Metropolitan Dade
County, Florida

DEPARTMENT OF ENVIRONMENTAL RESOURCES MANAGEMENT

1988 INTENSIVE CANAL STUDY
Evaluation of Water Quality in the Princeton Canal (C - 102)

Technical Report 92-1

1988 INTENSIVE CANAL STUDY: EVALUATION OF WATER QUALITY IN THE C-102 (PRINCETON CANAL)

Lisbeth Britt, Environmental Analyst
Maxine Cheesman, Hydrogeologist III
Metro Dade Department of Environmental Resources Management

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Metro Dade Department of Environmental Resources Management
33 S.W. 2nd Avenue
Miami, Florida 33130

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EXECUTIVE SUMMARY

This report is the ninth in a series of Intensive Canal Studies (ICS) conducted in Dade County, Florida by the Dade County Department of Environmental Resources Management. Previous ICS studies have included:

1980	Snapper Creek Canal (C-2)
1981	Miami Canal (C-6)
1982	Tamiami/Dressels Canals (C-4)
1983	Black Creek Canal (C-1)
1984	Coral Gables Waterway (C-3)
1985	Snake Creek Canal (C-9)
1986	Mowry Canal (C-103)
1987	L-31N Canal

The Princeton Canal (C-102) was chosen for this 1988 survey as a continuation of our investigation as to whether agricultural land use or agricultural practices are contributing to the degradation of ground and surface waters in south Dade County.

This survey and those conducted on the L-31N, C-103, and Black Creek indicate that, to date, agricultural practices have not degraded surface waters beyond the limits of Class III surface water quality standards established by the State of Florida. Standards set for Class III waters are appropriate for recreation and the propagation and maintenance of healthy and well balanced populations of fish and wildlife. Parameters examined are listed on page 6. It should be noted that testing was not comprehensive for pesticides used by local agriculture.

Comparison of the characteristics of each of the South Dade canals and their associated drainage basins also indicates that the following factors may affect the degree of surface water degradation by nutrients or the degree to which the degradation can be detected:

1. The specific design criteria for water quantity flow in the canal,

2. Whether the basin is well or poorly drained,

3. The amount of recharge and drainage in tributary canals,

4. The intensity of agriculture in the basin, and

5. The amount of rainfall in the basin.

At the same time that standards are not exceeded, these Intensive Canal Study data indicate that, over the time periods examined, agricultural fertilizer use contributed to a significant degradation of surface water by nutrients in the well drained basins of C-102 and C-103. In downstream locations in particular, the NOx-N (1.68 - 3.08 mg/l mean) and potassium (6.29 -6.5 mg/l mean) levels have been significantly above background mean levels (.05 mg/l NOx-N and 2.0 mg/l potassium). On the other hand, higher volume canals in poorly drained basins such as L-31N and Black Creek, do not exhibit downstream nutrient degradation, even where agricultural land use is predominant.

The implication of these findings is that agriculture in well drained areas imparts enough excess nitrogen to surface waters to cause significant degradation above background, especially where dilution is limited. Because of the interchange of surface and ground water in the Biscayne aquifer and because irrigation wells and private drinking water wells are located along these agricultural canals, future studies should include simultaneous testing of adjacent ground water for parameters of health concern.

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INTRODUCTION

Dade County's Canal Monitoring Programs

Dade County's Department of Environmental Resources Management (DERM) began monitoring canals for chemical pollutants in 1980 with the General Canal Program and an Intensive Canal Study Program. An Annual Pollutant Survey Program was added in 1981. These overlapping programs have the potential, if sampled continuously and on a long term basis, to characterize water quality trends in the major canal network that serves to both recharge the County's drinking water supply and drain stormwater runoff from urban and agricultural areas with ultimate disposal to marine waters.

The General Canal Program originally included monthly sampling of 50 sites from 15 different canals for general indicators including conductivity, fecal coliform bacteria, nitrates/ nitrites and dissolved oxygen content. The program was reduced to five sampling episodes in 1985, subsequently suspended for three years due to economic constraints and reinstated in 1989. Currently the program evaluates inorganic, organic, physical, and bacterial parameters with quarterly sampling.

The Annual Pollutant Survey consisted of one sampling episode in 14 of the 15 major canals in alternating wet and dry seasons. No canal was sampled the same season for two consecutive years. Samples were taken at upgradient and discharge sites for an indication of how land use affects the quality of surface water. Analytical parameters included a comprehensive investigation of organic compounds, trace elements, nutrients, minerals, and various physical measurements. The program was discontinued in 1986, but reinstated in 1989 as a component of the newer General Canal Program, which combined aspects of both programs.

An Intensive Canal Study (ICS) has been conducted on one canal per year since 1980. Intensive studies repeat the comprehensive analysis of the Annual Pollutant Survey but only on one canal. It includes quarterly sampling episodes at multiple sampling points along each canal. Bottom sediment sampling was added to the program in 1987.

The results of the surface water sampling programs have been reported annually since 1980, along with the results of DERM's ground water and Biscayne Bay monitoring programs. These DERM reports, along with ground water monitoring reports from the South Florida Water Management District, provide the continuity of historic data needed for the interpretation of newly acquired data. These data, in context with local land use, rainfall, and hydrogeological information, provide an indication of current and potential water quality trends.

The 1988 Intensive Canal Study - Princeton Canal (C-102)

The C-102 system in south Dade County (Figure 1) was selected for the 1988 Intensive Canal Study (ICS) as part of the continuing examination of surface water in agricultural areas. The 1983, 1986 and 1987 ICSs also assessed canals draining predominantly agricultural areas. The C-102 Basin drains more than 24 square miles of intensively cultivated multi-use agricultural land as well as some low density residential developments (1 - 5 acre estates with agriculture).

There are two canals within the C-102 basin: C-102 and C-102N. The C-102, which originates at the L-31N, functions to 1) drain flood waters from the basin, 2) recharge water to the basin for irrigation and drinking water purposes, and 3) maintain fresh ground water head elevation adequate to prevent salt water intrusion. Water can be supplied to the basin from L-31N, a major north/south canal in the South Dade Conveyance System. Water movement in the system is controlled by a series of 4 gated spillways or culverts (Figure 1) which can be opened or closed as required (Cooper and Lane, 1987).

During normal operation, the basin system west of Krome Avenue drains to the east. During flood conditions, Control Structure S-194, a gated culvert on the west side of Krome Avenue, can be closed, so that system flow west of Krome is to L-31N and southward into the C-111 basin. Flow in the C-102 east of Krome Avenue is generally to the southeast with discharge to Biscayne Bay via a gated spillway, S-21A. Structure-165 at S.W. 292 Street just west of US-1, is a gated spillway which controls stage elevations in the upper reaches of C-102 and regulates discharges to lower regions.

C-102N is a tributary to C-102. It originates at US-1 and S.W. 232 Street at a gated culvert, S-195. Northwest of S-195, Dade County constructed a more narrow 1.5 mile canal extension which also drains agricultural land. The County extension is directly connected to C-102N at S-195. Structure-195 controls southward flow to the confluence with C-102 at S.W. 122 Avenue and 260 Street. Structure-195 is closed unless flooding occurs.

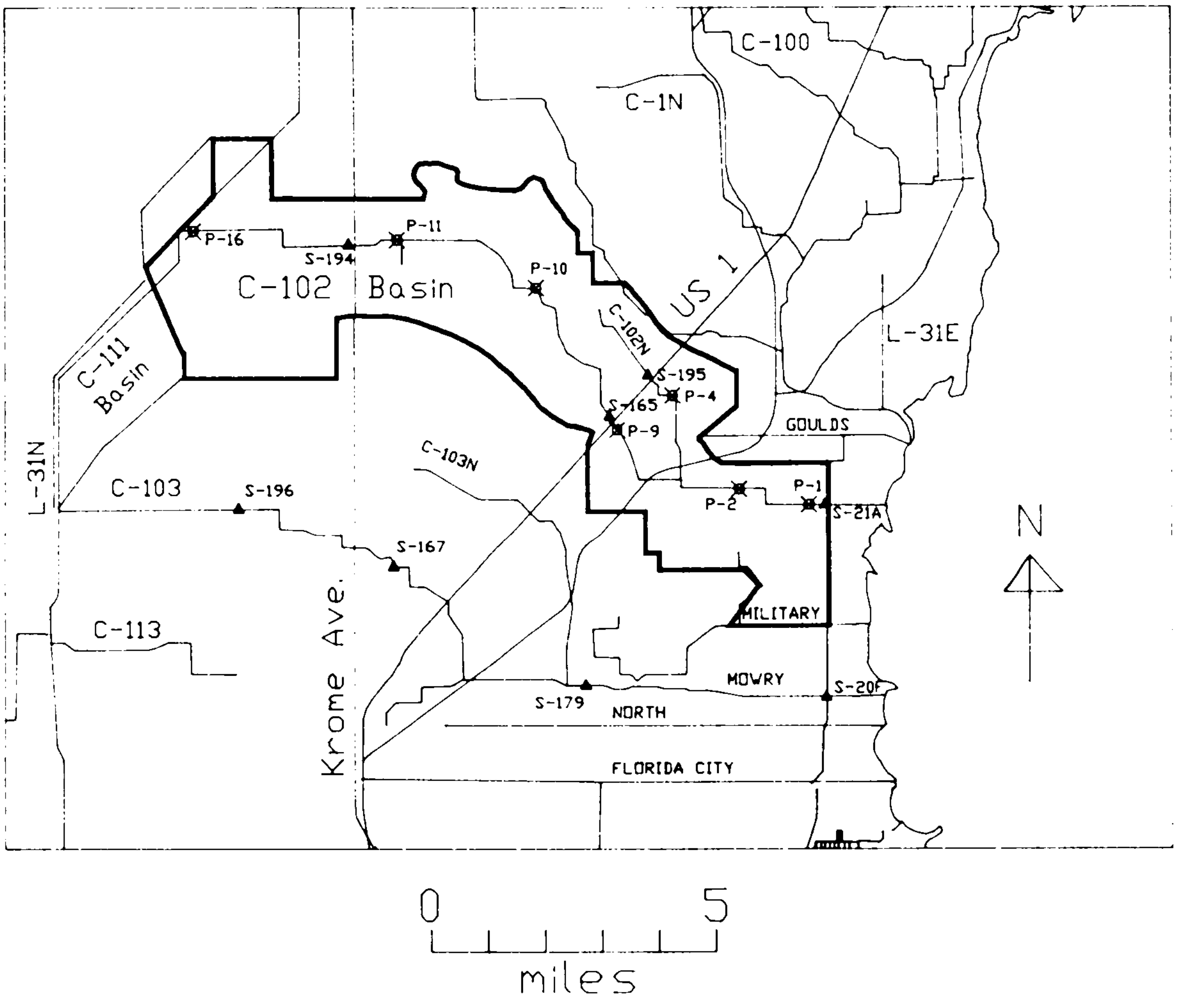
Sampling Sites

The ICS monitoring sites, located on Figure 1, are described in Table 1. Adjacent land uses and immediate upstream land uses, documented in 1988 aerial photographs and verified by field inspection, are described as upstream influences. As indicated, each sampling site is located adjacent to an agricultural land use. Additionally, residential septic tanks and drainfields, which are potential sources of nutrients, are present in the vicinity of 5 of 7 sites. Previous DERM studies (Stilwell, 1978 and Church et. al., 1980) found that septic tanks, even in high density residential areas, impact ground

