
September, 1986	0-5	0.3	16	10	6	228	79
	5-15	0.3	14	9	7	59	43
	15-30	0.4	14	9	7	29	37
December, 1986	0-5	0.5	16	12	9	326	91
	5-15	0.3	14	9	9	65	46
	15-30	0.3	14	9	10	13	38
March, 1987	0-5	0.1	19	12	10	301	79
	5-15	0.1	21	11	11	64	51
	15-30	0.1	19	9	9	23	50
June, 1987	0-5	0.2	18	9	11	255	73
	5-15	0.1	19	10	12	62	49
	15-30	0.1	22	11	14	19	48

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Table 16
Heavy Metal Contents of Soils at Riverside

Date	Depth	Cd	Cr	Cu	Ni	Pb	Zn
	(cm)	(mg/kg)					
August, 1985	0-5	0.4	12	10	10	86	89
	5-15	0.2	12	10	11	35	87
	15-30	0.1	11	9	11	24	72
March, 1986	0-5	0.2	10	11	6	54	92
	5-15	0.1	9	10	6	41	71
	15-30	0.1	8	10	5	51	84
June, 1986	0-5	0.2	11	10	5	75	111
	5-15	0.1	11	10	5	48	99
	15-30	0.1	10	11	5	29	94
September, 1986	0-5	0.6	10	13	5	88	104
	5-15	0.5	9	12	5	46	82
	15-30	0.5	7	12	4	38	77
December, 1986	0-5	<0.1	12	12	6	68	99
	0-15	<0.1	12	16	7	44	93
	15-30	<0.1	12	60	6	16	65
March, 1987	0-5	<0.1	15	13	7	89	114
	5-15	<0.1	13	12	6	46	88
	15-30	<0.1	11	10	5	28	76
June, 1987	0-5	<0.1	13	14	6	80	133
	5-15	<0.1	12	11	6	26	74
	15-30	<0.1	10	10	5	18	66

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Table 17
Heavy Metal Contents of Soils at UCR

Date	Depth	Cd	Cr	Cu	Ni	Pb	Zn
	(cm)	(mg/kg)					
August, 1985	0-5	0.9	14	9	10	88	118
	5-15	0.5	9	5	8	17	70
	15-30	0.1	8	6	8	8	57
March, 1986	0-5	0.9	15	11	5	105	176
	5-15	0.2	7	5	2	13	64
	15-30	0.1	4	13	2	4	50
June, 1986	0-5	0.4	12	8	4	59	120
	5-15	0.1	9	5	2	16	73
	15-30	0.1	7	4	1	6	60
September, 1986	0-5	0.3	11	10	4	76	112
	5-15	0.2	8	8	3	17	72
	15-30	0.1	7	6	2	10	60
December, 1986	0-5	<0.1	14	10	5	75	137
	5-15	<0.1	9	7	4	13	68
	15-30	<0.1	7	6	3	8	59
March, 1987	0-5	<0.1	13	10	5	64	113
	5-15	<0.1	9	7	3	10	66
	15-30	<0.1	8	6	3	7	59
June, 1987	0-5	0.3	16	11	5	62	155
	5-15	<0.1	8	7	3	14	66
	15-30	<0.1	6	5	2	5	60

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Table 18
Elemental Contents of Eucalyptus Leaf at Site 1

Element†	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	6200-14600	10320	3180	7260-12800	10312	1901	6270-18400	11518	5132	10400-20400	13480	4150
Mg	2100-3700	2780	700	1750-3750	2874	745	1720-3340	2624	671	1990-3320	2694	521
Na	1300-2550	1870	565	2110-3040	2790	706	1390-2650	1838	504	1450-2440	1770	401
K	4500-7850	6110	1525	6650-10700	7004	2085	4770-6710	5410	800	4470-9350	6496	2068
B	78-152	121	28	93-174	124	36	66-87	76	9	77-157	109	30
Cu	13-24	17	5	6-24	10	8	4-6	4.4	0.9	6-7	6.2	0.4
Cd	1.2-2.6	1.7	0.6	0.3-5.1	1.7	2.0	0.1-2.1	1.0	0.8	0.3-1.5	0.8	0.5
Zn	19-35	26	6	24-32	30	3	19-52	30	13	20-33	25	4.8
P	750-3830	2090	1228	1190-1850	1474	289	1120-3130	1774	785	1400-3330	2042	746
Fe	120-162	140	16	182-262	216	30	90-134	117	20	113-204	153	33
Mn	36-85	61	23	60-177	91	49	65-154	107	39	100-224	147	49

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Table 18 (continued)

Element[†]	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	8310-30100	14086	9224	7860-26700	13792	7803	5330-20600	11238	5682	4810-17200	9636	4807
Mg	1500-4000	2540	932	1980-4940	3244	1200	1390-3390	2860	834	2080-3760	2606	677
Na	970-2840	1714	751	1710-3720	2810	993	1250-3710	2256	908	1940-3110	2438	477
K	4060-7340	6198	1436	3010-5440	4552	1032	3130-6110	4166	744	6120-9770	7330	1435
B	84-170	140	35	108-169	148	25	113-195	148	31	84-140	113	21
Cu	4-12	6.6	3.4	4-5	4.4	0.5	4-5	4.6	0.5	4-8	6.0	1.6
Cd	0.1-1.1	0.7	0.4	0.5-1.9	1.0	0.6	0.1-3.8	1.4	1.5	0-0.5	0.3	0.2
Zn	21-36	28.0	6.8	18-45	26.2	9.6	16-32	22.2	6.1	14-38	22.8	9.8
P	1510-3310	2062	905	901-3990	2064	1283	1080-3850	2158	1043	1660-3130	2400	695
Fe	138-208	177	31	137-243	193	53	104-178	152	28	134-291	200	63
Mn	58-240	137	72	92-183	132	46	57-160	130	49	78-197	124	53

[†]Concentrations of elements are expressed in mg/kg dry wt.

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Table 19
Elemental Contents of Eucalyptus Leaf at Site 2

Element†	August 1986			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	6700-20000	13700	5390	6780-39900	18436	12722	7370-28200	10254	8784	9200-23000	13620	5774
Mg	2200-3400	2700	476	1900-5390	3414	1253	1840-4300	3262	912	2240-4780	3144	1034
Na	240-1370	702	513	1050-2480	1766	637	721-1480	1012	371	563-2640	1619	941
K	5600-13300	7940	3260	4380-9060	6326	2108	3790-5690	4980	753	5310-14600	9014	3445
B	64-136	94	31	92-128	114	17	63-141	105	28	37-113	81	33
Cu	7-18	11	5	4-6	5	1	4-5	4.2	0.4	5-8	6.8	1.3
Cd	0.1-7.6	2.2	3.1	0.1-3.2	1.3	1.3	0.1-4.0	1.5	1.7	0.1-1.9	0.8	0.8
Zn	10-68	25	24	10-48	25	14	11-67	31	22	12-43	27	14
P	710-1320	904	253	887-1300	1130	190	726-2500	1212	737	1010-2340	1526	503
Fe	112-285	201	100	148-326	227	67	92-177	135	36	107-276	182	76
Mn	93-201	164	45	81-185	120	56	90-203	141	57	102-321	177	99

†Concentrations of elements are expressed in mg/kg dry wt.

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Table 20
Elemental Contents of Eucalyptus Leaf at Site 3

Element[1]	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	6200-21600	11980	5750	0430-18900	16006	5124	9700-24400	18560	6534	6620-21700	14264	5731
Mg	1360-2650	2060	560	2000-3310	2478	461	1640-2800	2478	479	1580-2050	2178	495
Na	400-1060	760	273	985-1490	1173	207	741-1260	1005	188	1000-1660	1318	265
K	8550-12400	10250	1393	7330-10200	8584	1154	5010-9110	6534	1634	6200-15000	9522	3525
B	77-219	120	56	90-164	125	27	109-196	141	35	55-169	124	50
Cu	6-16	10	4	2-7	4	2	3-5	3.6	0.9	5-7	6	0.7
Cd	0.1-2.2	0.8	0.9	0.1-0.3	0.2	0.2	0-0.3	0.2	0.1	0.1-0.4	0.1	0.1
Zn	14-22	16	3	14-21	17	3	12-22	18	3.8	18-26	23	6
P	860-1730	1190	361	847-1780	1335	439	830-1980	1465	589	1110-2100	1562	355
Fe	116-240	200	62	140-256	199	49	133-204	164	26	73-161	125	32
Mn	31-128	68	40	39-130	90	47	40-207	107	63	27-147	90	50

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Table 20 :(continued)

Element†	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	5070-27300	12964	8517	9730-19100	12942	3991	8790-20300	12998	4454	10300-20000	15900	4270
Mg	1560-2236	2236	629	2010-3640	2628	634	1460-4480	2572	1183	2310-4160	3248	727
Na	352-815	540	198	1110-4010	2228	1166	1080-1710	1284	263	1250-3540	2088	891
K	4680-16200	9662	4010	5160-12000	8274	2734	2260-12900	7190	4141	4660-14200	6364	2780
B	79-185	113	43	104-199	145	39	117-221	172	37	102-220	172	57
Cu	4-8	5.8	1.5	4-6	5.0	0.7	2-6	4.6	1.7	6-7	6.2	0.4
Cd	<0.1-0.2	0.1	0.1	0.1-0.5	0.3	0.2	0-0.2	0.1	0.1	0-0.2	0.1	0.1
Zn	14-22	18.4	4.0	16-28	20.4	4.6	14-22	17.2	3.3	16-38	23.0	9.5
P	706-2120	1226	564	602-1400	1043	291	606-2320	1565	660	912-1930	1345	435
Fe	104-275	171	66	100-171	135	28	179-303	221	48	79-159	125	33
Mn	21-125	63	43	42-107	66	25	46-132	87	36	46-231	180	76

†Concentrations of elements are expressed in mg/kg dry wt.

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Table 21
Elemental Contents of Eucalyptus Leaf at Site 4

Element†	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	3900-9600	6060	2300	2970-11100	7150	3046	6010-12600	10422	3022	5340-12000	10548	3016
Mg	2500-3900	2890	585	2220-3450	2892	516	1550-2700	2246	487	2250-3000	3036	744
Na	670-4900	2054	1690	1370-3650	2508	1068	708-2070	1294	571	710-2280	1401	758
K	3500-8500	5230	1950	3720-10100	6044	2612	2710-4330	3596	594	2720-4000	3468	605
B	110-235	171	56	112-165	135	20	95-195	139	45	96-260	164	70
Cu	9-14	11	2	4-8	7	2	6-7	6.6	0.5	5-6	5.4	0.5
Cd	0.3-1.0	0.7	0.3	0.1-0.8	0.4	0.3	0.2-0.4	0.3	0.1	0.1-0.4	0.2	0.1
Zn	14-31	19	7	12-25	19	6	16-34	22	7	13-25	20	5
P	700-1980	1210	494	603-1390	951	306	404-993	769	250	752-1350	1046	254
Fe	84-145	106	24	126-139	131	6	98-192	133	37	92-166	117	29
Mn	44-177	112	57	63-199	112	54	104-276	177	79	80-299	190	97

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Table 21 (continued)

Element†	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	4210-13600	8880	3421	5050-16700	10218	4511	3730-12800	7990	3259	2860-9820	6646	2499
Mg	2750-3590	2912	502	2320-4160	2996	723	2410-3970	3338	652	2060-3590	3152	635
Na	661-1300	1100	380	1770-2840	2292	382	1770-3850	2624	761	2140-4650	3312	1223
K	3190-4650	3822	656	3560-4400	4060	388	3110-6530	4626	1275	4630-9150	6900	2014
B	97-189	144	40	104-276	176	66	98-199	152	44	70-218	143	67
Cu	4-7	5.2	1.3	4-5	4.2	0.4	5-7	6.0	1.0	5-11	8.0	2.4
Cd	0.1-0.4	0.3	0.2	0-0.6	0.2	0.2	0.1-0.7	0.3	0.3	0-0.2	0.1	0.1
Zn	16-29	22.0	5.1	10-24	16.2	5.2	13-34	22.0	7.8	9-25	18.2	6.6
P	954-2040	1477	444	598-1970	1125	507	917-1480	1181	213	1210-1700	1430	220
Fe	90-211	135	48	89-252	138	65	103-200	127	45	78-191	117	45
Mn	72-176	125	40	100-211	137	51	84-228	125	59	67-145	97	43

†Concentrations of elements are expressed in mg/kg dry wt.