FIGURE 1

THE C-102 BASIN

Sampling Points and Control Structures



Legend

P - sampling station

S - canal structure

Table 1

LOCATION AND LAND USE INFLUENCES ON C-102 MONITORING SITES

STATION	LOCATION	UPSTREAM INFLUENCES
P-16 background	C-102 S.W. 207 AVE & 192 ST.	Row crops, barnyards, septic tanks
P-11	C-102 S.W. 167 AVE & 200 ST.	Winter and summer row crops, groves, Package STP effluent
P-10	C-102 S.W. 147 AVE & 208 ST.	Groves, tropical vegetables, septic tanks
P-9	C-102 US 1 @ S.W. 244 ST.	Groves, row crops, FPL leased field nursery and powerline, commercial highway
P-4	C-102N S.W. 124 AVE & 236 ST.	Winter and summer row crops, FPL leased field nursery under powerlines, septic tanks
P-2	C-102 S.W. 112 AVE & 262 ST.	Groves, row crops, foliage nursery, fallow land, septic tanks
P-1 discharge	C-102 S.W. 97 AVE & 268 ST.	Groves, row crops, coastal wetlands, rock mining

water significantly less than agriculture in terms of contribution of nutrients. Also, homes served by septic tanks in agriculturally zoned lands are generally limited to 1 for each 5 acres of land.

Sampling Procedures and Laboratory Analysis

Sampling protocol and laboratory analyses were conducted according to established procedures. All samples were collected by DERM staff. Water samples were collected one meter below the surface with a Teflon point source bailer cleaned with an isopropanol wash, two distilled and one sample water rinses. Sample containers were pre-cleaned and preservative added by the DERM Laboratory according to EPA protocol. Physical parameters were measured using a YSI DO meter and a pH/conductivity meter.

Using a small boat, bottom sediment samples were collected from below the water column monitoring sites using a stainless steel petite ponar sampler. The sampler was cleaned with isopropanol and rinsed with distilled and sample waters. Several portions of the top layer of bottom sediment were collected and mixed in a stainless steel basin prior to sample withdrawal.

Most canal water samples were analyzed by the DERM laboratory, with the following exceptions: bacterial analyses were conducted by Florida Health and Rehabilitative Services, and one sampling episode in November for organochlorine pesticides and polychlorinated biphenyls, PCBs (EPA Method 608 Compounds) was analyzed by Spectrum Labs. Sediment samples were analyzed by Spectrum Labs and Engineers-Scientist Laboratory.

In instances where different detection limits were used by different laboratories, the lower detection limit was given more weight. This is because lower detection limits indicate a more sensitive analytical procedure in the absence of matrix effects. This is strictly applied in circumstances where any detection of a particular parameter is a human health concern e.g. PCBs. When parameters were reported below the detection limit, half the detection limit was used to perform calculations. This was necessary due to the requirements of the SYSTAT statistical software used to evaluate the data.

Analytical Parameters

The water column at each of the sites was monitored quarterly (January, April, July, October) for the parameters listed in Table 2. Additionally, minerals (sodium, calcium, magnesium, and potassium) were tested in July and October and EPA Method 608 Compounds (organochlorine pesticides and PCBs) were tested in November. EPA Method analytes for each test group are listed in Appendix 3. Sediments were analyzed at each site in

Table 2

PARAMETERS TESTED QUARTERLY IN THE WATER COLUMN FOR THE C-102 INTENSIVE CANAL STUDY

Physical Parameters

- Conductivity
- Turbidity
- Total Dissolved Solids
- Temperature
- pH
- Dissolved Oxygen

Trace Elements

- Arsenic
- Copper
- Zinc
- Mercury
- Cadmium
- Chromium
- Lead

Organics

- Phenols
- Halogenated Volatiles (EPA Method 601 compounds)
- Aromatic Volatiles (EPA Method 602 compounds)

Nutrients

- Ammonia
- Nitrates/Nitrites (NOx-N)
- Ortho/Total Phosphates

Bacteria

- Total and Fecal Coliform
- Fecal Streptococci

Major Inorganics

- Alkalinity
- Chlorides

April and November for trace elements and EPA Method 608 Compounds. Volatile organic compounds (EPA Method 610) were tested in sediments only in November.

Statistical Analysis and Data Standards

This report presents the raw data reported by the laboratories (Appendix 1) and the results of statistical tests (Appendix 2). Data were analyzed for normalcy using GEOEAS and SYSTAT. Parametric and non-parametric statistics provided in SYSTAT were used to generalize the data. Results are discussed in relation to surface water quality standards, data from DERM's surface water monitoring programs, and in relation to surrounding land use.

Surface water quality standards are set by the Dade County Environmental Protection Ordinance (Chapter 24-11), and the Florida Department of Environmental Regulation (FDER) Water Quality Standards (Chapter 17-3.121 F.S.). DERM surface water and FDER Class III surface water standards are shown on Table 4. The lower standard was applied during data analysis.

Fresh water canals in Dade County are classified by FDER as Class III waters. Standards for Class III waters are set to provide a healthy environment for recreation and wildlife. For this report, the FDER Class I (potable water) nitrate standard is applied because of the close interaction of surface and ground water in Dade County and the function of the canal to recharge groundwater.

No legal standard exists for residues in sediments for Dade County, although Florida has published some guidelines for metals. Since Dade's canals carry a small sediment load, any residue detected in sediments is considered significant because positive findings indicate the previous presence of a related chemical in the associated water column.

Data Collection and Comparative Studies

The goal of this study is to characterize the C-102 surface water. This is best accomplished by comparing the C-102 data to that collected from other Dade canals, particularly those in agricultural areas. Comparisons between canal data were made at upgradient, midreach, and discharge (to Biscayne Bay) locations in the C-102 to comparable data taken from the 1983 and 1986 Intensive Canal Studies respectively, the Black Creek Canal (Labowski et. al., 1988) and the C-103 (Cheesman, 1989). Background levels for each canal were also compared to data in the 1987 ICS on the L-31N canal system (Cheesman, 1990). The L-31N provides recharge to all three canals. These data were evaluated in context with ground water studies conducted in South Dade agricultural areas (Church et. al., 1980 and Anderson et. al., 1986 and 1988).

DISCUSSION OF ANALYTICAL PARAMETERS FOR C-102

The surface water analytes selected for analyses in an Intensive Canal Study are both naturally occurring and anthropogenic in origin. Since land use along the C-102 and in the entire canal basin is predominantly agricultural; water quality monitoring in the C-102 includes, but is not limited to, a wide variety of parameters which can be attributed to agriculture.

Large quantities of fertilizers and pesticides are applied to Dade County soils year-round (Howard, 1991). These compounds, at varying concentrations in water, can have negative impacts on the health of aquatic and human life. Substances which may be imparted to water from pesticides and fertilizers are both naturally occurring and synthetic and include, but are not limited to, the parent compounds, nutrients, trace elements, so called inert ingredients, and hydrocarbon derivatives.

When applied to soil, agrichemicals may be chemically or biologically altered or degraded, used by plants, adsorbed into soil or the limestone layer of the unsaturated zone, or leached from soils into the ground water. The quantity of these compounds entering surface water depends on rainfall, soil and unsaturated zone properties, plant uptakes, and application methods and frequency. Once in the water, factors such as dilution, nitrification, photosynthesis, photolysis, and aeration affect how the leachated compounds impact surface water and the biota therein.

These same factors can also mask the detection of some compounds and their effect on the surface water environment. Therefore, chemical analyses alone are not sufficient measurements of impact. Biological and practical factors must also be considered. For instance, aggressive aquatic plant growth is an obvious indicator of nutrient loading in Dade canals. Yet phosphorus, which is the most limiting nutrient in plant growth, is generally present in only minute quantities in Dade canals in any grab sample because it is quickly utilized by plant tissue. Only the ever present plant growth indicates that phosphorus is continually made available to our surface waters.

Some substances which are rarely detected in the water column are frequently detected in bottom sediments. For instance, many hydrocarbon derivatives are heavier than or insoluble in water and rapidly bind to or at least become mixed with bottom sediments. Since C-102 and Dade's canal system in general do not carry a large sediment load, the detection of compounds in canal sediment indicates a former presence in the water column of the canal.

Macronutrients

Fertilizers contain natural sources of **nitrogen, phosphorus**, and **potassium**. These three elements are of vital importance to plant and animal nutrition. As they are in insufficient amounts in Dade County soils to support the intensive agriculture practiced here, these required nutrients are applied heavily to soil in farmed areas. For instance, on the irrigated gravely loam soils common in South Dade, Hochmuth (1988) recommended that 70 pounds of nitrogen, 90 pounds of phosphate, and 90 pounds of potassium be applied to an acre of pole beans per growing season. Pole beans are the most commonly grown vegetable in Dade County. Tomatoes, the second most commonly grown vegetable, require double the amount for beans. Soil leachate from fertilizers is thus a common source of nitrogen in ground and surface waters.

Nitrogen occurs in water as **nitrite** (NO_2) or **nitrate** (NO_3) anions, and is often associated with the ammonium cation. Nitrogen in reduced or organic forms is converted by soil bacteria into nitrite and nitrate. Nitrates and ammonia can be converted to toxic nitrite by microorganisms found in soil, water, and the digestive tract. In oxygenated systems, nitrites are rapidly oxidized to nitrates. Therefore, in oxygenated waters such as surface water, the majority of N is in the nitrate (NO_3) form. Nitrite is generally considered to be an indicator of recent pollution.

Nitrates are extremely soluble and are rapidly leached from soil by rain or irrigation waters. Once in the ground water yet beyond the root zone of plant uptake, nitrate can accumulate beyond safe levels for drinking water. In the digestive tract, at normal concentrations, nitrates are readily excreted in the urine of most adults. At very high concentrations in the digestive tract, nitrate ion is reduced to toxic nitrite. The health condition resulting from nitrite exposure, methemoglobinemia, impairs oxygen transport and can be lethal. Nitrites have been lethal to infants in concentrations as low as 1 mg/l as N (Environmental Health Letter, 1991). As a result, the nitrate/nitrite standard in ground and Class I (potable) waters has been set at 10 mg/l.

Nitrate/nitrite levels were measured collectively as mg NOx-N/ liter. In the 1988 Intensive Canal Survey, at the upgradient sampling location (P-16), NOx-N in C-102 averaged 0.05 mg/l. Nitrate values at all canal stations east of P-11 in the C-102 exhibited statistically significant (95% confidence level) degradation above the background value (.05 mg/l NOx-N), but not above 3.8 mg/l. Since similar agricultural land uses (Table 1) can be assumed to provide excess nitrogen all along the canal; most likely from soil leachate to the ground water (Church et. al, 1980), the NOx-N values in the C-102 must become diluted by influx of low level NOx-N waters (.05 mg/l) from the L-31N (Cheesman, 1987). Diluted surface water, then, only serves as a weak indicator of the effects of leachate from the basin.

In the undiluted C-102N tributry, NOx-N reached 7.65 mg/l during October. Although this high nitrate/ nitrite value is within the safe limit of 10 mg/l for potable water, it could indicate a significant degradation of the water in relation to the more diluted C-102. (A duplicate sample taken for quality assurance at P-4 in October measured 2.68 mg/l).

Ammonia, measured as mg NH_3/l, is naturally occurring in water. Although un-ionized ammonia is the most toxic species, surface waters usually contain the ionized (ammonium) form, NH_4^+. The water chemistry and toxicity of ammonia are affected by pH, ionic strength, and temperature. Availability and origin are related to levels of nitrogen. Ammonia is limited to a standard of 0.05 mg/l (as N) for fresh water.

Although there may be high influxes of ammonia in surface water, it is rapidly converted (until equilibrium is reached) to NOx-N as long as water conditions are oxidizing. Therefore, measured values of ammonia exhibit an inverse relationship to NOx-N and dissolved oxygen. This inverse relationship is substantiated by the NH_3, NOx-N, and DO data from C-102 sampling stations. NH_3 concentrations were highest at background where NOx-N and DO were lowest. At discharge, the reverse was detected.

Phosphorus in elemental form is particularly toxic but does not bioaccumulate. Because it is readily assimilated by soil and by the limestone matrix of the unsaturated zone, and not readily leached, ground water does not significantly contribute to the phosphorus found in surface waters. Total phosphate levels in ground water test wells in DERM's monitoring program in the C-102 Basin average 0.02 mg/l. Phosphorus, a component of both fertilizers and sewage, is essential for metabolism. Considerably large sources of it would have to enter surface water from direct discharges to lead to measurable levels.

A low phosphorus level is the single most limiting nutrient for plant growth (Drever, 1988). Algal plant life in canals indicates the presence of phosphorus. Sufficient phosphorus enriches water and promotes plant growth. As long as plant life is present in a canal, phosphorus will be quickly removed from the water column. If phosphorus runoff is continuous, eutrophication usually results.

Phosphates, as ortho-phosphates ($O-PO_4$), are the most thermodynamically stable of the P forms likely to be in water. Analytical procedures, which aim to convert all P present in the sample to the ortho form, report final results as total phosphorus ($T-PO_4$ in mg/l). The median (median values are reported for non normal data) $T-PO_4$ in C-102 was 0.014 mg/l and did not vary significantly from background to discharge.

Potassium salts, naturally occurring and synthetically applied in fertilizers and pesticides, are highly soluble but rarely occur in high concentration in natural waters. At present, there is no standard for potassium in surface water. Elevated levels of potassium, though not a threat to canal biota or human health, can be indicators of leachate potential from soils to ground water.

Potassium ions assimilated by plants become available for re-solution when the plants mature and die and are tilled into the soil. Potassium is leached into the soils as plants decay. Through this natural recycling process, some leaching to ground water and runoff to surface water is to be expected (Hem, 1989).

A 1980 DERM Technical Report on Nitrate Monitoring (Church et al, 1980) found that ground water samples taken in South Dade agricultural areas indicated significantly elevated nitrate and potassium levels compared to control sampling sites located on undeveloped land. Slightly elevated potassium levels were associated with residential land use, but nitrate was not similarly elevated. On control sites located in undeveloped areas, neither nitrate nor potassium levels were elevated.

Potassium concentrations were significantly higher (95% confidence level) in the C-102 midreach and downstream than at background, increasing from 2.5 to 6.3 mg/l. Based on the elevated nitrate levels found at the same sites, elevated potassium is attributable to agricultural practices on adjacent farmlands and to a lesser extent to residential septic tank leachate.

Trace Elements, Pesticides and other Organics

Fertilizers can also contain micronutrients such as **zinc, copper,** and **magnesium**. Zinc and magnesium occur naturally in the Biscayne aquifer. Although detected as high as 80 µg/l in the C-102 and C-102N, zinc did not exceed the 1000 µg/l standard. **Copper** was detected at P-4 and P-9 in the July sampling episode at a low level of 1.5 µg/l (well below the 30 µg/l standard). **Magnesium** ranged from 4.1 to 7.6 mg/l along the entire canal (no standard currently available).

Micronutrients (zinc, copper and magnesium) are also used in the salt forms in pesticides. Historically, **lead, arsenic, cadmium** and **mercury** were also common in pesticide formulation, but due to their high toxicity and tendency to bioaccumulate, they are now little used. **Lead** (standard of 30 µg/l) and **arsenic** (standard 50 µg/l) were sometimes detected in the water column at very low levels. **Cadmium** exceeded the 0.8 µg/l standard at all sampling sites in January, where detection was as high as 9 µg/l. This could indicate either a contamination of the January samples from field or laboratory procedures or an isolated pollution incident. **Mercury** was not detected in the water column above the 0.4 µg/l detection limit.

The **pesticides, hydrocarbons** and **volatile organic compounds (VOCs)** analyzed for during the ICS are given in Appendix 3. Only phenol was detected in the water column of the C-102. All pesticides and VOCs analyzed for were below detection limits. This does not confirm the absence of all pesticides and hydrocarbons, only that those tested for were not detected. The variety of pesticides used and the frequency of new uses make testing samples for all possible pesticides prohibitively expensive.

Phenol, a hydroxylated benzene derivative was detected on two sampling occasions; one time each at P-16 (background) at 8 µg/l in April and at P-9 (midreach) at 6 µg/l in July. Although these levels are well above the current 1 µg/l standard, the 1982 DERM Water Quality Report suggests that background phenols are naturally occurring in the hydrologic system of Dade's freshwater wetlands.

Physical Properties and Other Inorganics

Physical properties were screened to detect irregularities in the water column. Under normal circumstances, the physical properties of Dade's surface waters do not vary significantly, even at different times of the year (Labowski et. al., 1983 and 1986, Cheesman, 1988 and 1988). The relative stability of these parameters provides a basis for interpretation of other monitored parameters.

Physical data taken for the C-102 ICS indicated no significant (95% confidence level) changes in pH, alkalinity, chlorides, temperature, or conductivity. Turbidity decreased downstream from background, while Total Dissolved Solids and Dissolved Oxygen increased significantly from background.

Dissolved oxygen (DO) measured in mg/l is used as an important gauge of water quality. Insufficient DO causes anaerobic decomposition of organic materials and may result in fish kills. Sufficient DO ensures low residuals of biologically available materials and ensures biochemical oxidation of ammonia and nitrite to nitrate.

The Florida Class III water standard requires that, for a one day minimum for warm water, DO does not fall below 5 mg/l.

Typically, DO does not meet the minimum standard in Dade's canals because of the close interaction of surface and ground water. Ground water is typically low in dissolved oxygen (<1.0 mg/l). The background DO measurement for C-102 averaged 2.4 mg/l and was consistent with DO values found in other Dade canals.

However, downstream in the C-102 and in the C-102N, DO increased to an average of 6 mg/l at discharge. The significant (95 % confidence level) increase in DO from background to discharge is most likely a result of plant growth in the canal which releases oxygen into the water through photosynthesis. Plant growth can be stimulated by nutrient loading from agricultural runoff.

The recharge waters from the L-31N are high in organic content and colored by tannins leaching from Everglades vegetation (DERM, 1990). It is also possible that plant growth may be stimulated by increased light penetration as the tannins become diluted downstream by inflows of groundwater.

Bacteria

Fecal and **Total Coliform** and **Fecal Streptococci** were used as health indicators for water because they are indicators of the fecal waste from humans and animals, including water fowl. Because they are very short lived in the surface water environment, coliform and streptococci presence may indicate localized and recent sources of pollution. In the early 1980's, prior to the regionalization of Dade County's sewage treatment facilities, total and fecal coliform were the major surface water quality problem in Dade County canals (Labowski, 1983). More recent DERM water quality reports (Cheesman, 1987 and 1988) indicate that bacteria are no longer a major problem in surface waters. This is the case in the C-102 ICS. Fecal coliform exceeded the FDER standard (<800 MPN) only once (at P-11) with 1300 MPN.

The Presence of Organics and Trace Elements in Sediments

Currently there are no standards for chemicals found in soils or sediments, although guidelines are being developed by Florida Department of Environmental Regulation. In low sediment loaded waters like C-102, the presence of contaminants in sediments indicates past residence in the water column of the canal. As such, detections in sediments are considered an indication of possible pollution.

Bottom sediments were sampled in April and November for trace elements and organochlorine pesticides and PCBs (EPA Method 608 Compounds). Volatile organic compounds (EPA Method 610) were tested for in November. Data are presented in Appendix 1.

Acenaphthene, a hydrocarbon derivative used in plastics and certain pesticides, was detected once at a low level of 1.9 µg/g at background (P-16). Polychlorinated Biphenyl Hydrocarbon, **PCB-1232**, was detected in sediments of the C-102N (P-4) in November at 89.7 µg/kg. PCB contamination might be attributable to the location of the canal immediately adjacent to a major power line easement where PCBs were historically used as insulator fluid for electric transformers. However, PCBs were not detected at P-9, also adjacent to the power easement. PCB exposure presents an immediate danger to human health and/or life. However, as long as PCBs remain bound to bottom sediment and are subject to microbial degradation, they pose no immediate hazard to humans. PCBs were not detected in the water column in this study.

Lead was detected in sediments at each site (18 - 52 mg/kg). **Mercury** was detected in very low quantities (<0.01 -0.03 mg/kg). **Cadmium** was also detected in sediment samples at background, midreach and discharge points, but at relatively low levels (<1 - 2.3 mg/kg). Both **zinc** and **copper** were present in the sediments at all sampling points. Zinc values ranged up to 40 µg/g. Copper ranged up to 7.4 µg/g.