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Table 22
Elemental Contents of Eucalyptus Leaf at Site 5

Element†	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	4000-7500	5500	1263	11200-26000	18580	5307	7730-21700	14326	6337	8770-15200	12574	2611
Mg	1400-2300	1760	378	2980-5350	4146	888	1640-3790	2832	814	2250-3950	2950	628
Na	3700-6500	4320	1221	1680-3260	2608	810	817-2870	1757	735	1220-4170	2308	1116
K	5700-9700	7140	1608	6030-10200	6380	2191	4020-8600	5568	2100	5210-12900	7884	3047
B	50-270	111	90	182-566	320	156	109-397	211	116	60-247	165	64
Cu	10-19	14	4	7-11	9	2	5-9	6.4	1.7	6-8	7	1
Cd	0.6-2.2	1.3	0.7	0.1-1.3	0.6	0.5	0-0.3	0.1	0.1	0-0.3	0.2	0.1
Zn	18-25	19	3	40-85	59	18	38-77	49	16	24-55	40	14
P	570-1090	866	211	879-1830	1302	409	998-1480	1186	183	920-1800	1432	366
Fe	73-171	108	40	133-200	169	29	98-136	120	15	90-136	111	23
Mn	141-297	187	69	156-264	202	51	145-174	155	22	88-204	143	44

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Table 22 (continued)

Element†	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	4910-20200	10172	6220	5560-18200	10090	5595	4520-18900	12066	6816	4340-12900	8428	3157
Mg	2130-3620	2680	618	2320-4210	3018	737	2120-5490	3550	1362	2350-5040	3258	1075
Na	1010-6120	2848	2080	1310-4990	3350	1315	1370-4400	3212	1342	2360-7250	5190	1922
K	4180-12400	7700	3500	3780-8670	6576	1930	4280-6870	5394	1112	5920-14100	9778	3393
B	100-564	279	188	99-474	278	177	102-437	238	126	105-163	136	24
Cu	5-12	8.4	2.5	6-8	7.0	0.7	5-8	7.0	1.4	8-12	10.2	1.6
Cd	<0.1-0.3	0.1	0.1	0-0.5	0.3	0.3	0.1-0.7	0.3	0.2	0-0.2	0.1	0.1
Zn	25-36	31.8	4.4	32-39	36.0	3.2	36-70	45.0	14.4	19-42	28.8	10.8
P	782-1160	980	178	846-1920	1267	413	887-1350	1072	176	1150-2130	1684	431
Fe	113-198	141	34	116-234	147	49	80-194	125	43	76-167	120	35
Mn	54-147	103	37	76-202	124	51	62-244	137	82	60-202	126	88

†Concentrations of elements are expressed in mg/kg dry wt.

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Table 23
Elemental Contents of Eucalyptus Leaf at Riverside

Element†	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	5900-15500	10080	4050	4930-18500	10934	6138	9120-25500	17264	5793	12800-28400	19360	6429
Mg	1610-2250	1890	261	1610-2750	1968	451	590-2590	1804	798	1350-2850	1992	720
Na	640-3630	2315	1380	914-4220	2137	1367	610-3220	1953	1159	824-3850	2457	1321
K	4150-11800	9330	2980	4670-14900	9206	4200	4960-8410	6983	1885	5560-10600	7348	1908
B	148-272	209	53	110-174	143	24	151-340	230	78	152-283	230	60
Cu	8-16	11	3	4-9	7	3	5-9	6.4	1.7	5-8	7	1.4
Cd	0.1-0.5	0.2	0.2	0.1-0.5	0.2	0.2	<0.1	<0.1	0	0-0.1	<0.1	0
Zn	17-35	24	8	15-27	23	5	15-42	23	11	16-43	27	11
P	1020-1540	1308	192	1110-1360	1226	94	801-1310	978	214	779-1360	1028	210
Fe	67-139	103	33	94-147	115	26	93-215	123	52	93-225	145	61
Mn	21-94	60	29	20-130	69	42	49-182	103	49	61-211	129	56

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Table 23 (continued)

Element[f]	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	3950-13400	8730	3356	3590-15400	8782	4736	6690-14000	9020	3708	7560-19500	14932	5617
Mg	1550-2060	1812	188	1670-2550	2180	358	1190-2200	1738	418	1230-2990	2046	727
Na	586-3290	2053	1177	1260-4940	2702	1667	623-4220	2217	1710	678-4210	2009	1621
K	4570-13900	8476	3599	5340-16800	9402	4835	4510-8170	5996	1414	4710-10500	6788	2540
B	95-216	131	49	134-229	178	36	144-287	198	54	125-253	200	55
Cu	7-11	8.6	1.7	3-9	5.8	2.2	4-13	7.4	3.4	7-9	7.6	0.9
Cd	<0.1	<0.1	0	0	0	0	0-0.4	0.1	0.2	0	0	0
Zn	18-28	23.0	3.6	13-23	19.2	3.8	13-24	20.6	4.5	16-33	22.6	7.2
P	1090-1600	1280	197	1060-1550	1280	179	950-1440	1117	199	850-1390	1067	199
Fe	73-99	84	10	73-143	106	25	79-154	108	34	110-250	158	54
Mn	22-61	46	15	24-102	70	34	27-110	66	33	60-185	130	65

[f]Concentrations of elements are expressed in mg/kg dry wt.

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Table 24
Elemental Contents of Eucalyptus Leaf at UCR

Element†	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	10000-26500	17560	6620	16300-25900	21760	3728	9060-29900	17892	8983	13100-25400	20620	5141
Mg	1740-3220	2560	564	1940-3410	2746	690	1500-3070	2340	698	1760-3050	2498	543
Na	320-474	403	60	794-1280	972	197	532-723	610	71	614-1070	753	188
K	9160-12700	10790	1360	8240-14900	10828	2456	6500-11100	8280	1726	7420-14000	10064	2661
B	218-445	205	93	143-251	181	41	132-242	179	42	98-301	199	72
Cu	8-14	12	3	2-8	5	2	3-6	4	1.2	4-13	6.2	3.8
Cd	0.3-1.4	0.9	0.5	0.1-0.6	0.2	0.2	<0.1	<0.1	0	<0.1	<0.1	0
Zn	16-33	21	7	11-31	20	7	10-21	15	5	13-25	19	6
P	625-1720	1180	410	801-3700	1856	1200	807-2010	1138	496	959-1990	1336	431
Fe	121-251	155	56	127-245	166	50	82-162	133	31	96-201	155	42
Mn	68-117	92	20	57-207	104	62	39-187	111	60	72-194	138	46

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Table 24 (continued)

Element†	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	6410-20700	13162	5477	5900-15100	11632	4236	10300-23000	14460	4917	10500-23500	16800	5980
Mg	1270-2730	1908	536	1600-2820	2272	549	2180-2670	2316	210	2320-2800	2464	191
Na	251-431	345	69	942-1440	1204	186	542-1100	953	234	747-1170	967	165
K	8210-15300	10670	2085	8620-10600	9870	806	4090-7630	5894	1522	5720-8390	7102	1198
B	121-198	167	29	90-288	162	76	130-269	216	65	128-240	193	46
Cu	2-7	3.2	2.2	4-7	5.4	1.1	3-5	4.0	0.7	5-7	5.4	0.9
Cd	<0.1	<0.1	0	0.1-0.3	0.2	0.1	0-0.3	0.1	0.1	0	0	0
Zn	13-24	15.0	5.3	9-25	16.2	5.8	9-28	15.0	6.8	9-19	13.0	14.2
P	847-2090	1328	517	906-2330	1635	640	817-1580	1171	342	857-1830	1372	457
Fe	82-128	101	20	84-171	117	42	86-242	132	64	84-110	95	14
Mn	45-211	96	66	46-217	99	60	51-179	103	54	105-156	135	22

†Concentrations of elements are expressed in mg/kg dry wt.

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Table 25
Elemental Contents of Oleander Leaf at Site 1

Element†	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	32700-38500	35920	2335	31200-40200	35580	3284	27800-51900	37840	8930	24900-38500	29400	5577
Mg	3000-4600	3740	655	2970-4030	3340	493	1640-3300	2472	593	2370-3100	2706	270
Na	910-2200	1202	525	475-2000	1141	584	1130-1990	1436	358	1020-1810	1338	381
K	7500-14400	11500	2835	10500-16800	13260	2682	7480-13100	9988	2031	13700-15200	14240	643
B	102-132	118	12	85-114	98	12	76-100	83	10	39-70	55	15
Cu	14-22	18	3	6-10	8	2	5-10	7	2	8-12	10	2
Cd	0.1-1.6	0.9	0.6	0.3-1.3	0.7	0.4	0.1-0.4	0.4	0.3	0.1-0.9	0.3	0.3
Zn	18-39	27	8	22-37	25	7	17-26	21	4	17-39	24	9
P	1570-2360	1968	305	1520-3040	2406	567	2080-3760	2800	649	1810-2250	1936	189
Fe	81-223	142	65	146-232	192	36	64-142	106	30	88-143	115	24
Mn	29-69	48	15	30-63	47	15	26-53	38	10	30-43	35	5

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Table 25(continued)

Element†	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	29600-42300	35300	5286	20300-34800	27440	5693	22500-36600	30600	5348	16100-24100	20060	3777
Mg	3440-4630	3830	512	2280-4150	3104	778	1640-3280	2470	600	2650-3120	2858	191
Na	1340-2310	1602	426	1600-2700	2148	478	1110-2460	1628	582	943-3190	2001	924
K	10800-17300	15100	2527	9640-15300	12988	2208	6890-11800	9564	1994	15600-17000	16500	624
B	92-112	100	8	101-166	126	26	104-148	131	17	45-79	64	12
Cu	5-11	7.0	2.4	7-12	9.0	1.9	5-7	6.2	0.8	7-12	9.4	2.1
Cd	0.2-1.0	0.5	0.3	0.1-0.7	0.3	0.2	0.1-0.9	0.4	0.3	0-0.6	0.2	0.2
Zn	15-29	24.6	5.5	16-23	17.8	2.9	14-27	20.0	6.0	17-19	17.8	0.8
P	1740-2690	2080	359	1970-2450	2236	189	2050-2850	2424	303	2050-2370	2190	156
Fe	131-195	159	30	101-134	122	14	77-157	106	31	94-167	139	30
Mn	20-67	43	17	26-51	39	11	26-53	38	11	25-44	34	7

†Concentrations of elements are expressed in mg/kg dry wt.

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Table 26
Elemental Contents of Oleander Leaf at Site 2

Element†	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	26100-35100	30640	3620	26200-41100	36200	6586	21500-35200	28800	6138	24400-38300	29140	5704
Mg	3350-4000	3760	243	3320-4540	3892	443	1720-2910	2312	541	2460-3940	3164	777
Na	260-340	308	38	270-380	321	54	553-659	590	43	612-712	657	42
K	9800-14700	11560	2217	11000-14800	12140	1526	7530-12500	9738	2004	9870-17500	13042	3329
B	76-120	90	18	63-104	90	16	67-101	82	13	31-61	48	12
Cu	11-18	14	3	8-10	9	1	6-12	8.6	2.4	9-14	11.2	2.2
Cd	0.8-1.3	1.0	0.2	0.6-1.0	0.8	0.2	0.4-0.6	0.4	0.1	0.2-0.8	0.6	0.2
Zn	20-24	22	2	21-28	25	3	19-27	22	3.5	22-39	28	8
P	1290-2170	1676	336	1670-2370	1978	306	1770-2460	2014	316	1430-2400	1878	369
Fe	91-151	124	27	160-262	214	38	83-126	97	17	96-136	111	15
Mn	38-61	53	9	56-90	69	17	34-95	53	24	39-72	54	12

†Concentrations of elements are expressed in mg/kg dry wt.