DOCUMENTED SURFACE AND GROUND WATER DEGRADATION FROM NON-POINT AGRICULTURAL SOURCES IN SOUTH DADE COUNTY, FLORIDA

A 1977 DERM study (Stilwell, 1978) documented the highest nitrate levels in Dade County surface and ground waters (including public water supply wellfields) in the C-103 (Mowry) drainage basin. Follow-up studies (Church et al, 1980) were conducted to try to determine the source(s) of degradation. Relative comparisons were made between nitrate, potassium, and sodium ion levels measured in the vicinity of undeveloped land and residential and agricultural land uses. Nitrate levels were reported highest in agricultural areas.

Moreover, elevated nitrate levels in agricultural areas were associated with elevated levels of potassium (both are in fertilizer). Elevated nitrate levels measured in the vicinity of package sewage treatment plant effluents, on the other hand, were associated with elevated levels of sodium. The study concluded that where elevated levels of nitrate were associated with elevated potassium, agriculture was the main nitrate contributor.

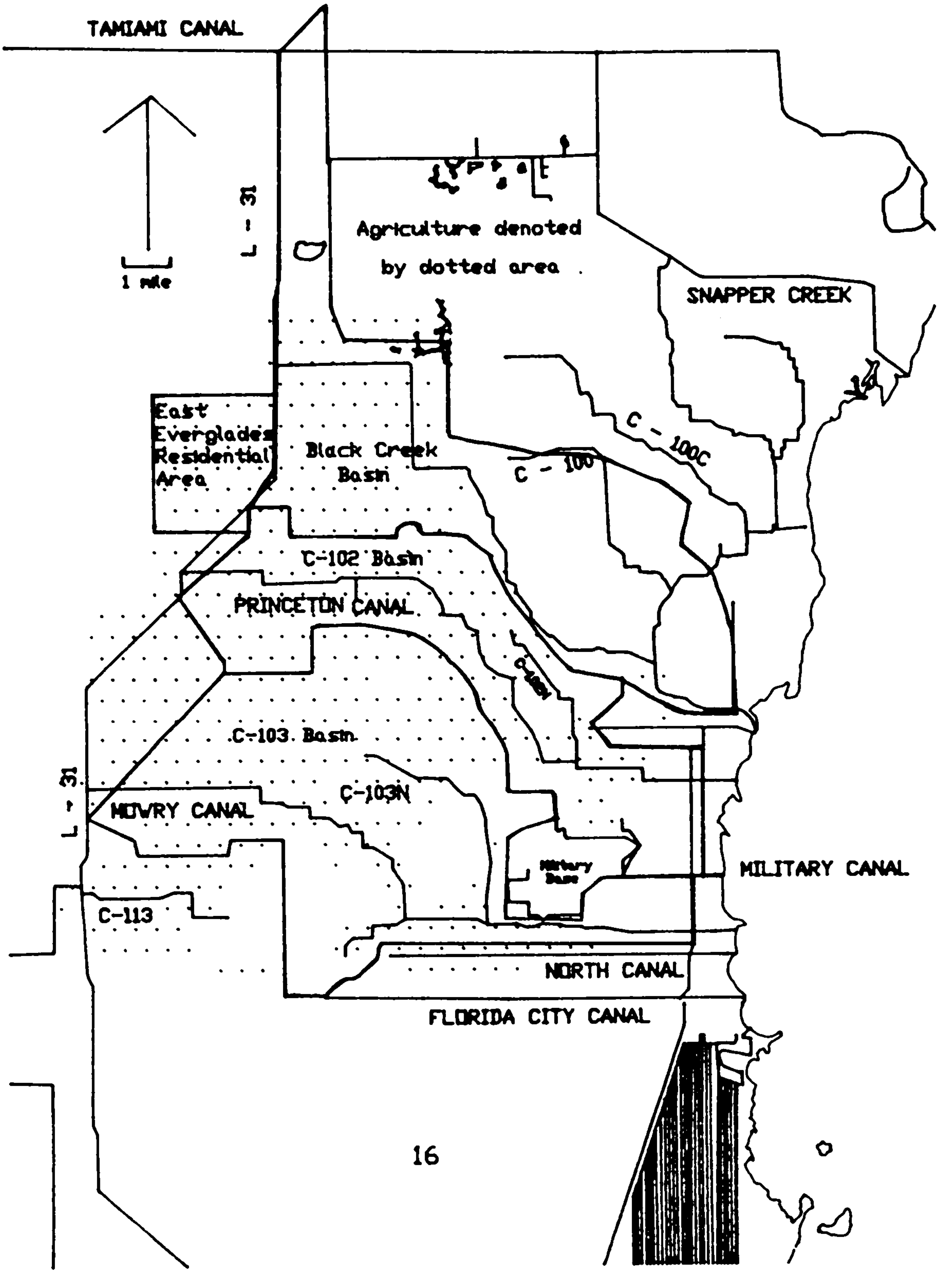
The 1980 DERM Nitrate Monitoring Program (Church et al, 1980) also reported that nitrate and potassium were more elevated in ground water in the C-102 and C-103 Basins than in the Black Creek Basin, even though at the time, agricultural acreage was greater in the Black Creek Basin. The study concluded that the differences in nitrate concentrations could be explained by the greater transmissivity of the Biscayne Aquifer in the drainage basins south of Black Creek.

An unpublished study by the South Florida Water Management District (Anderson et al, 1988) also suggested agriculture as a source of slight degradation to ground water quality in the East Everglades (elevated inorganic parameters). The study encompassed an approximately 10 square mile agricultural/residential area bordering on the west side of L-31N and lying south of Black Creek (Figure 2). The 1987 Intensive Canal Study (Cheesman, 1990) confirmed that where agricultural land use predominated over freshwater wetlands along the L-31N as in the East Everglades, surface water quality was slightly degraded from background levels of nitrate/nitrite, potassium, magnesium and chlorides. The lesser degradation in the East Everglades relative to the other agricultural drainage basins is probably due to lower hydraulic conductivity resulting from shallowness of the Biscayne Aquifer in these western reaches. Also, agriculture here is a relatively new phenomenon and not as extensive as in the south Dade basins.

As expected, Intensive Canal Survey and General Canal Program data on the Black Creek Canal (Labowski et al, 1988), C-103

Figure 2

Three South Dade Drainage Basins
and the Presence of Agricultural Land Use



(Cheesman, 1989), and C-102 support the conclusion that slight water quality degradation has occurred at upgradient (western) sampling points for each canal. More significantly, ICS data taken downstream in the C-102 and C-103 indicate a statistically significant (95% confidence level) degradation in NOx-N and potassium. DERM General Canal Program data indicate that nitrate/nitrite degradation downstream in C-102 and C-103 occurred as early as 1983. On the other hand, Black Creek Canal did not show downstream degradation for tested parameters for any reported year. (This analysis does not include the Black Creek discharge area adjacent to the Dade County Landfill at S.W. 97 Avenue.)

A Description of Land Use and Drainage Characteristics in the South Dade Drainage Basins

As with the 1980 study (Church et al, 1980), DERM Surface Water Program findings were used to determine how land use and other factors might be affecting water quality along each canal. Aerial photos were used to document land use surrounding the canals and their tributaries. Additionally, the hydrogeology of the associated drainage basin, soil drainage qualities, crop densities, land management practices and other physical properties which could affect water quality were investigated.

The most probable explanation for the small degree of degradation in the L-31N and Black Creek Canals is their greater capacity for carrying water and the resulting dilution of pollutants. The L-31N is part of the South Dade Conveyance System and at the time of these studies was designed to move 1730 cfs south to Everglades National Park. Control structures along L-31N diverted 305 cfs to Black Creek, 260 cfs to C-102 and 210 cfs to C-103 (Cooper and Lane, 1987). The wider and deeper design criteria for recharge allows 20 percent more water to flow through Black Creek as compared to C-102 and C-103. Therefore, Black Creek canal receives a greater dilution of surface water constituents with low nutrient recharge water than either C-102 or C-103.

A second factor contributing to the relatively low nutrient levels in Black Creek is that the basin is poorly drained. The portion of Black Creek Basin north of of S.W. 136 Street is an area identified by the South Florida Water Management District (Cooper and Lane, 1987) and the South Dade Soil and Water Conservation Service (1987) as having low ground elevations and therefore a water table closer to the surface than in the the C-102 and C-103 basins. A shallow water table indicates that higher water stages are maintained overall (including in the canal), resulting in slower movement of water underground toward the drainage canal. Therefore, potentially rich leachate does not migrate as rapidly downgradient toward the drainage canal.

Each of the three basins, Black Creek, C-102 and C-103, contains multi-use agriculture characteristic of South Dade; a mixture of fruit groves, tropical and temperate row crops, container and field grown foliage and tree nurseries, animal barnyards, and low density housing served by septic tanks. Black Creek Canal is also bordered by urban-residential neighborhoods served by sewers. The location of the three basins and the presence or absence of agriculture are depicted in Figure 2.

Black Creek Canal has continuous, intensive agricultural land use only in the poorly drained area west of S.W. 137 Avenue. East of 137 Avenue and south of S.W. 136 Street, the Black Creek Basin is better drained, but agricultural land was intermittent or nonexistent. Also, there was no agricultural land along the Black Creek tributaries, the C-1N and C-100B. Instead, residential land use served by a sewered collection system was predominant. This substantially reduces the potential for household nutrient contribution from residential development to ground water.

In contrast, C-102, C-103 and their tributaries are bordered by intensive agriculture most of the length of their systems, except at US-1 which is commercially developed and near Biscayne Bay which is mangrove forest. The limited residential developments, most of which are on 1 - 5 acre agricultural parcels, are served by septic tanks and often contain barnyards and fruit groves. Finally, in contrast to Black Creek Basin, both basins have relatively lower water table elevations and are well drained (Cooper and Lane, 1987). This permits rapid down gradient movement of ground water toward the drainage canal, potentially increasing the concentration of nutrients toward the canals.

Also of possible significance, the C-102 and C-103 are excavated in transverse glades in the coastal ridge (South Dade Soil and Water Conservation Service, unpublished, 1987). Transverse glades contain marl soils rather than the moderately permeable gravely loam soils which predominate in the C-102 and C-103 Basins. The marl soils, which are limited to the area immediately adjacent to the canals, are less permeable than loam soils and so more subject to overland runoff.

Comparative Analysis of the C-102 and C-103 Canals

Because of their very similar nutrient degradation profiles, the C-102 and C-103 were examined for other similarities. The canals are physically comparable; both drain agricultural land, originate at the L-31N, and have tributary drainage canals at a downstream location. This configuration allows characterization of the upper reaches of the main canal without interference from tributaries. The tributary canals are a focal point of the study because they originate in farm fields but are not flushed by surface recharge waters as are the main canals.

Additionally, the two canals somewhat parallel one another as they make their way toward their discharge into Biscayne Bay. While land uses may differ somewhat, multi-use agriculture is predominant; both cross commercially zoned land at US 1, and their control structures are similarly located (Figure 1). Finally, the canals' hydrology and water chemistry are very similar.

Canal Hydrology

The C-102 and C-103 drainage basins pass through relatively level topography composed of Miami Oolite rock overlain in the western areas by well-drained rocky substrate and in the southeast by Perrine and Biscayne Marls (South Dade Soil and Water Conservation Service, unpublished, 1987). Marl soils also predominate in the areas immediately adjacent to the canals.

In addition to inflow from L-31N, these canals, like other canals in well drained areas of Dade County, are recharged by ground water seepage and rainfall following wet season storm events. Substances applied to the characteristically thin, well drained soil may leach to ground water carried by rainfall or irrigation water. Most pollutants entering receiving waters from these non-point recharge waters are difficult to document because pollutants are rapidly diluted.

In the dry season, ground water is recharged by water infiltration from the canal as long as the canal stages are maintained by recharge from L-31N. If the canal contains pollutants not originating from ground water, the surface water will contaminate adjacent ground water. This is potentially the case in the C-102 and C-103 when herbicides have been applied for canal maintenance. Then it is possible for adjacent irrigation wells to draw the freshly applied herbicides through the side of the canal into the ground water environment where they do not degrade as rapidly.

On the other hand, if canal stages are not maintained with recharge water, the canal and immediately adjacent ground water will reach an equilibrium and pollutants or their degradation products present in the ground water can diffuse into the canal and vice versa. Data from the C-102N and C-103N tributaries showed that this was potentially the case in unflushed canals where nutrients are not being diluted except during a storm event.

Although the canals were sampled over a wet and dry season, there are insufficient ICS data to statistically analyze seasonal variations of contaminant levels. However, for 1988, NOx-N levels at all downstream sampling sites are somewhat lower in April as compared to the other quarterly sampling episodes in July, October, and January. The 1988 rainfall data from the South Florida Water Management District (Table 3) show that the April sampling episode followed three consecutive months with rainfall below one inch per month. The dry conditions could have decreased the liklihood of nitrates leaching to the ground water. April is also the end of the winter growing season and fertilizers are not being applied to new plantings.

Data Analysis of the C-102 and C-103

Comparative background and discharge data (means and medians) for tested parameters for the L-31N, C-102, C-103 and the C-102N and C-103N are presented in Table 4. All data are from this report and the respective Intensive Canal Surveys (Cheesman, 1989, Cheesman, 1990). Parameter analysis shows the C-102 and C-103 systems were very similar in their trends for nutrient values from background to discharge. While generally meeting water quality standards, they show downstream degradation in NOx-N and potassium, two of the major components of fertilizer. The degradation is even more significant in the north tributaries which are not diluted by surface recharge waters.

Nitrate/Nitrite Loading from C-102 to Biscayne Bay

Biscayne Bay Monitoring data collected by DERM since 1979 has documented the highest mean NOx-N levels in all of the Bay monitoring stations at the mouths of C-102 and C-103, 3.75 mg/l and 2.14 mg/l, respectively. Ambient Bay concentrations range from 0.02 - 0.06 mg/l NOx-N, indicating a rapid dilution of NOx-N immediately off shore.

A DERM draft report (Weaver, 1992) attributes higher than average phytoplankton concentrations at these canal mouths to eutrophication. Additionally, there is a slight depletion of dissolved oxygen in these areas. The report warns that although the existing state of eutrophication has not been detrimental, a continual increase in nutrient input could reduce dissolved oxygen to levels which would reduce productive biological communities.

Summary

Agricultural practices have the potential to degrade surface waters in South Dade County via interaction with ground water carrying agricultural leachate. The degradation is physically evident from abundant aquatic plant growth which must be mechanically and chemically removed from the canals to ensure proper basin drainage. This degradation is evident in well recharged (and therefore diluted) portions of the canal, so

TABLE 3

1988 Daily Rainfall Data in the Vicinity of The C-102 and C-103 Basins

STATION: S331_R DBKEY: 05967 1988 1988 1988 1988 1988

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	.00	→ .00	.00	.00	1.51	.00	.00	.50	.13	1.49	.00	.00
2	.00	.00	.00	.00	.00	.00	.00	.00	.05	.14	.00	.00
3	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
4	.00	.00	.00	.00	.00	.00	.19	.00	.00	.00	.00	.00
5	.00	.00	.00	.00	.00	.28	.00	.00	.00	.00	.00	.00
6	.00	.00	.00	.00	.00	2.88	.20	.00	.00	.00	.15	.00
7	.00	.00	.00	.00	.00	.78	.64	1.10	.00	.00	.00	.00
8	.24	.14	.00	.00	.00	3.27	.09	.00	.00	.00	.00	.00
9	.00	.00	.00	.00	.00	.00	.12	.00	.00	.00	.00	.00
10	.44	.00	.00	.00	.00	.48	.00	2.72	.00	.00	.00	.00
11	.06	.00	.00	.00	.00	.00	.00	.23	.91	.00	.00	.00
12	.00	.00	.00	.00	.00	1.41	→ .23	.30	.00	→ .00	.00	.00
13	.00	.00	.00	.00	.00	2.90	.00	.00	.00	.00 ←	.00	.00
14	.35	.00	.00	.00	.00	.61	.00	4.01	.00	.00	.00	.00
15	.00	.00	.00	.00	.00	.07	.00	2.38	.00	.00	.00	.00
16	.00	.00	.00	.00	2.24	.00	.08	.00	.00	.00	.00	.00
17	.00	.00	.00	.00	.10	.00	.43	.25	.00	.00	.00	.00
18	.00	.00	.00	.00	.00	.00	.61	.00	.00	.00	.00	.00
19	.00	.00	.34	→ .00	.16	.69	1.42	.86	.00	.00	.00	.00
20	.00	.00	.00	.00 ←	.00	.42	.07	1.82	.00	.00	.00	.00
21	.23	.26	.00	.00	.00	.00	.00	.07	.00	.00	.00	.00
22	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
23	.00	.00	.00	.00	.00	.00	3.10	.00	.00	.00	.00	.00
24	.00	.00	.00	.00	.00	.40	.07	.00	.00	.00	.00	.00
25	.32	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
26	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
27	.00	.00	.00	.00	1.54	.00	.00	3.33	.00	.00	.00	.00
28	.00	.00	.00	.00	.00	.00	.21	.26	.00	.00	.00	.00
29	.00	.00	.00	.00	.47	.00	.03	.00	.00	.00	.00	.00
30	.00		.00	.62	.41	.48	.10	.00	.00	.00	.00	.00
31	.00		.00		.12		.45	.00		.00		.00
MAX	0.44	0.26	0.34	0.62	2.24	3.27	3.10	4.01	0.91	1.49	0.15	0.00
MEAN	0.05	0.01	0.01	0.02	0.21	0.49	0.26	0.58	0.04	0.05	0.01	0.00
MIN	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SUM	1.64	0.40	0.34	0.62	6.55	14.67	8.04	17.83	1.09	1.63	0.15	0.00

**** DATA IS PROVISIONAL AFTER ****

DATA TAG LEGEND

M - MISSING DATA
S - ORIGINAL HAD MORE THAN 4 SIGNIFICANT DIGITS
L - LINE-AVERAGE
? - QUESTIONABLE
> - GREATER THAN
T - TRACE AMOUNT
G - AMOUNT ACCUMULATED WAS GREATER THAN

DATA TAG LEGEND

P - SUMMARY COMPUTED FROM PARTIAL RECORD
E - ESTIMATED
< - LESS THAN
A - INCLUDES PREVIOUS DAYS WITH X
X - INCLUDED IN NEXT AMOUNT TAGGED A
R - RAINFALL WAS RECORDED

→ : Indicates a sampling date

Source : South Florida Water Management District

Table 4

Mean/Median Results of the 1988 ICS on the C-102 Canal at Background and Discharge as Compared to the C-103 and L-31N and Established Surface Water Standards

Parameters	Unit Measure	Standards		Background			Discharge		Unflushed	
		DERM***	DER**** Class 3	L31N	C102	C103	C102	C103	C102N	C103N
Alkalinity	mg/l	-----	-----	215	206*	208	206*	173	192	208
Ammonia	mg/l	<0.5	-----	.46	.37	.45	0.125	.042	.22	0.025
Arsenic	ug/l	<50	-----	< 2	< 2	< 5	< 2	6	2.3	5
Coliform Bact.	MPN/	<1000	< 2400	< 20	173*	-----	173*	-----	697	-----
Fecal Colif.	100 ml	-----	< 800	< 20	0.0	-----	0.0	-----	25	-----
Cadmium	ug/l	-----	< 1.2	< .1	< .1	-----	< .1	-----	< .1	-----
Calcium	mg/l	-----	-----	-----	77	70.1	95.6	89.9	83.8	103.1
Chromium	ug/l	< 50	-----	-----	BDL	-----	BDL	-----	BDL	-----
Copper	ug/l	<400	< 30	< 1.0	BDL	0.28	BDL	1.16	1.5	1.07
Cyanide	ug/l	0.0	< 5.0	-----	BDL	-----	BDL	-----	BDL	-----
Conductivity	umhos	< 500	-----	533	596*	510	596*	887	602	575
Chlorides	mg/l	< 500	< 250	74	45	53	45	219	55	27.5
Diss. Oxygen	mg/l	>or=4	>or=5	2.73	2.6	-----	6.7	-----	5.2	-----
Lead	ug/l	< 950	< 30	1.0	0.50	-----	0.7	-----	-----	-----
Magnesium	mg/l	-----	-----	-----	6.98	7.1	4.53	6.25	7.1	3.5
Mercury	ug/l	0.0	<or=.2	< 0.1	BDL	-----	BDL	-----	BDL	-----
Nitrate/Nitrite	mg/l	-----	<or=10**	0.02	0.05	0.07	3.08	1.68	3.7	3.5
pH	units	6.0-8.5	6.5-8.5	-----	7.05	-----	7.5	-----	6.8	-----
Ortho-P	mg/l	-----	-----	.005	.007	.01	.007	.01	.005	0.01
Total-P	mg/l	-----	-----	.012	0.014*	.025	0.014*	.027	.018	0.02
Potassium	mg/l	-----	-----	-----	2.48	1.8	6.29	6.5	6.9	8.2
Sodium	mg/l	-----	-----	-----	27.5	31.6	22.3	37.4	23	11
Zinc	ug/l	<1000	< 30	< .01	28.9	< 10	2.5	17	26	< 10
TDS	mg/l	<1000	<1000	-----	358	-----	406	-----	401	-----
Turbidity	NTUs	< 50	-----	3.6	2.98	3.25	0.54	1.7	.62	< 1.0

*Parameters exhibiting as one population or as non normal data are presented as median values

**Nitrate/nitrite standards are from FDER Class I Potable Water Standards

***DERM standards are from Chapter 24-11(4), Dade County Code

****FDER standards are from Chapter 17-3 Part III, 4/87, Florida Statutes

----No mean or median values are available.

nutrient loadings must be very large. The degradation is more easily detected in canals with lower flow rates such as the C-102N. The loadings from the canals into Biscayne Bay are also quickly diluted offshore.