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Table 27
Elemental Contents of Oleander Leaf at Site 5

Element[1]	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	31600-44900	38600	4846	24700-38600	32480	6123	21900-42600	28920	8021	24700-33000	27540	3269
Mg	4000-5800	5040	684	3520-5220	4370	693	2210-3010	2762	319	3500-4160	3828	266
Na	660-850	738	71	543-817	646	112	732-1250	961	190	767-801	790	14
K	7300-10200	8600	1125	10400-15400	12420	1906	8950-13500	10292	1852	11000-13200	12140	856
B	133-227	178	36	119-160	138	19	114-127	122	5	68-77	72	4
Cu	14-21	16	3	7-12	9	2	5-14	8.2	3.5	6-10	7.6	1.5
Cd	0.5-1.4	0.9	0.4	0.2-0.4	0.3	0.1	0-0.1	0.1	0.04	0-0.1	<0.1	0
Zn	16-32	24	7	23-40	30	7	25-52	33	12	23-25	24	1
P	1460-2190	1752	343	2110-3350	2542	502	1470-3190	2026	683	1880-2120	2012	95
Fe	92-169	116	35	143-166	158	9	112-178	138	27	86-121	103	14
Mn	56-95	68	15	49-65	54	8	35-71	56	15	35-50	42	6

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Table 27 (continued)

Element[†]	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	21400-30000	27540	7310	13300-21200	18840	3228	13400-23800	17200	4112	18100-21400	19440	1403
Mg	3100-5190	4036	840	2400-3500	3128	427	1970-3120	2500	465	2140-4540	3304	1100
Na	1130-1350	1288	86	1170-1660	1404	188	1010-1340	1152	131	843-1140	1035	117
K	10000-15700	12920	2086	8920-11900	10408	1135	6270-9120	8280	1193	9580-15300	12436	2375
B	106-126	114	9	105-121	113	6	64-105	90	16.3	59-122	83	26
Cu	6-13	8.0	2.8	9-15	11.8	2.4	5-9	6.8	1.5	8-12	9.8	1.8
Cd	0.1-0.3	0.2	0.1	0-0.2	0.1	0.1	0-0.2	0.1	0.1	0-0.7	0.2	0.3
Zn	22-29	26.2	2.8	23-31	27.4	3.6	23-31	25.2	3.3	18-21	18.6	1.3
P	2010-2380	2194	158	2330-3040	2656	264	1900-3170	2322	495	1860-2290	2032	178
Fe	92-131	110	18	100-160	124	23	94-133	110	17	80-144	103	24
Mn	27-48	37	8	30-59	44	11	27-45	37	7	31-41	36	5

[†]Concentrations of elements are expressed in mg/kg dry wt.

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Table 28
Elemental Contents of Oleander Leaf at UCR

Element†	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	26000-47600	38520	8620	23100-38600	30380	5876	21200-37800	30640	6624	20100-26500	22560	2550
Mg	2850-3350	3140	264	2470-3470	3048	440	1960-2800	2340	323	2020-2220	2136	81
Na	650-1500	1230	342	948-1370	1095	164	1010-1600	1356	299	657-1010	897	139
K	10900-12000	13020	2200	11800-17200	16040	4335	7770-15700	10808	3160	13900-18000	17860	3272
B	97-202	165	46	100-145	112	19	88-121	103	13	40-66	51	9
Cu	8-20	13	6	7-11	8	2	5-7	6	0.7	6-7	7	0.4
Cd	0.1-2.1	0.8	0.8	0.1-0.6	0.2	0.2	0-0.1	<0.1	0	0-0.1	<0.1	0
Zn	23-45	37	10	24-49	32	10	24-43	35	8	19-24	22	2
P	910-1580	1322	286	1260-1700	1558	172	1080-1750	1396	248	1350-1710	1578	152
Fe	178-229	202	24	166-209	188	16	85-141	113	21	96-139	115	18
Mn	39-64	52	10	32-44	37	5	24-46	33	8	26-35	30	4

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Table 28 (continued)

Element[†]	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	25000-43400	33840	7867	18000-29700	24360	4185	19500-29600	24900	3726	17200-28900	21680	4430
Mg	2810-3600	3160	379	2290-2920	2590	258	1820-2620	2270	311	1920-2500	2294	239
Na	1270-1900	1660	237	1360-2070	1682	320	1210-2560	1860	554	1090-1680	1418	262
K	14500-23200	18120	3771	12800-17900	14940	1872	5590-11000	8786	2179	16200-22600	18720	2720
B	89-117	104	12	82-135	112	22	71-113	100	17	79-95	85	7
Cu	4-9	6.0	2.0	6-11	7.8	2.2	3-6	4.6	1.1	7-13	9.0	2.5
Cd	<0.1-0.4	0.1	0.1	0	0	0	0-0.2	0.1	0.1	0	0	0
Zn	22-36	29.0	5.6	24-31	28.8	2.9	19-33	25.6	5.3	21-25	23.4	1.5
P	1430-2080	1730	235	1670-1890	1796	99	1360-1770	1650	179	1750-2370	2064	284
Fe	115-143	129	12	127-132	130	2	88-131	109	16	83-149	115	26
Mn	32-50	36	8	20-32	27	5	24-39	33	6	25-47	35	8

[†]Concentrations of elements are expressed in mg/kg dry wt.

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Table 29
Elemental Contents of Acacia Leaf at Site 3

Element	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	21700-29400	25660	3305	30600-39800	35660	4148	25500-43800	33620	6989	20400-31100	23960	4308
Mg	1050-1500	1360	178	1050-1610	1294	265	881-1490	1148	270	935-1460	1217	208
Na	700-1450	1108	311	1100-1560	1428	186	698-1110	910	149	805-1440	1155	210
K	8000-11100	10400	920	7180-15800	11748	3918	7930-11000	9180	1183	7760-8640	8240	344
B	53-81	67	11	35-69	48	14	40-52	43	7	19-35	28	6
Cu	13-23	17	4	5-16	11	6	6-9	7.8	1.1	7-10	8.8	1.1
Cd	0.1-1.1	0.5	0.5	0.1-1.4	0.7	0.7	<0.1	<0.1	0	<0.1	<0.1	0
Zn	21-23	23	2	17-20	22	5	11-23	16	5	19-27	24	3.4
P	1320-2170	1734	317	977-2520	1713	652	896-2020	1241	458	1170-1770	1424	216
Fe	85-131	104	17	120-159	132	21	91-188	120	46	86-102	117	38
Mn	34-46	38	5	33-66	48	13	40-90	70	25	42-92	59	21

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Table 29 (continued)

Element†	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	27500-40200	34980	5280	15500-29700	22640	5562	15600-24400	18980	3348	17700-26000	20100	3373
Mg	1600-1910	1712	117	903-1370	1160	228	734-1190	942	204	1010-1450	1276	174
Na	762-1640	1358	347	1480-1920	1668	201	1210-1680	1418	188	1190-1890	1546	319
K	9620-13800	11704	1510	7780-8930	8578	466	5010-9300	7256	1940	6240-8900	7292	1499
B	71-79	76	3	41-81	54	17	43-70	59	10	65-89	76	10
Cu	4-8	6.0	1.6	5-8	7.2	1.3	5-7	6.2	0.8	9-17	10.6	3.8
Cd	<0.1-0.2	0.1	0.1	0-0.1	0.04	0.05	0-0.1	0.04	0.05	0	0	0
Zn	17-28	22.8	4.1	11-16	13.4	1.8	9-11	10.0	1.0	16-19	17.2	1.3
P	1360-2210	1816	373	1210-1970	1396	323	660-1330	852	272	1170-1810	1548	265
Fe	91-138	114	21	72-159	106	33	73-146	107	30	98-119	105	9
Mn	38-64	46	11	38-57	43	8	34-84	48	20	37-64	48	11

†Concentrations of elements are expressed in mg/kg dry wt.

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Table 30
Elemental Contents of Acacia Leaf at Site 4

Element[†]	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	18300-33800	24300	7160	24200-53700	38720	10911	25600-40100	32060	5543	16700-26000	21200	4139
Mg	1050-2000	1520	336	1070-2120	1350	493	904-1250	1096	134	947-1590	1237	292
Na	470-1200	722	296	1020-1440	1148	178	605-917	690	129	763-2090	1059	577
K	6700-9000	8160	924	8200-10000	9256	658	6100-9190	7060	1248	4600-6950	5778	882
B	38-69	57	12	44-58	52	6	51-66	55	7	30-51	38	8
Cu	11-19	16	4	5-7	6	1	5-7	6	0.7	5-6	5.2	0.4
Cd	0.1-1.6	0.9	0.6	0.1-0.4	0.1	0.2	0-0.1	<0.1	0	<0.1	<0.1	0
Zn	13-19	16	2	11-14	13	1	8-11	9.6	0.9	11-17	13	2.3
P	1230-1790	1550	224	1400-2000	1704	216	1070-1540	1276	180	1200-1530	1378	141
Fe	73-100	89	12	64-109	86	22	61-82	74	11	59-110	73	21
Mn	33-78	54	18	54-74	65	8	52-87	67	15	40-72	51	13

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Table 30 (continued)

Element[†]	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	25500-34400	29120	4527	12700-19600	15780	2918	14000-21900	17760	3071	15700-17600	16480	795
Mg	1270-1890	1516	242	929-1420	1148	207	817-1320	1097	249	1040-1420	1262	182
Na	567-833	662	110	1390-2090	1652	289	766-1400	1095	225	917-1160	1048	97
K	7360-9960	8500	1064	5950-7740	6804	796	3780-6440	4566	1103	5270-7110	6766	778
B	66-93	80	12	61-85	75	10	63-116	88	26	40-87	61	17
Cu	4-6	4.8	0.8	4-7	5.2	1.3	4-5	4.6	0.5	5-9	6.4	1.5
Cd	<0.1-0.1	<0.1	<0.1	0	0	0	0	0	0	0	0	0
Zn	11-14	12.6	1.5	8-10	9.0	0.7	6-8	7.0	0.7	10-12	10.8	0.8
P	1840-2370	2028	211	1400-1890	1666	214	815-1420	1072	224	1340-1970	1540	251
Fe	82-100	87	7	57-81	65	11	51-71	57	8	73-87	80	6
Mn	50-78	58	12	38-64	45	11	32-63	46	12	43-63	52	8

[†]Concentrations of elements are expressed in mg/kg dry wt.

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Table 31
Elemental Contents of Acacia Leaf at Riverside

Element†	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	8700-18000	12820	3530	6220-18800	11400	5190	6570-14300	9466	2946	6195-16900	9680	3836
Mg	2320-4230	3200	800	2050-3750	2718	778	2110-2530	2334	151	1770-3040	2274	505
Na	2470-4920	3560	980	2260-2980	2752	292	1310-2790	2370	805	1670-2620	1940	395
K	11100-12200	11520	460	11400-14400	12300	1233	5820-8340	6706	1097	10200-16800	13320	2347
B	101-144	124	18	67-99	82	12	63-87	75	11	42-53	47	4
Cu	15-24	17	4	7-24	14	6	6-12	9	2	6-11	8	2
Cd	0.5-0.8	0.7	0.1	0.1-2.5	0.9	1.0	0-0.1	<0.1	0	<0.1	<0.1	0
Zn	34-56	44	9	26-48	35	9	34-42	39	3	20-34	26	6
P	994-1460	1205	165	1010-1200	1078	78	831-925	872	34	1220-1760	1498	226
Fe	89-264	166	71	114-191	146	31	81-152	124	27	66-104	83	15
Mn	24-39	31	6	16-29	23	6	15-44	26	13	20-28	25	3

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Table 31 (continued)

Element†	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	7350-15900	10414	3951	3460-10400	7482	2733	5280-9160	7426	1720	4340-9080	6676	2314
Mg	1600-3700	2610	937	1750-3600	2528	765	1740-3040	2302	470	1950-2630	2218	300
Na	1390-2090	1820	201	2280-3260	2782	384	1140-2540	2096	561	1330-3710	2168	928
K	11800-14400	13040	1074	7540-12400	7880	3899	5350-7740	6124	940	8080-13400	11256	1943
B	72-89	80	8	55-78	66	8	47-82	63	14	45-84	65	16
Cu	5-7	5.4	0.9	4-8	6.4	1.5	5-10	7.0	1.9	8-12	10.2	1.6
Cd	<0.1-0.1	<0.1	<0.1	0-0.1	0	0	0-0.2	0.1	0.1	0	0	0
Zn	20-35	26.6	5.8	21-41	30.0	7.3	20-33	27.0	5.8	15-33	24.4	8.3
P	942-1200	1095	118	733-1200	973	188	721-906	845	72	1400-2340	1854	337
Fe	72-102	85	12	113-164	139	19	104-238	180	59	92-172	136	35
Mn	19-23	21	2	12-38	23	10	17-46	27	12	19-34	26	6

†Concentrations of elements are expressed in mg/kg dry wt.

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Table 32
Elemental Contents of Acacia Leaf at UCR

Element†	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Devi-ation	Range	Mean	Std. Devi-ation	Range	Mean	Std. Devi-ation	Range	Mean	Std. Devi-ation
Ca	10600-15000	12820	2033	7470-16300	12714	3678	8730-16000	12634	2802	8770-14100	10812	2014
Mg	2400-2800	2600	177	1980-3250	2614	565	1770-3750	2558	732	2190-2760	2456	249
Na	3300-6800	4560	1417	2400-4540	3322	958	2050-3520	2686	546	2950-4280	3690	935
K	7700-11200	9640	1394	8100-10400	9242	966	5160-7860	6330	1283	10600-17800	13020	2811
B	125-261	178	52	89-155	114	26	70-122	95	21	45-69	54	10
Cu	7-13	10	2	8-12	10	2	4-7	6	1	7-10	8	1
Cd	0.1-0.2	0.1	0.04	0.1-0.3	0.1	0.1	0-0.1	<0.1	0	<0.1	<0.1	0
Zn	21-30	24	4	21-33	27	5	24-32	28	3	22-31	36	4
P	1050-1330	1150	115	1030-1610	1174	246	832-1070	911	102	1230-1900	1494	292
Fe	118-240	176	62	127-190	162	23	84-170	122	32	89-128	104	17
Mn	21-60	32	15	16-40	28	9	17-35	25	8	16-30	26	8

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Table 32(continued)

Element[†]	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	9040-20000	13244	4670	6430-13700	7938	3302	4870-10900	7552	2785	5550-8410	6886	1250
Mg	1850-3200	2520	583	1850-3030	2184	494	1580-2390	1928	314	2050-2850	2492	292
Na	3490-5910	4532	1033	2370-4710	3668	907	1950-3390	2488	563	2380-4470	3808	822
K	8630-13700	10982	2193	5230-11400	7832	2679	4240-6820	5306	1010	8310-13900	10552	2541
B	64-128	92	25	62-100	83	16	73-129	100	26	53-78	69	11.0
Cu	3-5	3.8	0.8	3-17	8.4	5.3	3-7	5.6	1.7	9-20	13.8	4.3
Cd	<0.1-0.1	<0.1	<0.1	0-0.2	0.1	0.1	0-0.1	0.1	0.1	0-0.8	0.2	0.3
Zn	12-20	16	3.5	11-27	18.0	6.2	12-27	19.8	6.6	18-24	20.6	2.4
P	1000-1190	1112	70	904-1670	1118	312	639-1030	799	159	1480-2910	2014	556
Fe	98-114	105	6	72-135	94	27	66-107	91	20	128-166	151	19
Mn	13-28	20	7	12-29	19	6	13-22	19	4	15-35	22	8

[†]Concentrations of elements are expressed in mg/kg dry wt.

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Table 33
Elemental Contents of Ice Plants at Site 3

Element[†]	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	36100-41100	38000	2580	38500-54900	48360	6958	35400-43800	37920	3388	36700-51400	44340	5680
Mg	7000-8200	7600	542	7260-9850	8527	1109	7800-9110	8642	546	7040-8910	7940	795
Na	20300-26500	23380	2325	25800-35900	32500	5126	29900-35500	32180	2234	21900-26300	24540	1919
K	13100-17500	15840	1766	14300-22100	17020	3448	12900-20300	17540	2855	16000-20000	17080	1559
B	102-153	122	20	61-78	66	8	62-68	67	7	34-51	44	6
Cu	11-22	14	5	2-9	6	3	5-6	5.4	0.5	6-8	7	0.7
Cd	0.7-2.3	1.6	0.6	0.9-2.2	1.4	0.5	0.4-0.8	0.5	0.2	0.3-0.6	0.5	0.1
Zn	40-61	47	8	41-53	47	5	52-70	58	8	50-73	62	11
P	1330-1580	1394	105	1590-2200	1880	244	1540-1990	1810	165	1390-1730	1546	131
Fe	54-62	57	3	72-88	80	7	52-70	51	13	51-72	61	9
Mn	46-113	78	26	45-107	86	25	40-99	55	29	44-86	64	16

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Table 33 (continued)

Element[†]	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	41800-54000	47380	5336	27100-43700	33840	6600	25400-29400	27920	1624	32000-40500	37560	3366
Mg	6820-8780	7614	914	6390-9510	7826	1183	7660-9600	8388	801	9530-12200	11026	969
Na	19200-28300	22780	3478	27400-43500	32240	6604	23700-28300	25460	3100	24500-30400	28440	2452
K	14200-17900	16000	1508	11600-21400	15000	3786	12700-15200	13640	984	13500-16300	15340	1220
B	60-86	73	9	79-95	87	7	26-66	52	16	52-119	81	25
Cu	3-5	4.2	0.8	3-5	4.0	0.7	3-5	3.8	0.8	8-15	11.0	3.1
Cd	0.8-1.0	0.9	0.1	0.5-1.1	0.7	0.2	0.1-0.9	0.4	0.3	0-0.8	0.4	0.4
Zn	43-67	56.4	9.2	28-59	38.0	12.3	32-48	36.8	6.4	41-60	51.2	8.2
P	1450-1910	1592	183	1450-1900	1676	178	1280-1540	1392	103	1570-1860	1720	140
Fe	53-87	62	14	41-53	48	5	40-82	51	18	70-99	86	12
Mn	56-87	74	12	42-76	59	14	32-74	51	18	83-125	107	16

[†]Concentrations of elements are expressed in mg/kg dry wt.

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Table 34
Elemental Contents of Ice Plants at Site 4

Element†	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	25000-38400	28960	5649	28500-40500	34060	5059	29100-37600	32240	3275	37000-49300	43840	4762
Mg	8100-9500	8840	546	10300-11700	10760	546	8580-9010	8824	188	9450-10300	9720	386
Na	18000-22700	19800	2045	29000-36300	32699	3341	31400-34800	31800	2214	28500-32400	29440	1673
K	14800-18800	16380	1585	18600-27400	22640	3124	9930-21500	16546	4477	11900-20000	14860	3501
B	58-74	66	7	52-71	64	8	54-59	57	2	40-47	43	3
Cu	8-18	12	4	4-9	5	2	4-6	5	0.7	5-6	5.4	0.5
Cd	0.2-1.8	0.8	0.6	0-2.7	0.8	1.1	0-0.8	0.3	0.3	0.2-0.5	0.3	0.1
Zn	27-38	34	5	46-120	62	32	37-52	42	6	33-42	38	4
P	1810-2380	1988	241	2500-3770	2938	621	1960-3190	2376	483	1610-2420	1892	311
Fe	50-60	54	4	64-95	77	12	35-38	36	2	46-61	53	5
Mn	54-78	57	14	51-132	83	36	66-88	79	10	78-133	100	23

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Table 34(continued)

Element†	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	19200-41000	28680	8168	22300-27100	24240	1784	10900-25100	18400	5117	25800-37100	30760	5439
Mg	7270-9140	8176	809	8190-10400	9206	833	5630-9280	7550	1297	9460-13100	10808	1404
Na	19800-27000	21780	3035	26100-30100	28520	1525	14400-25300	18820	4216	21600-28100	23800	2538
K	10500-20400	16140	4061	12400-21700	17020	3972	8760-13800	11472	2258	18500-22100	21020	1480
B	59-71	64	5	57-101	74	18	40-81	60	18	44-68	56	9
Cu	4-5	4.6	0.5	3-6	4.6	1.1	3-5	4.2	0.8	4-23	12.6	7.2
Cd	<0.1-0.5	0.2	0.2	0-0.6	0.2	0.3	0-0.1	0	0	0-0.4	0.1	0.1
Zn	23-36	28.4	5.2	19-33	25.4	5.3	21-24	22.2	1.1	25-40	32.2	6.5
P	1480-2170	1804	259	1890-2430	2168	202	1670-2810	2270	517	2300-2590	2462	141
Fe	42-70	55	10	42-52	47	4	42-60	50	7	57-78	66	8
Mn	33-85	50	27	33-86	46	22	18-70	41	19	35-132	74	50

†Concentrations of elements are expressed in mg/kg dry wt.

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Table 34(continued)

Element†	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	19200-41000	28680	8168	22300-27100	24240	1784	10900-26100	18400	5117	25800-37100	30760	5439
Mg	7270-9140	8176	809	8190-10400	9206	833	5630-9280	7550	1297	9460-13100	10808	1404
Na	19800-27000	21780	3035	26100-30100	28520	1525	14400-25300	18820	4216	21600-28100	23800	2538
K	10500-20400	16140	4861	12400-21700	17020	3972	8760-13800	11472	2258	18500-22100	21020	1480
B	59-71	64	5	57-101	74	18	40-81	60	18	44-68	56	9
Cu	4-5	4.6	0.5	3-6	4.6	1.1	3-5	4.2	0.8	4-23	12.6	7.2
Cd	<0.1-0.5	0.2	0.2	0-0.6	0.2	0.3	0-0.1	0	0	0-0.4	0.1	0.1
Zn	23-36	28.4	5.2	19-33	25.4	5.3	21-24	22.2	1.1	25-40	32.2	6.5
P	1480-2170	1804	259	1890-2430	2168	202	1670-2810	2270	517	2300-2590	2462	141
Fe	42-70	55	10	42-52	47	4	42-60	50	7	57-78	66	8
Mn	33-85	50	27	33-85	46	22	18-70	41	19	35-132	74	50

†Concentrations of elements are expressed in mg/kg dry wt.

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Table .35
Elemental Contents of Ice Plants at Site 5

Element[f]	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	23400-32700	28540	4785	27300-46300	36800	6921	29800-40900	37000	5520	37300-57400	49380	8981
Mg	8100-10600	9500	1057	7980-9860	8996	670	7320-9480	8330	918	7850-10700	9328	1105
Na	26600-53500	38640	10569	41700-5340	45780	4525	39800-49200	42320	3946	30300-50200	36140	8379
K	4300-5700	4980	516	5830-10800	8206	1883	5180-9700	7574	1987	5470-9630	7858	1626
B	95-169	135	27	70-94	81	11	54-121	84	27	46-122	73	31
Cu	9-12	10	1	4-11	7	3	5-7	6	1	6	6	0
Cd	0.3-0.7	0.5	0.2	0.1-1.3	0.4	0.5	0-0.1	0.1	0.1	<0.1	<0.1	0
Zn	23-34	28	5	30-62	45	12	44-66	52	9	46-51	49	2
P	850-1300	1058	173	1670-2510	2252	334	1650-2010	1778	137	1150-1410	1226	105
Fe	41-60	50	9	70-79	74	3	35-57	43	8	43-62	55	8
Mn	23-47	35	10	46-72	56	12	22-35	30	5	33-62	46	12

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Table 35(continued)

Element†	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	42700-47120	47120	2928	24400-32900	27700	2745	19800-33800	26780	5266	33200-41600	36982	3518
Mg	9410-10100	9648	306	8390-11100	10020	1041	7410-11800	7320	3544	9960-12400	11732	1031
Na	33500-40700	37040	2931	33300-43900	38340	3786	32600-44600	35840	4958	29100-39200	34860	3807
K	8100-14700	12020	2440	8460-15400	11230	2913	6820-12200	9392	2168	7690-14400	11378	2591
B	72-103	85	12	62-112	78	20	53-120	83	32	83-123	103	16
Cu	4-5	4.8	0.4	5-6	5.4	0.5	4-6	5.2	0.8	9-16	12.8	3.1
Cd	<0.1-0.1	<0.1	<0.1	0-0.1	0	0	0	0	0	0-0.2	0.1	0.1
Zn	44-58	51.2	5.4	36-47	41.0	5.5	36-64	49.8	11.2	39-63	51.4	9.1
P	1690-2500	2262	364	1990-2820	2306	328	1510-1900	1702	160	1400-2300	1850	328
Fe	42-64	53	9	44-56	49	5	43-54	48	4	70-91	76	10
Mn	42-67	54	12	17-28	24	4	17-41	31	9	35-78	56	16

†Concentrations of elements are expressed in mg/kg dry wt.