There are indications that the physical characteristics of the drainage basin and the intensity of agriculture can affect the degree of nutrient degradation. Well recharged surface waters in high water table areas, even where agriculture is predominant, as in the East Everglades and western Black Creek Basin, show only slightly elevated inorganic parameters. However, canals in well drained basins, such as the C-102 and C-103, are more likely to exhibit a significant degree of degradation from background, and especially where lack of recharge waters limit dilution.

SUMMARY OF FINDINGS

Overall, the C-102 and C-102N tributary exhibited no serious violation of Class I or Class III water quality standards. Only dissolved oxygen (DO) levels did not meet minimum standards upstream in the C-102 and this is in keeping with background DO levels in the L-31N. However, both canals were significantly degraded above background in nitrate (0.01 - 7.6 mg/l) and potassium (1.4 - 7.2 mg/l) levels midreach and even more significantly at discharge. In the C-102N tributary, nitrates approached the current Class I, potable standard (10 mg/l) during one sampling event.

Except for cadmium, all trace elements sampled were detected in the sediments at each sampling point along the main canal. PCB-1232, a known carcinogen in electrical transformer coolant, was detected in the sediment of the C-102N as high as 385 µg/kg. Finally, acenaphthene, a priority pollutant polynuclear aromatic hydrocarbon used in the manufacture of plastics and pesticides, was detected one time in sediment at the background site (1.9 µg/g).

The main interest in the data collected and analyzed for the C-102 and C-102N water columns is the distinct differences in the data upstream and downstream from the intersection of the two canals. Statistical analysis (Table 5) indicates that nitrate/nitrite (NOx-N), potassium, calcium, total dissolved solids (TDS) and dissolved oxygen (DO) in the C-102N and in the C-102 downstream from the canals' intersection were significantly higher than in the C-102 upstream from the intersection. At the same time, ammonia, turbidity, magnesium and sodium were significantly lower than in the C-102 upstream from the canals' intersection.

These significant differences were probably attributable to a lack of flushing in the C-102N, a dead end canal, and continual flushing of the upper reaches of C-102 from conveyances from L-31N, rather than differences in land use or concentration of leachate in ground water. Flushing with recharge water tends to dilute the concentration of the components of surface water and therefore the degrading effects of pollutants leached or drained into the canals from adjacent land uses.

The C-102N, which originates within agricultural fields, has no headwaters for recharge. Any recharge of the C-102N is a result of 1) seepage from ground water underlying agricultural fields, 2) rainfall, or 3) overland runoff from a severe storm event. In the dry season, water recharge from these sources is substantially diminished. Then, some chemical parameters in the surface water, because of lack of dilution and extended

Table 5
Kruskal Wallace Analysis of Varience
1988 ICS Data from Station to Station
along the C-102 Canal

Parameter	Sampling Sites							Means/Medians*		
	P-16 Bkgr.	P-11	P-10	P-9	P-4	P-2	P-1 Disch.	Pop1	Pop2	Pop3
Ammonia	NPD	NPD	PD	PD	PD	PD	PD	0.343	0.129	
Nitrates	NPD	NPD	PD	PD	[illegible]	[illegible]	[illegible]	0.051	0.937	[illegible]
DO	NPD	NPD	PD	PD	PD	PD	PD	2.62	6.7	
Turbidity	NPD	NPD	NPD	PD	PD	PD	PD	2.98	0.546	
TDS	NPD	NPD	NPD	NPD	PD	PD	PD	358	406	
Magnesium	NPD	NPD	NPD	NPD	PD	PD	PD	6.98	4.53	
Calcium	NPD	NPD	NPD	PD	PD	PD	PD	77	95.6	
Sodium	NPD	NPD	NPD	NPD	PD	PD	PD	27.5	22.3	
Potassium	NPD	NPD	NPD	PD	PD	PD	PD	2.48	6.29	
Ortho-P	NPD	NPD	NPD	NPD	NPD	NPD	NPD	0.007		
Total-P	NPD	NPD	NPD	NPD	NPD	NPD	NPD	0.014*		
Conductivity	NPD	NPD	NPD	NPD	NPD	NPD	NPD	596*		
T-Col	NPD	NPD	NPD	NPD	NPD	NPD	NPD	173		
F-Col	NPD	NPD	NPD	NPD	NPD	NPD	NPD	0.0*		
Temperature	NPD	NPD	NPD	NPD	NPD	NPD	NPD	25.7		
Chlorides	NPD	NPD	NPD	NPD	NPD	NPD	NPD	45		
pH	NPD	NPD	NPD	NPD	NPD	NPD	NPD	7.05		
Alkalinity	NPD	NPD	NPD	NPD	NPD	NPD	NPD	206*		

Pop 1 = NPD - No probable difference from background

Pop 2 = PD - One order of probable difference above or below background

Pop 3 = PDP - Two orders of probable difference above background

Medians are presented for one population parameters exhibiting non-normal data resident time in the canal, may become more concentrated due to evaporation. The high nutrient levels in the canal do not necessarily indicate that the adjacent ground water is equally nutrient rich (this would be the case only if the canal is well drained); but the condition is cause for concern for adjacent drinking water wells which could be partially recharged with water from the canal.

In contrast, the C-102 received recharge and flushing from its origin at the main north-south conveyance canal, L-31N. Data shows that the effect of this flushing is carried several miles downstream to P-11. However, further downstream at P-10, dilution is diminished and increased nitrates are detected.

Still further downstream, two miles upstream from the C-102/ C-102N confluence, a control structure, S-165, generally impedes or stops the flow of recharge water and its diluting effects on the downstream side at P-9, resulting in even more significant increases in nitrates, potassium, and calcium. Finally, the C-102 receives recharge at the point of confluence with the C-102N after a storm event. These waters, significantly polluted above ambient concentrations, contributed to more degradation downstream in the C-102 at P-2 and P-1, where the degraded waters drain into Biscayne Bay.

Nitrate degradation of surface and ground waters in South Dade has been well documented since 1977 and has consistently been attributed to agriculture. For this study, comparisons were made of three South Dade drainage basins in agricultural areas (Black Creek, C-102, and C-103). The comparisons indicated that agricultural land use alone does not explain the differential nutrient degradation of surface water in the basins.

The following factors may affect the degree to which land use and ground/surface water interaction can lead to surface water degradation or the degree to which degradation can be detected:

1. The specific design criteria for water quantity flow in the canal,
2. Whether the basin is well drained,
3. The lack of recharge and limited drainage in tributary canals,
4. The intensity of agriculture in the basin, and
5. The amount of rainfall in the basin.

Specifically, Black Creek Canal, which conveys greater volumes of water and is fed by a drainage basin of relatively lower hydraulic conductivity and somewhat less intense agriculture, was only slightly degraded with nitrates. In contrast, C-102 and C-103 were significantly impacted by nitrates compared to ambient levels. Both canals are located in relatively well drained basins, have intensive agriculture their entire lengths, have unflushed tributaries which drain into the main canal, and have a 20% less water carrying capacity design than Black Creek.

The most serious implication of the data collected on the C-102 is that degraded ground water conditions in the South Dade agricultural areas contribute significantly to degradation of surface waters. At the same time, the surface water degradation may not have always been evident from data collected by surface water sampling due to the dilution effects discussed.

RECOMMENDATIONS:

1. To better characterize the interaction of ground and surface waters, ground water monitoring sites should be added to Dade County's Intensive Canal Studies to better characterize water table elevation, movement and quality in ground water adjacent to the canals. The surface and ground water data should be collected simultaneously and analyzed as Basin Water Quality Studies. In South Dade in particular, the monitoring should be designed to estimate nutrient loadings to surface water from agriculture.

2. The C-102N, an unflushed canal tributary of the C-102, has exhibited a nitrate level approaching the drinking water standard of 10 mg/l NOx-N. Domestic wells adjacent to the canal should be tested periodically for nitrate levels, particularly in drought conditions. If nitrate levels are detected approaching or exceeding the drinking water standard, the homeowners should be advised of the health implications for infants.

3. Since there are documented effects of nutrient degradation at the mouth of C-102 (located in Biscayne National Park), and as domestic drinking water supplies are located in agricultural areas, feasible means should be made to reduce nutrient loading in the C-102 basin and to reduce nitrate levels in C-102 to background levels. In order to determine which agricultural practices could reduce these loadings, existing fertilizer application guidelines and practices should be investigated to ensure applicability to the gravely loam and marl soils in the South Dade drainage basins.