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Table 36
Elemental Contents of Ice Plants at Riverside

Element†	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	31300-55900	45360	8930	35200-44300	37620	3870	36000-51600	42300	6398	38100-52800	44700	5630
Mg	5870-10100	7830	1541	5010-7890	6300	1082	5440-7390	6538	741	6240-7110	6716	340
Na	36700-69500	51020	8960	36700-55300	42200	7636	42900-61000	61840	7764	38400-50800	43460	5972
K	20700-31200	27460	4030	10200-18900	15060	3596	7810-26000	18862	7364	10200-23100	14640	5279
B	77-143	108	24	58-118	88	27	62-110	83	18	73-109	88	13
Cu	10-18	15	4	8-9	8	0.5	6-11	9	2	6-8	7	1
Cd	0.6-1.3	0.8	0.3	0.3-10	0.6	0.3	<0.1	<0.1	-	<0.1	<0.1	-
Zn	38-101	61	25	27-44	41	11	33-75	52	16	43-77	56	13
P	2080-2450	2260	135	1790-2400	2170	233	1490-3240	2370	621	1600-3120	2052	608
Fe	84-97	85	8	74-82	79	3	47-54	51	3	74-147	96	29
Mn	54-86	70	13	29-40	33	5	32-47	38	7	38-61	50	8

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Table 36 (continued)

Element†	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	39300-49000	43700	4076	24100-41800	33460	6443	26200-33800	29880	3122	21500-29300	24520	2506
Mg	6240-7280	6112	764	5050-7040	6288	814	4900-6390	5574	716	5520-7320	6382	893
Na	36900-44000	40180	2950	30600-50900	41680	7319	32900-40600	37340	3063	40800-57400	48500	6948
K	11200-23900	16140	4915	14000-21800	16720	3112	8110-11900	10336	1765	12900-21600	17240	3520
B	89-131	113	16	105-143	122	18	77-143	98	28	92-110	101	6
Cu	5-8	6.6	1.1	6-10	7.4	1.7	4-5	4.4	0.5	8-10	9.0	1.0
Cd	<0.1-0.2	<0.1	<0.1	0.1-0.5	0.3	0.2	0-0.1	0.1	0.1	0	0	0
Zn	45-83	60.0	18.1	37-55	45.2	8.6	26-64	38.0	15.0	34-47	40.2	4.8
P	1680-2330	2046	287	1700-2010	1808	119	1360-2110	1612	291	1950-3110	2454	503
Fe	92-107	96	11	70-100	85	13	46-60	52	6	96-136	122	18
Mn	27-34	32	3	26-52	34	10	35-40	37	2	28-87	54	28

†Concentrations of elements are expressed in mg/kg dry wt.

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Table 37
Elemental Contents of Ice Plants at UCR

Element†	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	39100-49000	43500	3985	47600-80300	60360	12314	38800-66700	50800	11511	50400-58000	54320	3670
Mg	8150-9500	8710	575	6640-8950	8066	1029	5660-8030	7586	1417	7140-7780	7370	296
Na	36400-46000	39780	3870	36300-43700	39840	4324	42500-62700	50240	9650	34800-39200	37160	2101
K	7750-12500	9470	2325	4590-8760	6594	1529	5050-9800	7358	1890	4570-6240	5616	824
B	214-544	321	132	60-155	104	35	75-147	94	30	63-94	77	15
Cu	8-29	14	8	3-12	7	5	5-7	6	1	5-7	6	1
Cd	0.1-3.5	1.0	1.4	0.1-1.3	0.5	0.6	<0.1	<0.1	-	0-0.3	<0.1	0
Zn	20-36	30	10	16-36	23	8	21-27	24	3	20-36	29	6
P	1330-1720	1524	147	1380-1840	1616	212	1140-1940	1572	316	1410-1700	1562	108
Fe	73-129	100	20	76-111	92	15	52-78	62	11	80-110	90	12
Mn	45-157	112	49	92-96	94	3	49-153	95	44	50-121	96	33

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Table 37 (continued)

Element[†]	September 1986			December 1986			March 1987			June 1907		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	50100-68300	62400	4325	37500-56400	46700	6084	35600-48500	41320	5364	40600-46300	43780	2378
Mg	7190-10300	8640	1225	6780-9710	8414	1324	6050-9000	7376	1224	7900-12200	9938	1885
Na	37900-57600	43940	8800	35200-57600	44380	10721	27900-48300	37280	9435	35800-50000	43580	6615
K	6460-9400	7638	1123	5830-10100	7148	1727	4790-7230	5856	1206	4470-9390	6576	2501
B	78-131	93	22	110-141	126	12	90-128	107	15	88-143	112	22
Cu	3-5	4.2	0.8	4-6	5.0	0.7	4-6	4.6	0.9	7-14	9.8	2.8
Cd	<0.1-0.1	<0.1	<0.1	0.1-0.3	0.1	0.1	0-0.1	0	0	0	0	0
Zn	21-40	30.6	7.9	20-30	25.8	3.7	21-30	25.2	3.3	24-26	25.2	0.8
P	1120-1880	1558	274	1200-1960	1740	274	907-1690	1370	356	1390-2260	1704	342
Fe	69-76	69	6	58-74	67	7	50-61	56	4	79-96	87	8
Mn	50-168	98	62	39-167	100	55	25-138	74	58	41-166	83	72

[†]Concentrations of elements are expressed in mg/kg dry wt.

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Table 38
Elemental Contents of Ivy Leaf at Site 1

Element[1]	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	16300-26600	20760	3915	14300-20700	16980	2694	16300-19900	17940	1571	20900-25600	23280	1839
Mg	1600-2400	1920	295	1320-2020	1566	295	975-1530	1207	204	1350-1850	1622	191
Na	2650-7900	5530	2275	1160-2640	1662	570	992-1360	1198	147	504-1200	934	262
K	10100-14200	13120	3175	11000-15900	12640	1901	11600-13800	12460	1016	10200-13100	11460	1159
B	92-100	97	4	64-78	72	6	79-89	84	4	50-65	55	6
Cu	10-28	16	7	4-12	7	3	5-6	5.4	0.5	6-7	6.8	0.4
Cd	1.0-3.1	2	1	0.9-3.0	1.8	0.9	0.4-1.1	0.8	0.3	1.0-3.1	1.9	1.0
Zn	24-36	30	5	18-36	25	8	19-27	24	5	25-50	36	9
P	1600-2650	1990	397	1720-2390	1900	281	1750-1870	1798	54	1530-1880	1724	147
Fe	92-136	107	21	94-161	133	32	72-101	86	11	90-129	111	14
Mn	24-68	46	19	24-40	31	7	15-33	23	7	34-89	63	25

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Table 38 (continued)

Element[†]	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	24400-29600	26420	1936	10200-14700	12380	2073	10200-14300	11920	1525	17200-26600	21260	3708
Mg	1850-2300	2088	170	1340-1930	1612	212	780-1460	1116	258	1300-1790	1598	150
Na	1800-3520	2646	582	1780-4140	2600	902	1500-2580	2038	490	1535-2260	1859	265
K	10400-16500	14120	2670	10100-12900	11340	1137	7650-10100	8918	1074	9670-15000	11894	2166
B	82-100	91	7	80-129	106	22	69-91	80	8	90-103	100	2
Cu	5-10	7.2	1.8	6-10	7.6	1.5	3-5	4.2	0.8	6-9	7.6	1.1
Cd	0.4-3.0	1.8	1.6	0.5-1.6	1.0	0.4	0.4-1.8	1.0	0.5	1.2-4	1.9	1.2
Zn	27-56	44.8	12.2	15-36	24.0	7.6	16-31	21.0	6.0	25-56	38.6	15.3
P	1410-2350	1834	417	1760-2320	2084	216	1300-1770	1466	193	1540-2120	1880	245
Fe	89-151	122	26	69-95	81	11	73-170	104	40	126-198	169	29
Mn	40-75	61	15	10-29	20	8	7-41	21	13	38-113	28	11

[†]Concentration of elements are expressed in mg/kg dry wt.

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Table 39
Elemental Contents of Ivy Leaf at UCR

Element†	August 1985			December 1985			March 1986			June 1986		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	14300-20500	18340	2630	11300-19600	15280	3155	19400-28500	22380	3634	19400-23300	20740	1604
Mg	1740-2500	2290	360	1390-1810	1526	173	1350-2480	1780	476	1780-2390	2024	252
Na	1400-1670	1560	124	471-944	695	168	788-1120	961	134	1060-1440	1232	147
K	14500-18200	16200	1465	3050-13600	8922	3806	11200-14700	13020	1365	13800-15800	14900	728
B	106-197	161	37	30-61	48	11	50-83	64	13	51-98	64	19
Cu	13-17	14	2	5-12	7	3	6-7	6.8	0.4	7-8	7.2	0.4
Cd	0.1-1.0	0.4	0.4	0.1-0.9	0.3	0.3	0-0.2	0.1	0.1	0-0.1	0.1	0.1
Zn	45-75	53	12	30-66	52	13	55-76	63	8	40-62	53	5
P	1460-1740	1630	102	1100-2100	1608	400	1500-1940	1758	182	1370-1630	1474	104
Fe	92-164	123	26	62-180	104	45	87-167	132	37	109-190	143	36
Mn	17-33	26	6	12-40	25	13	15-33	24	7	26-48	37	8

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Table 39 (continued)

Element[†]	September 1986			December 1986			March 1987			June 1987		
	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation	Range	Mean	Std. Deviation
Ca	19000-24400	21100	2309	10300-12300	11760	838	10000-14100	12560	1527	15100-19400	16620	1899
Mg	1680-2170	1972	222	1610-2020	1744	164	1250-1830	1478	241	1500-2150	1816	306
Na	1740-2030	1912	125	1200-1890	1514	252	1470-1820	1638	136	626-1140	800	211
K	14900-22800	18380	2861	10400-13000	12280	1071	8540-10700	9520	830	14300-16800	15700	1022
B	74-88	80	7	43-85	63	18	48-70	57	9	48-85	60	15
Cu	5-7	6.0	1.0	6-8	7.0	1.0	4-6	5.6	0.9	7-13	9.2	2.5
Cd	0.1-0.4	0.2	0.1	0-0.2	0.1	0.1	0-0.1	0.1	0.1	0-0.3	0.1	0.1
Zn	38-58	46.6	10.0	25-37	32.2	4.5	28-50	39.6	9.8	28-54	37.6	10.6
P	1670-2010	1850	141	1550-1800	1672	94	1270-1600	1424	120	1560-1930	1726	146
Fe	101-151	126	20	92-123	102	13	88-130	114	17	185-219	202	17
Mn	27-50	36	10	16-66	30	20	15-30	23	6	18-44	28	11

[†]Concentration of elements are expressed in mg/kg dry wt.

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Table 40
Elemental Contents (in mg/kg dry wt) of Damaged and Green Leaf at Selected Study Sites

Location	Element	December, 1985		September, 1986	
		Damaged Leaf	Green Leaf	Damaged Leaf	Green Leaf
Irvine II	Na	2840	1680	3308	1010
	B	259	565	257	368
	Zn	64	40	31	34
Pomona I	Na	2195	3210	1840	1960
	B	163	101	154	112
	Zn	28	32	22	33

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Table 41
Elemental Contents of Healthy and Damaged
Leaves of Ornamental Plants in Site I

Element	Bottle Brush (Irvine I)		Eucalyptus (Irvine I)		Eucalyptus (Irvine II)	
	Healthy	Damaged	Healthy	Damaged	Healthy	Damaged
Ca	7200	4320	6560	6300	7800	11910
Mg	2240	1930	3412	3820	2445	3285
Na	2550	1520	4573	3900	1875	2230
K	9480	14600	5837	5090	7320	10960
P	1080	1010	977	1100	1370	1885
B	125	88	129	81	201	176
Al	179	87	113	105	138	124
Fe	302	111	95	178	143	108
Cu	12	8	7	6	8	8
Cd	1.8	0.6	0.4	0.1	0.1	0.1
Zn	12	11	24	24	38	61
Pb	16	0.9	4	2	4	10

†All measurements are in mg/kg d.w.