APPENDIX 1

DATA TABLES

1988 INTENSIVE CANAL STUDY - METALS

SITE	DATE	AS	CD	CR	CU	PB	HG	ZN
			ug/l					
P-1	Jan-88	<2	1.8	<1	<1	<2	<0.4	<3
P-1	Apr-88	<2	<0.1	<1	<1	<2	<0.4	<3
P-1	Jul-88	<2	<0.1	<1	<1	3	<0.4	10
P-1	Oct-88	<2	<0.1	<1	<1	<2	<0.4	<3
P-2	Jan-88	<2	2	<1	<1	<2	<0.4	<3
P-2	Apr-88	<2	<0.1	<1	<1	<2	NS	<3
P-2	Jul-88	<2	<0.1	<1	<1	3.8	<0.4	10
P-2	Oct-88	<2	<0.1	<1	<1	<2	<0.4	60
P-4	Jan-88	<2	2	<1	<1	<2	<0.4	<3
P-4	Apr-88	2.3	<0.1	<1	<1	<2	<0.4	<3
P-4	Jul-88	<2	<0.1	<1	<1	<2	<0.4	50
P-4	Oct-88	<2	<0.1	<1	<1	<2	<0.4	3.2
P-9	Jan-88	<2	2	<1	<1	<2	<0.4	<3
P-9	Apr-88	<2	<0.1	<1	<1	<2	<0.4	<3
P-9	Jul-88	<2	<0.1	<1	<1	3	<0.4	80
P-9	Oct-88	3	<0.1	<1	<1	<2	<0.4	<3
P-10	Jan-88	<2	9	<1	<1	<2	<0.4	<3
P-10	Apr-88	<2	<0.1	<1	<1	<2	NS	<3
P-10	Jul-88	<2	<0.1	<1	<1	2.6	<0.4	20
P-10	Oct-88	<2	0.1	<1	<1	<2	<0.4	55.8
P-11	Jan-88	<2	1.9	<1	<1	<2	<0.4	<3
P-11	Apr-88	<2	<0.1	<1	<1	<2	NS	<3
P-11	Jul-88	<2	<0.1	<1	<1	2	<0.4	10
P-11	Oct-88	<2	<0.1	<1	<1	<2	<0.4	<3
P-16	Jan-88	<2	1.9	<1	<1	<2	<0.4	<3
P-16	Apr-88	<2	<0.1	<1	<1	<2	NS	<3
P-16	Jul-88	2.2	<0.1	<1	<1	2	<0.4	50
P-16	Oct-88	<2	0.4	<1	<1	<2	<0.4	7.8
P-2FD	Jan-88	<2	2	<1	<1	<2	<0.4	<3
P-10FD	Apr-88	<2	<0.1	<1	<1	<2	NS	<3
P-9FD	Jul-88	<2	<0.1	<1	<1	2.9	<0.4	10
P-4FD	Oct-88	<2	<0.1	<1	<1	<2	<0.4	4.5

1988 INTENSIVE CANAL STUDY - ORGANICS

3a	DATE	PHENOL ug/l	CYANIDE ug/l
P-1	Jan-88	<4	<5
P-1	Apr-88	<4	NS
P-1	Jul-88	<4	NS
P-1	Oct-88	<4	<4
P-2	Jan-88	<4	<5
P-2	Apr-88	<4	NS
P-2	Jul-88	<4	NS
P-2	Oct-88	<4	<4
P-4	Jan-88	<4	<5
P-4	Apr-88	<4	NS
P-4	Jul-88	<4	NS
P-4	Oct-88	<4	<4
P-9	Jan-88	<4	<5
P-9	Apr-88	<4	NS
P-9	Jul-88	<4	NS
P-9	Oct-88	<4	<4
P-10	Jan-88	<4	<5
P-10	Apr-88	<4	NS
P-10	Jul-88	6	NS
P-10	Oct-88	<4	<4
P-11	Jan-88	<4	<5
P-11	Apr-88	<4	NS
P-11	Jul-88	<4	NS
P-11	Oct-88	<4	<4
P-16	Jan-88	<4	<5
P-16	Apr-88	8	NS
P-16	Jul-88	<4	NS
P-16	Oct-88	<4	<4
P-2FD	Jan-88	<4	<5
P-10FD	Apr-88	<4	NS
P-9FD	Jul-88	<4	NS
P-4FD	Oct-88	<4	<4

INTENSIVE CANAL STUDY 1988 - NUTRIENTS

SITE #	DATE	NH3mg/l	NOXmg/l	O-PO4mg/l	T-PO4mg/l
P-1	Jan-88	0.06	3.19	0.007	0.03
P-1	Apr-88	0.03	2.11	0.005	0.014
P-1	Jul-88	0.12	3.31	0.007	0.01
P-1	Oct-88	0.09	3.73	0.009	0.012
P-2	Jan-88	0.13	3.12	0.006	0.014
P-2	Apr-88	0.05	2.03	0.012	0.011
P-2	Jul-88	0.15	3.22	0.004	0.001
P-2	Oct-88	0.12	3.83	0.008	0.011
P-4	Jan-88	0.23	2.8	0.006	0.012
P-4	Apr-88	0.22	2.12	0.005	0.017
P-4	Jul-88	0.23	2.32	0.001	0.033
P-4	Oct-88	0.18	7.65	0.008	0.012
P-9	Jan-88	0.04	0.82	0.009	0.014
P-9	Apr-88	<0.01	0.41	0.007	0.02
P-9	Jul-88	0.02	1.43	0.006	0.018
P-9	Oct-88	0.01	1.31	0.009	0.011
P-10	Jan-88	0.27	0.44	0.006	0.016
P-10	Apr-88	0.03	1.26	0.005	0.018
P-10	Jul-88	0.04	0.06	0.007	0.013
P-10	Oct-88	0.19	0.37	0.008	0.015
P-11	Jan-88	0.42	0.06	0.006	0.041
P-11	Apr-88	0.09	0.05	0.007	0.017
P-11	Jul-88	0.44	<0.01	0.003	0.058
P-11	Oct-88	0.32	0.23	0.01	0.016
P-16	Jan-88	0.48	<0.01	0.006	0.036
P-16	Apr-88	0.07	0.05	0.006	0.022
P-16	Jul-88	0.49	0.02	0.006	0.012
P-16	Oct-88	0.43	<0.01	0.009	0.014
P-2FD	Jan-88	0.06	1.6	0.006	0.002
P-10FD	Apr-88	0.02	1.91	0.005	0.015
P-9FD	Jul-88	0.01	1.36	0.002	0.025
P-4FD	Oct-88	0.16	2.68	0.008	0.014

SITE #	DATE	ALKmg/l	TURBntu	TDSmg/l
P-1	Jan-88	106	0.7	378
P-1	Apr-88	193	0.3	392
P-1	Jul-88	206.5	0.36	525
P-1	Oct-88	217	0.4	400
P-2	Jan-88	107	1	371
P-2	Apr-88	204.2	0.3	397
P-2	Jul-88	215.3	0.28	413
P-2	Oct-88	216.2	0.6	421
P-4	Jan-88	110	1.1	400
P-4	Apr-88	216	0.7	413
P-4	Jul-88	220.9	0.2	409
P-4	Oct-88	221.2	0.5	385
P-9	Jan-88	105	0.2	326
P-9	Apr-88	207.4	0.2	381
P-9	Jul-88	212	0.11	402
P-9	Oct-88	227.5	0.3	359
P-10	Jan-88	107	0.2	353
P-10	Apr-88	212.2	0.6	377
P-10	Jul-88	224	13.8	337
P-10	Oct-88	207	0.9	327
P-11	Jan-88	106	1.6	363
P-11	Apr-88	186.4	3	386
P-11	Jul-88	216.8	2.2	362
P-11	Oct-88	199.2	1.1	311
P-16	Jan-88	106	1.2	358
P-16	Apr-88	183.5	7.1	377
P-16	Jul-88	216	3	338
P-16	Oct-88	197.2	3.6	309
P-2FD	Jan-88	108	0.8	388
P-10FD	Apr-88	198.6	0.5	398
P-9FD	Jul-88	212	0.14	376
P-4FD	Oct-88	220.5	0.4	397

INTENSIVE CANAL STUDY - 1988 - FIELD DATA

SITE #	DATE	TEMP C	pH	CONDx100	DO
P-1	Jan-88	23	6.93	6.23	9.6
P-1	Apr-88	27	7.02	3.56	10
P-1	Jul-88	27.5	7.2	6.72	6.45
P-1	Oct-88	26.6	7.26	7.47	5.51
P-2	Jan-88	24	6.88	6.24	9.6
P-2	Apr-88	26.5	6.96	3.66	9.3
P-2	Jul-88	26	7.01	6.31	4.3
P-2	Oct-88	26.25	7.2	7.47	4.65
P-4	Jan-88	24.9	6.76	6.38	6.1
P-4	Apr-88	25	6.82	3.67	5.5
P-4	Jul-88	25.8	6.65	6.42	4.1
P-4	Oct-88	26.12	7.19	7.62	5.29
P-9	Jan-88	25.5	6.75	5.96	1.55
P-9	Apr-88	28	6.74	4.41	1.25
P-9	Jul-88	26.5	7.02	6.15	3
P-9	Oct-88	25.5	7.05	7.35	1.7
P-10	Jan-88	22.2	7.03	5.73	8
P-10	Apr-88		7.35	3.47	ns
P-10	Jul-88	29	7.2	5.7	3.5
P-10	Oct-88	26.84	7.23	6.64	1.87
P-11	Jan-88	21.5	7.04	5.55	4.1
P-11	Apr-88		7.39	3.63	ns
P-11	Jul-88	27.5	7.1	5.71	3
P-11	Oct-88	26.49	7.21	6.4	1.2
P-16	Jan-88	22	6.71	5.75	2.3
P-16	Apr-88				ns
P-16	Jul-88	27	7.6	5.68	2.5
P-16	Oct-88	26.45	7.14	5.86	0.06

INTENSIVE CANAL STUDY - 1988 - BACTERIA

SITE #	DATE	CLmg/l	T-COLmpn	F-COLmpn	F-STREP
P-1	Jan-88	45	800	<20	NS
P-1	Apr-88	79	80	<20	<20
P-1	Jul-88	53	1300	<20	<20
P-1	Oct-88	43	40	20	<20
P-2	Jan-88	49	300	<20	NS
P-2	Apr-88	89	80	40	40
P-2	Jul-88	43	11000	700	<20
P-2	Oct-88	53	130	80	<20
P-4	Jan-88	56	230	<20	NS
P-4	Apr-88	72	2400	80	170
P-4	Jul-88	48	80	<20	<20
P-4	Oct-88	45	80	20	<20
P-9	Jan-88	60	130	<20	NS
P-9	Apr-88	87	230	40	2400
P-9	Jul-88	52	1300	<20	230
P-9	Oct-88	52	40	20	<20
P-10	Jan-88	65	130	<20	NS
P-10	Apr-88	82	110	20	20
P-10	Jul-88	46	500	<20	80
P-10	Oct-88	46	<20	<20	<20
P-11	Jan-88	65	500	<20	NS
P-11	Apr-88	92	1300	1300	20
P-11	Jul-88	49	130	<20	<20
P-11	Oct-88	57	300	300	230
P-16	Jan-88	65	20	<20	NS
P-16	Apr-88	89	230	230	300
P-16	Jul-88	49	20	20	<20
P-16	Oct-88	40	20	<20	40
P-2FD	Jan-88	48	NS	NS	NS
P-10FD	Apr-88	78	NS	NS	NS
P-9FD	Jul-88	56	NS	NS	NS
P-4FD	Oct-88	46	40	40	<20