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Table 42 Relative salt tolerance of landscape plants [a,b]

Very sensitive[c]
(Max. EC_W = 0.7-1.4 mmho/cm or dS/m)

Star jasmine *(Trachelospermum jasminoides)*
Pyrenees cotoneaster *(Cotoneaster congestus)*
Oregon grape *(Mahonia Aquifolium)*
Photinia *(Photinia x Fraseri)*

Sensitive[c]
(Max EC_W = 1.4-2.7 mmho/cm or dS/m)

Pineapple guava *(Feiojoa Sellowiana)*
Chinese holly, cv. Burford *(Ilex cornuta)*
Rose, cv. Grenoble *(Rosa sp.)*
Glossy abelia *(Abelia x grandiflora)*
Southern yew *(Podocarpus macrophyllus)*
Tulip tree *(Liriodendron Tulipifera)*
Algerian ivy *(Hedera canariensis)*
Japanese pittosporum *(Pittosporum obira)*
Heavenly bamboo *(Nandina domestica)*
Chinese hibiscus *(Hibiscus Rosa-sinensis)*
Laurustinus, cv. Robustum *(Viburnum Tinus)*
Strawberry tree, cv. Compact *(Arbutus Unedo)*
Crape Myrtle *(Lagerstroemia indica)*

Moderately sensitive[c]
(Max. EC_W = 2.7-4.0 mmho/cm or dS/m)

Glossy privet *(Ligustrum lucidum)*
Yellow sage *(Lantana camara)*
Orchid tree *(Bauhinia purpurea)*
Southern Magnolia *(Magnolia grandiflora)*
Japanese boxwood *(Buxus microphylla var. japonica)*
Dodonaea, cv. atropurpurea *(Dodonaea viscosa)*
Oriental arborvitae *(Platycladus orientalis)*
Thorny elaeagnus *(elaeagnus pungens)*
Spreading juniper *(Juniperus chinensis)*
Xylosma *(Xylosma congestum)*

Moderately sensitive[c](cont.)

Japanese black pine *(Pinus Thunbergiana)*
Indian hawthorn *(Raphiolepis indica)*
Pyrachantha, cv. Graberi *(Pyracantha Fortuneana)*
Cherry Plum *(Prunes cerasifera)*

Moderately tolerant[c]
(Max. EC_W = 4.0-5.5 mmho/cm or dS/m)

Weeping bottlebrush *(Callistemon viminalis)*
Oleander *(Nerium oleander)*
European fan palm *(Chamaerops humilis)*
Blue dracaena *(Cordyline indivisa)*
Spindle tree, cv. Grandiflora *(Euonymus japonica)*
Rosemary *(Rosmarinus officianalis)*
Aleppo pine *(Pinus halepensis)*
Sweet gum *(Liquidambar Styraciflua)*

Tolerant[c]
(Max. EC_W >5.5 mmho or dS/m)

Brush cherry *(Syzygium paniculatum)*
CenizNatal plum *(Carissa grandiflora)*
Natal plum *(Carissa grandiflora)*
Evergreen Pear *(Pyrus kawakamii)*
Bougainvillea *(Bougainvillea spectabilis)*
Italian stone pine *(Pinus pinea)*

Very tolerant[c]
(Max. EC_W > 6.8 mmho/cm or dS/m)

White iceplant *(Delosperma alba)*
Rosea iceplant *(Drosanthemum hispidum)*
Purple iceplant *(Lampranthus productus)*
Croceum iceplant *(Hymenocyclus croceus)*

Purple iceplant *(Lampranthus productus)*
Croceum iceplant *(Hymenocyclus croceus)*

a. Data adapted from Maas (13).
b. Species are listed in order of increasing tolerance based on appearance as well as growth reduction.
c. EC_W = Electrical conductivity of the irrigation water. Salinitiesexceeding the maximum permissible water salinity (Max. EC_W) may cause leaf burn, loss of leaves, and/or excessive stunting. The maximum values shown were derived from maximum permissible EC_e data by a factor of $EC_e = 1.5EC_W$. This relationship should be valid for normal irrigation practices. The electrical conductivity of the irrigation water can be designated as mmho/cm or dS/m (see Table 3-1).

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Table 43 Relative boron tolerance of agricultural crops and landscape plants[a,b]

Agricultural crops

Very sensitive (<0.5 mg/L)

Lemon *(Citrus limon)*
Blackbery *(Rubus sp.)*

Sensitive (0.5 - 1.0 mg/L)

Avocado *(Persea americana)*
Grapefruit *(Citrus x paradisi)*
Orange *(Citrus sinensis)*
Apricot *(Prunus Persica)*
Peach *(Prunus Persica)*
Cherry *(Prunus avium)*
Plum *(Prunus domestica)*
Persimmon *(Diospyros kaki)*
Fig, kadota *(Ficus carica)*
Grape *(Vitis vinifera)*
Walnut *(Juglans regia)*
Pecan *(Carya illinoinesis)*
Cowpea *(Vigna unguiculata)*
Onion *(Allium Cepa)*
Garlic *(Allium sativum)*
Sweet potatoe *(Ipomea Batatas)*
Wheat *(Triticum aestivum)*
Barley *(Hordeum vulgare)*
Sunflower *(Helianthus annus)*
Bean, mung *(Vigna radiata)*
Sesame *(Sesanum indicum)*
Lupine *(Lupinus Hartwegii)*
Strawberry *(Fragaria sp.)*
Artichoke, Jerasulem *(Helianthus tuberosus)*
Bean, Kidney *(Phaseolus vulgaris)*
Bean, lima *(Phaseolus lunatus)*
Peanut *(Archis hypogaea)*

Moderately sensitive (1.0 - 2.0 mg/L)

Pepper, red *(Capsicum annum)*
Pea *(Pisum sativa)*
Carrot *(Daucus carota)*
Radish *(Raphanus sativus)*
Potato *(Solanum tuberosum)*
Cucumber *(Cucmis sativus)*

Moderately tolerant (2.9-4.0 mg/L)

Lettuce *(Lactuca sativa)*
Cabbage *(Brassica oleracea capitata)*
Celery *(Apium graveolens)*
Turnip *(Brassica rapa)*
Bluegrass, Kentucy *(Poa pratensis)*
Oats *(Avena sativa)*
Corn *(Zea Nats)*
Artichoke *(Cynara Scolymus)*
Tobacco *(Nicotinana Tabacum)*
Mustard *(Brassica juncea*
Clover, sweet *(Melitoltus indica)*
SquaMuskmelon *(Cucumis melo)*

Tolerant (4.0-6.0 mg/L)

Sorghum *(sorghum bicolor)*
Tomato *(Lycopersicon Lycoperscium)*
Alfalfa *(Nedicago sativa)*
Vetch, purple *(Vicia benghalensis)*
Parsley *(Petroselinum crispum)*
Beet, red *(Beta vulgaris)*
Sugarbeet *(Beta vulgaris)*

Agricultural crops (continued)

Very tolerant (6.0-15.0 mg/L)

Cotton *(Gossypium hirsutum)*
Asparagus *(Asparagus officinalis)*

Ornamentals

Very Sensative (<0.5 mg/L)

Oregon grape *(Mahonia Aquifolium)*
Photina *(Photinia x Fraseri)*
Xylosma *(Xylosma congestum)*
Thorny elaeagnus *(Elaeagnus pungens)*
Lauristinus *(Viburnum Tinus)*
Wax-leaf privet *(Lingustrum japonicum)*
Pineapple guava *(Feijoa Sellowiana)*
Spindle tree *(Euonymus japonica)*
Japanese pittosporum *(Pittosporum Tobira)*
Chinese holly *(Ilex cornuta)*
Juniper *(Juniperus chinensis)*
Yellow sage *(Lantana Camara)*
American elm *(Ulmus americana)*

Sensitive (0.5 - 1.0 mg/L)

Zinnia *(Zinnia elegans)*
Pansy *(Viola tricolor)*
Violet *(Viola odorate)*
Larkspur *(Delphinum sp.)*
Glossy abelia *(Abelia x grandiflora)*
Rosemary *(Rosemarinus officinalis)*
Oriental aborovitae *(Platycladus orientalis)*
Geranium *(Pelargonium x hortorum)*

Moderately sensitive (1.0-2.0 mg/L)

Gladioli *(Gladiolus sp.)*
Marigold *(Calendula officinalis)*
Poinsettia *(Euphorbia pulcherrima)*
China aster *(Callistephus chinesis)*
Gardenia *(Gardenis sp.)*
Southern yew *(Podocarpus macrophyllus)*
Bruch cherry *(Syzygium paniculatum)*
Blue dracaena *(Cordyline indivisa)*
Ceniza *(Leucophyllum frutescens)*

Moderately tolerant (2.0- 4.9 mg/L)

Bottlebrush *(Callistemon citrinus)*
California poppy *(Eschsholzia californica)*
Japanese boxwood *(Buxus microphylla)*
Oleander *(Nerium oleander)*
Chinese hibiscus *(Hibiscus Rosa-sinensis)*
Sweetpea *(Lathyrus odoratus)*
Carnation *(Dianthus Caryophzyllus)*

Tolerant (6.0-8.0 mg/L)

Indian hawthorn *(Raphiolopis indica)*
Natal plum *(Carissa grandiflora)*
Oxalis *(Oxalis Bowiei)*

a. Data taken from Maas (13).
b. Maximum concentrations tolerated in soil water without yield or vegetative growth reductions. Boron tolerances vary depending upon climate soil conditions and crop varieties. Maximum concentrations tolerated in the applied irrigation water are approximately equal to these values for soil-water or slightly less.

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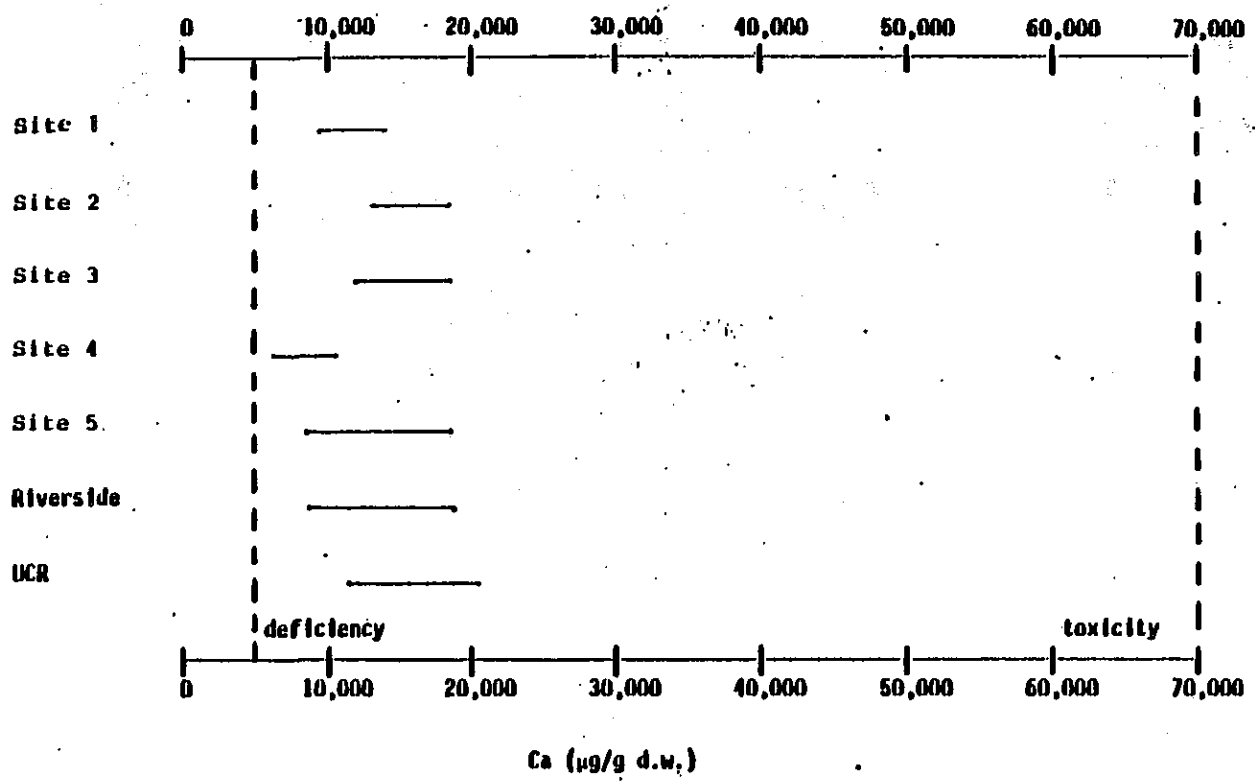

Figure 1. Ranges of Ca levels in leaves of Eucalyptus at the study site.

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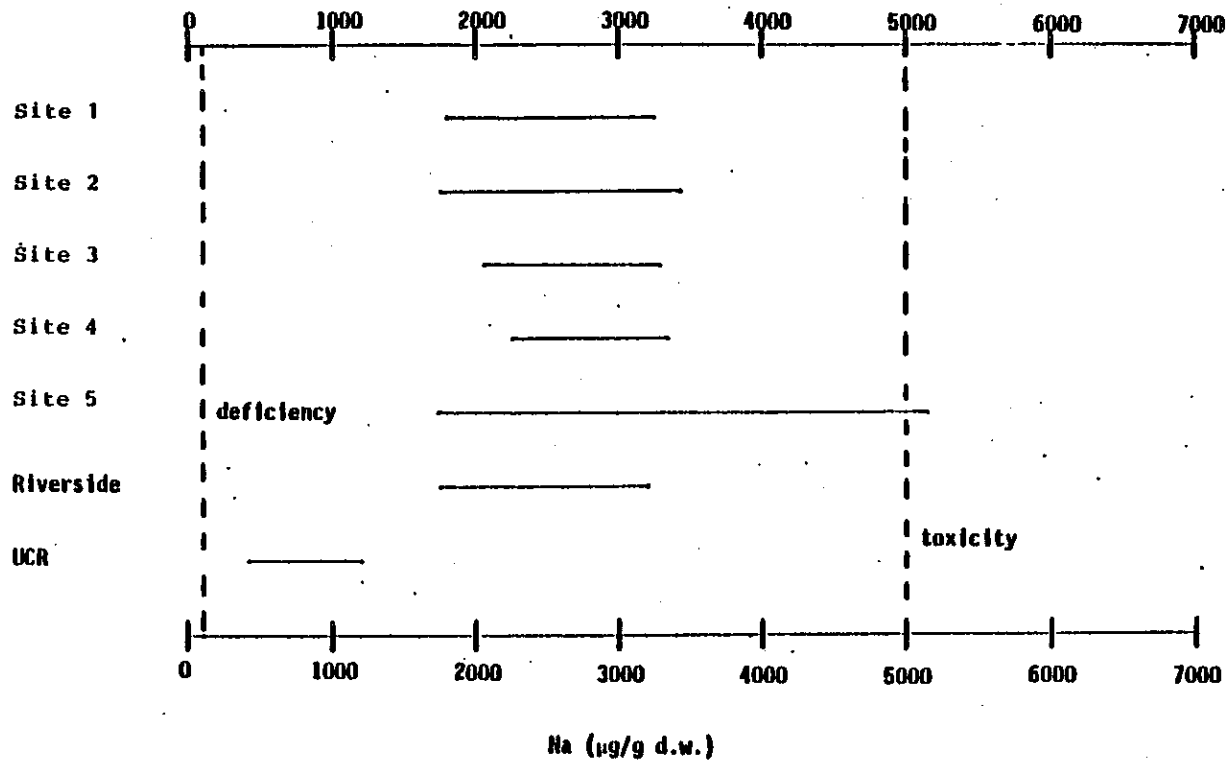

Figure 2. Ranges of Na levels in leaves of Eucalyptus at the study sites.

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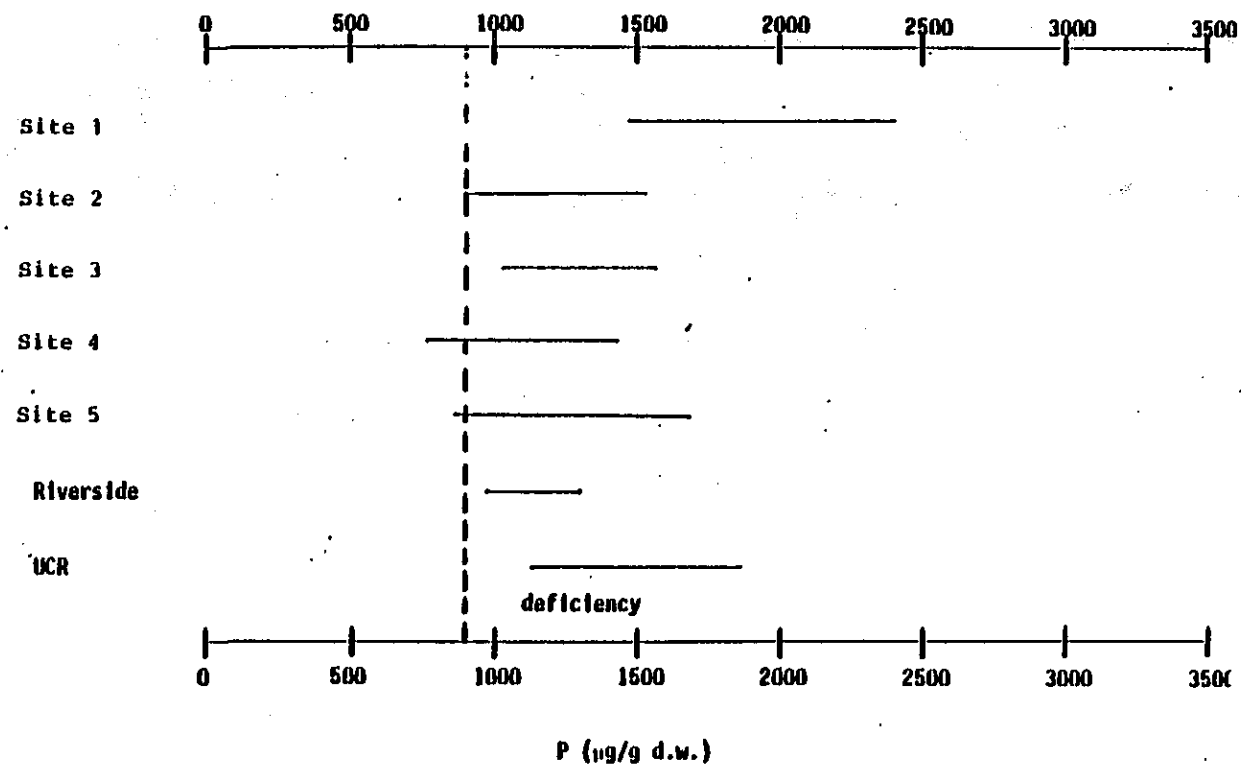

Figure 3. Ranges of P levels in leaves of Eucalyptus at the study sites.

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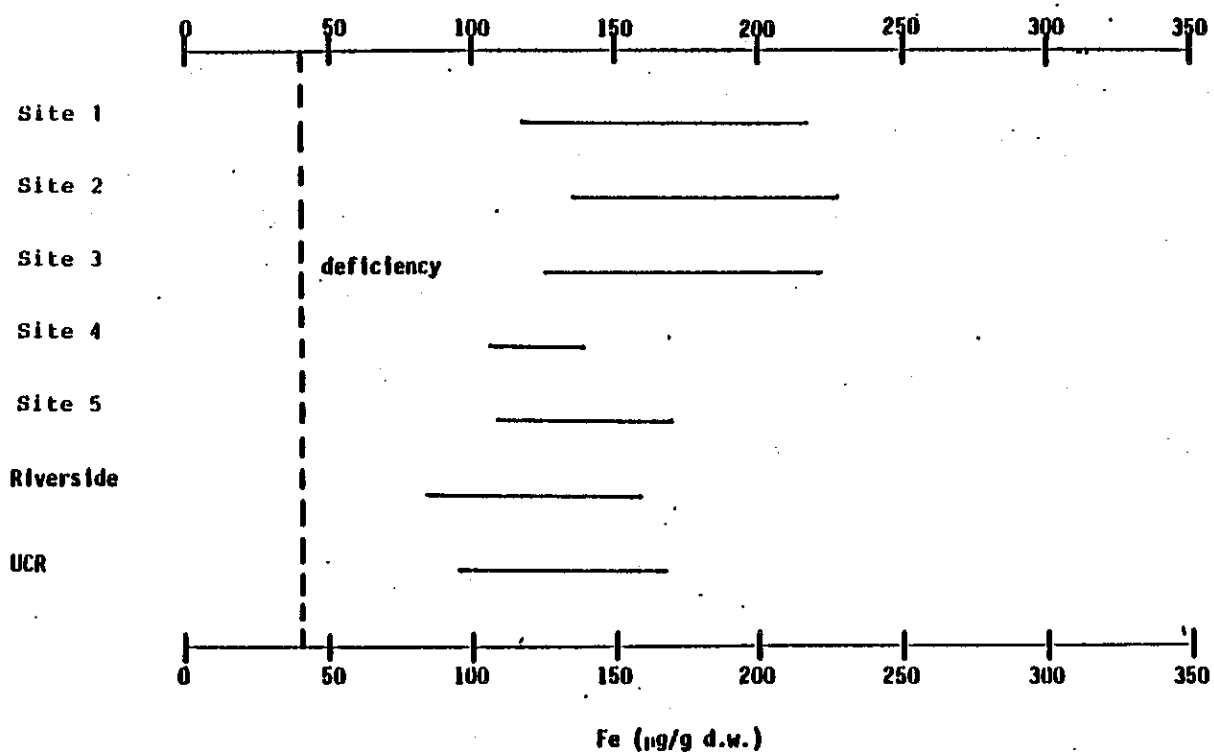

Figure 4 Ranges of Fe levels in leaves of Eucalyptus at the study sites.

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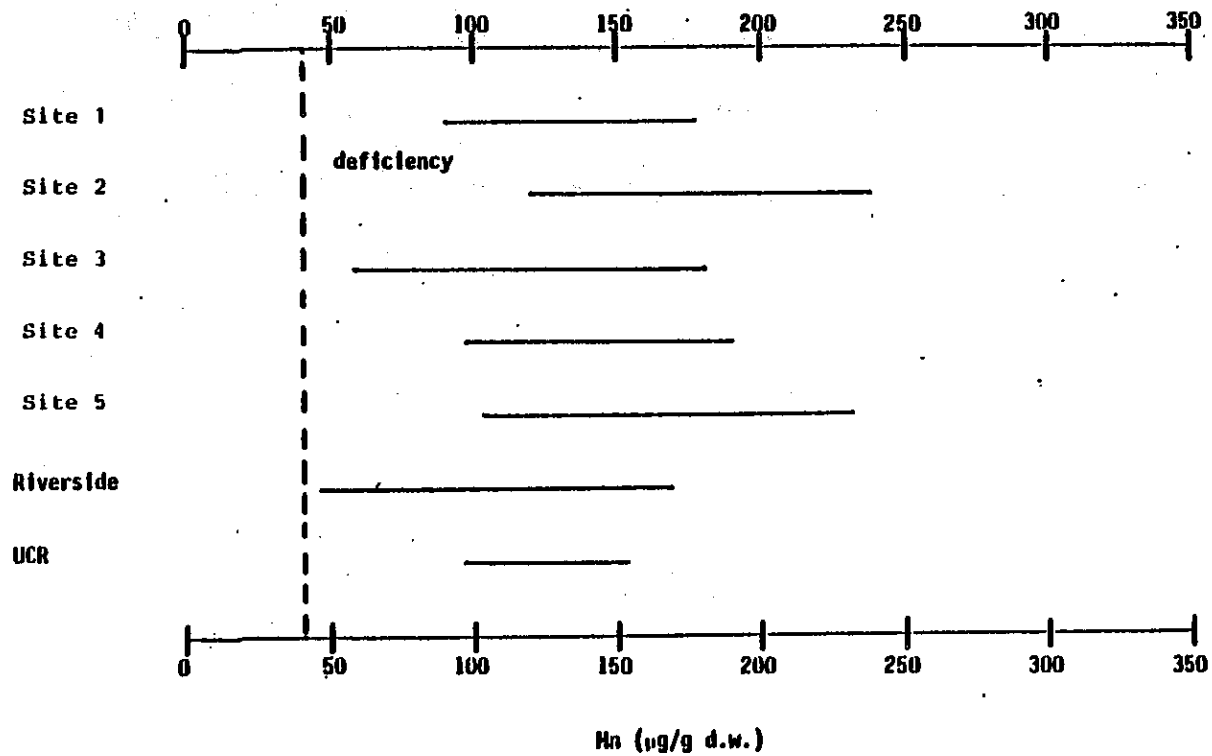

Figure 5 Ranges of Mn levels in leaves of Eucalyptus at the study sites.

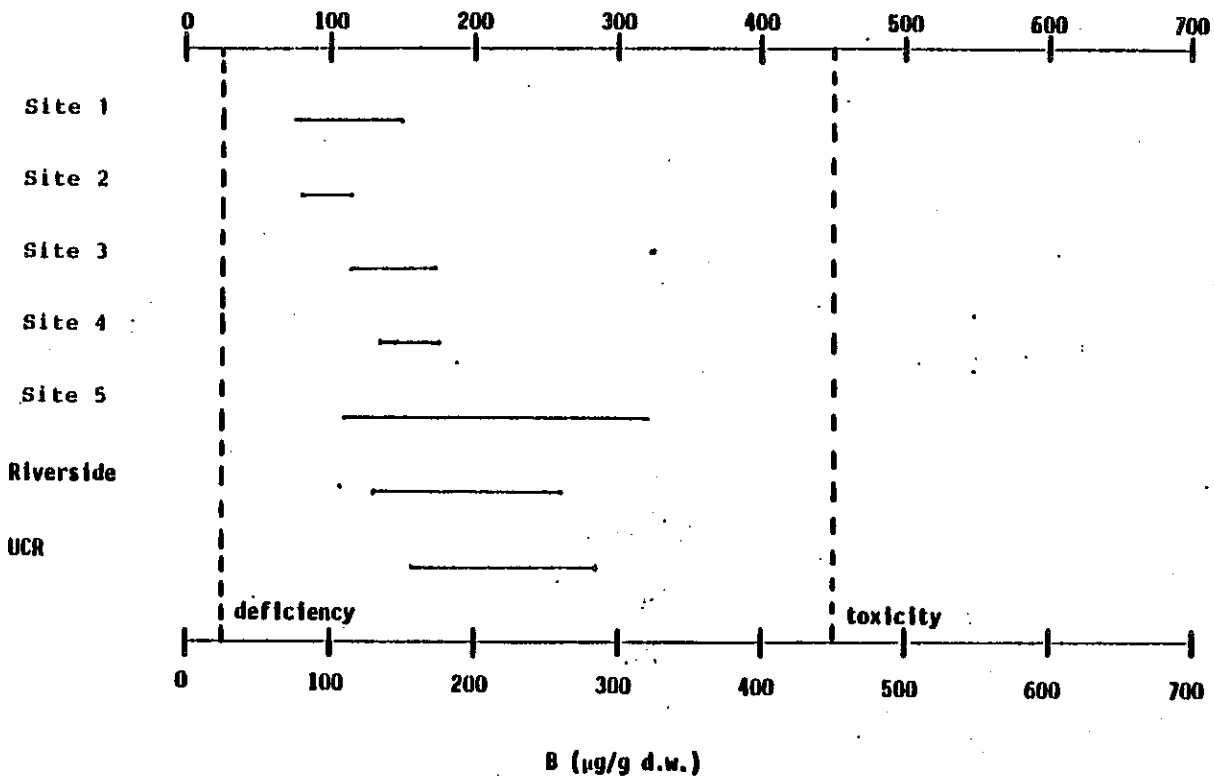

Figure 6 Ranges of B levels in leaves of Eucalyptus at the study sites.

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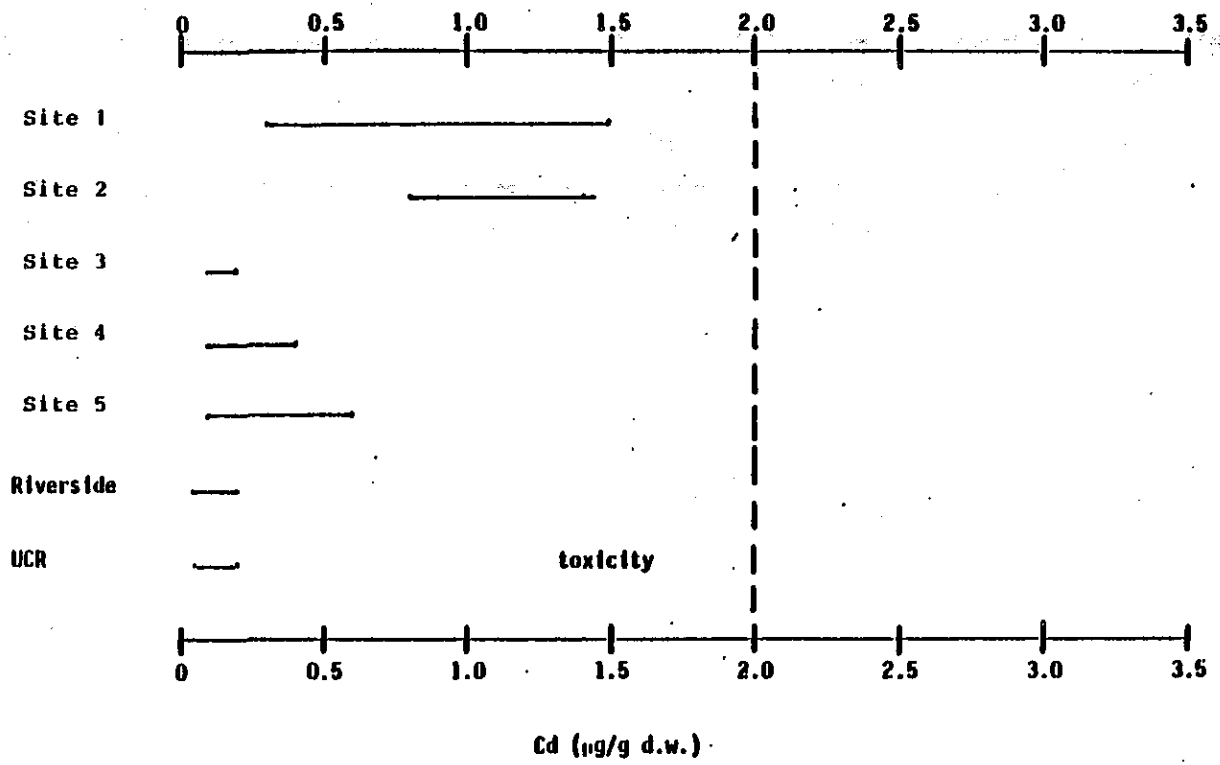

Figure 7 Ranges of Cd levels in leaves of Eucalyptus at the study sites.

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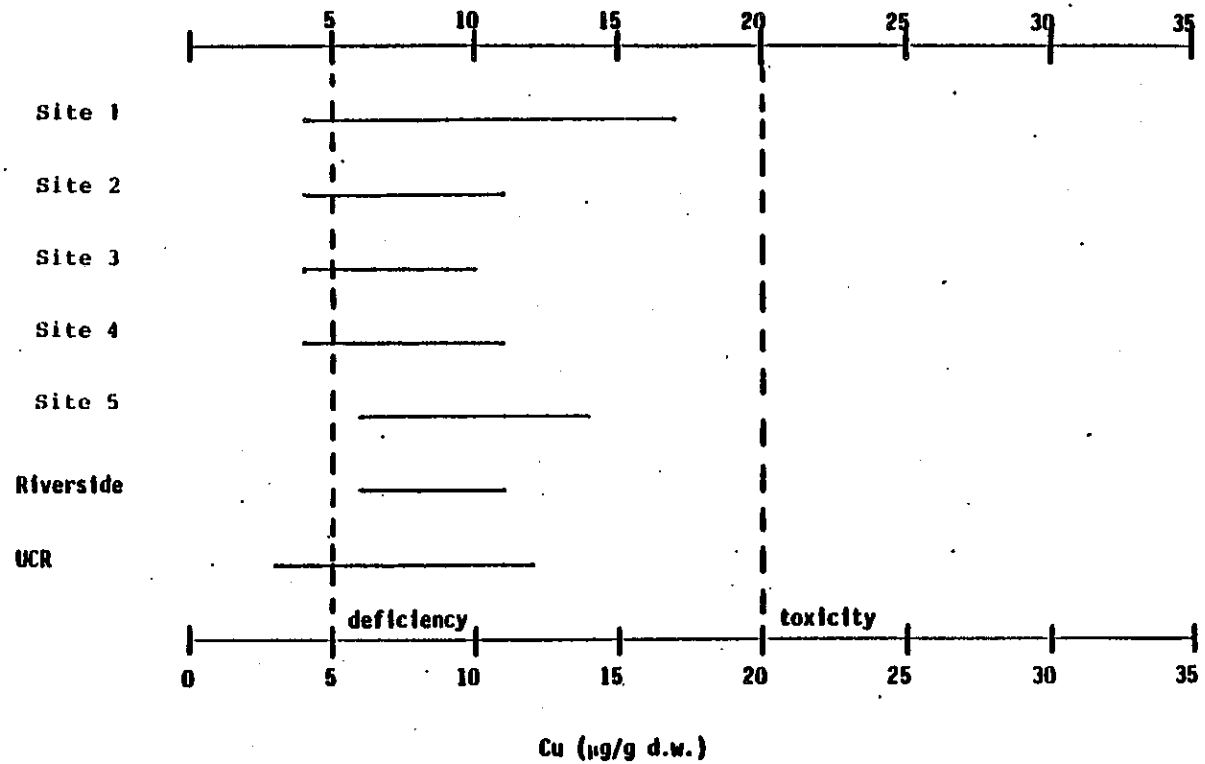

Figure 8 Ranges of Cu levels in leaves of Eucalyptus at the study sites.

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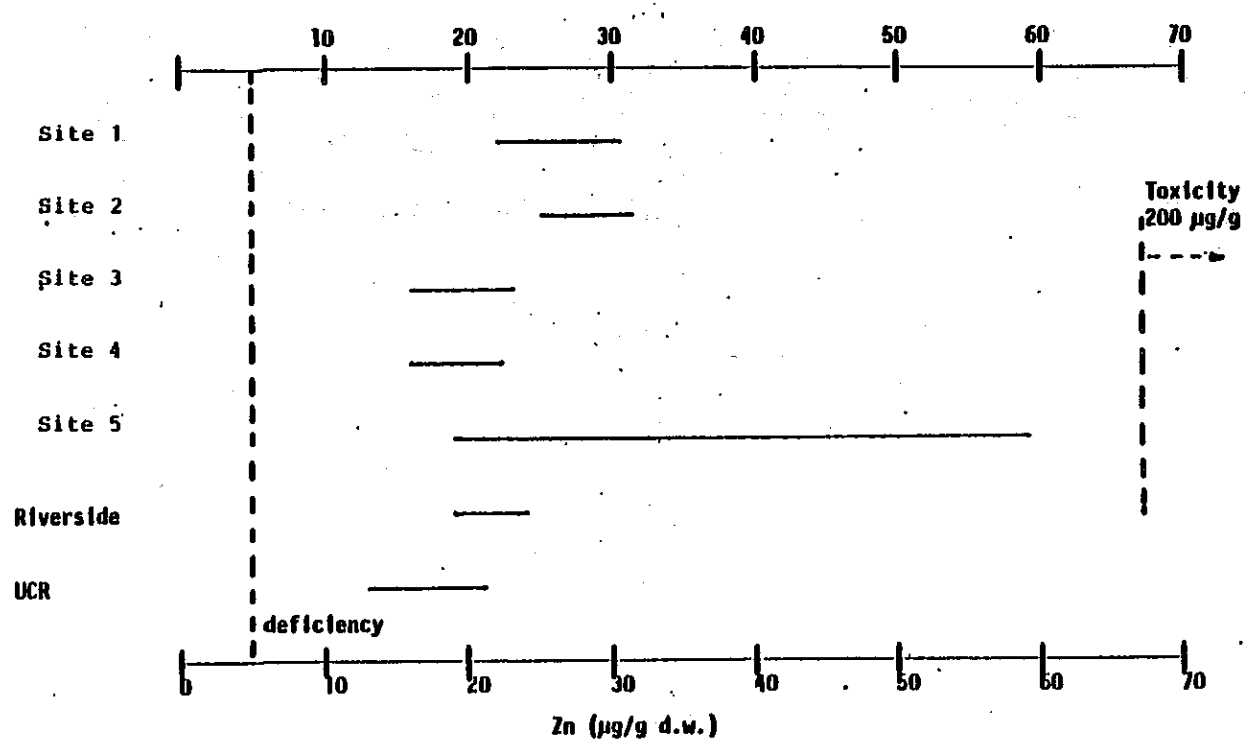

Figure 9 Ranges of Zn levels in leaves of Eucalyptus at the study sites.

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