INTENSIVE CANAL STUDY, 1988 - CATIONS

SITE #	DATE	Na mg/l	K mg/l	Ca mg/l	Mg mg/l
P-1	Jul-88	25.89	6.3	100	4.8
P-1	Oct-88	19.6	6.6	106	4.9
P-2	Jul-88	22.9	6.4	97.1	4.6
P-2	Oct-88	19.1	6.3	99.8	4.5
P-4	Jul-88	23.1	6.6	97.5	4.1
P-4	Oct-88	22.8	7.2	104	4.3
P-9	Jul-88	30.6	5.6	82.5	7.3
P-9	Oct-88	26.2	5.6	85.2	6.9
P-10	Jul-88	29.2	2.1	78.9	7.5
P-10	Oct-88	23.7	4.5	79.9	5.8
P-11	Jul-88	29.3	1.8	75.5	7.6
P-11	Oct-88	23.1	3.3	81.3	6.3
P-16	Jul-88	29.2	1.7	74.4	7.4
P-16	Oct-88	25.1	1.4	72.3	6.5
P-9FD	Jul-88	31.1	5.5	83.5	7.5
P-4FD	Oct-88	22.5	6.8	101	4.5

1988 ICS - Sediment Sample Results

Metals

Sample Site	Date	As	Cd	Cr	Cu	Pb	Zn	Hg
P-1	4/88	<3	<1	<3	3.4	<3	14	NS
P-1	11/88	0.5	<1	3.5	4.5	20	5.5	.03
P-2	4/88	NA	NS	NS	NS	NS	NS	NS
P-2	11/88	2.3	2.3	11.8	5.5	51.9	4.6	.02
P-4	4/88	<3	<1	<3	7.4	<3	40	NS
P-4	11/88	0.5	<1	3.1	6.1	18.8	5.1	.03
P-9	4/88	<3	<1	<3	6.8	<3	20	NS
P-9	11/88	0.4	<1	3.9	6.9	18.6	12.8	<.01
P-10	4/88	<3	<1	<3	4.9	<3	17	NS
P-10	11/88	0.7	<1	5.5	5.5	28.4	29.4	<.01
P-11	4/88	<3	<1	<3	3.8	<3	32	NS
P-11	11/88	0.8	1.9	5.6	4.7	20.5	8.4	0.2
P_16	4/88	5	<1	<2	3.6	<3	22	NS
P-16	11/88	1.4	1.0	7.9	4.0	25.8	6.9	<.01

NS - not sampled units on 4/88 - μg/g units on 11/88 - mg/kg

EPA 608s

On sample date 4/88 all sites, all parameters were BDL

On sample date 11/88, Site P-4, PCB 1232 - 89.7 μg/kg
Site P-4 dup, PCB 1232 _ 385 μg/kg
All remaining sites, all parameters - BDL

EPA 610s sampled only 4/88

P-16, acenaphthene - 1.9 μg/g
All remaining sites, all parameters, - BDL

APPENDIX 2

STATISTICAL OPERATIONS

STATISTICAL OPERATIONS

The data for parameters quantified in the water column were tested for normalcy using probability plots, skewness, and the Kolmogorov Smirnov One-Sample Test. Probability plots and skewness were performed using EPA computer software, GEO-EAS. Kolmogorov-Smirnov Test was done on SYSTAT.

When data are plotted on log scale probability paper, normal distribution results are linear. The results of normal vs. non-normal data are as follows:

Normal Data		Non-Normal Data	
Parameter	Means	Parameter	Median
log Turbidity	1.46*	NOx-N	1.4
Temperature (°C)	25.7	T-PO_4	0.014
Dissolved O_2	4.58	Alkalinity	206
log pH	7.05*	Conductivity	596
log NH_3	0.102*	Calcium	84.4
O-PO_4	0.007	Magnesium	6.05
TDS	379	Potassium	5.6
log Chlorides	44.98*	Sodium	24.4
log T-Coliform	173*	Fecal-Colif.	0.0
log Fecal Strep	30.06*		

* Value expressed as antilog (geometric mean)

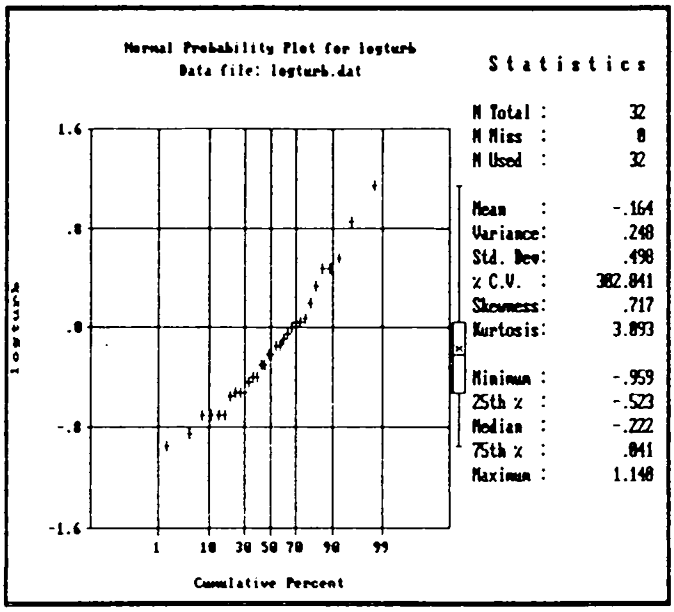
[Probability plots are included in this appendix.]

Skewness is a measure of data symmetry around a common mean. For normal distribution the value for skewness is zero. A skewed distribution means that the majority of the values fall at one end of a curve with very few at the other. A positive skew means that the tail of the distribution curve is pulled to the right because data points are biased by a few high values, while a majority of them are low. A negative skew means that the distribution is pulled to the left because most of the values are high with a few very low values.

The Kolmogorov-Smirnov (K-S) One Sample Test was used to compare data from one sample site to another to a normal distribution. It is a nonparametric test for goodness of fit. The test calculates the deviations of observed and expected (normal distribution) cumulative frequencies. If deviations exceed a critical value, based on sample size, then data are not assumed normal. SYSTAT assigns a probability rating to determine if the population is normal.

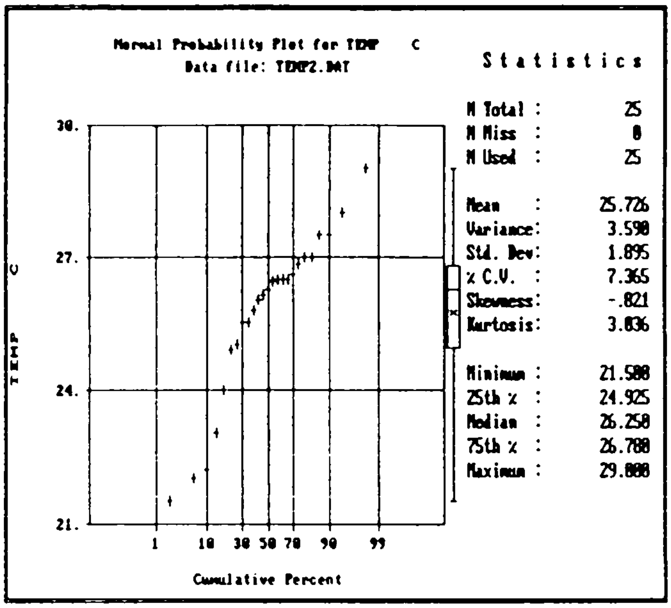
The Kruskal Wallace Analysis of Variance was used to test if data at one site is significantly different from data at all other sites. Similar data are considered to fall within the same population. Results are presented in Table 5.

PARAMETERS EXHIBITING NORMAL DATA SETS



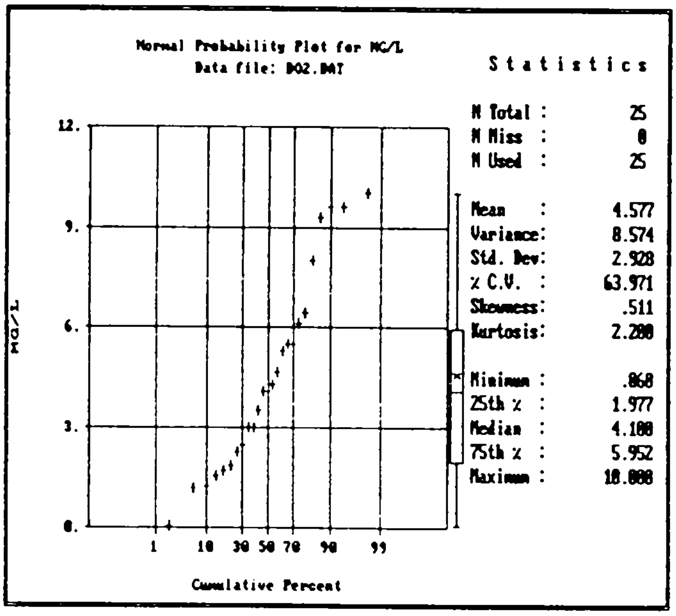
Statistics

N Total :	32
N Miss :	0
N Used :	32
Mean :	-.164
Variance:	.248
Std. Dev:	.498
% C.V. :	302.841
Skewness:	.717
Kurtosis:	3.093
Minimum :	-.959
25th % :	-.523
Median :	-.222
75th % :	.041
Maximum :	1.148



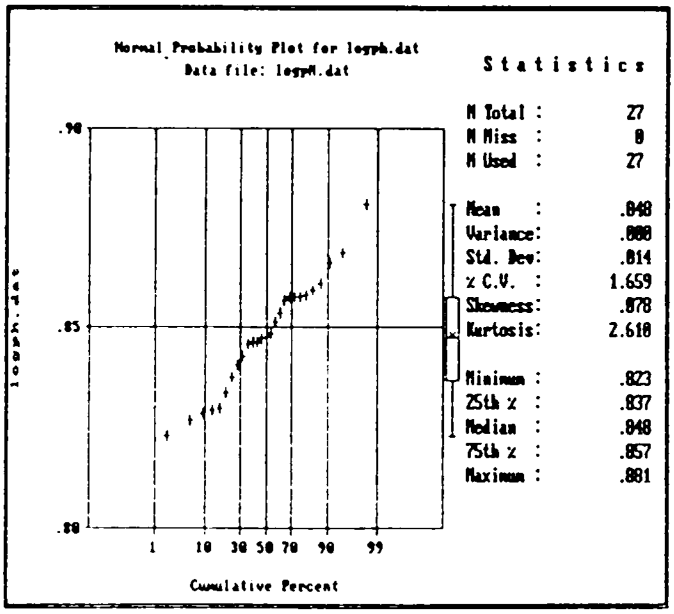
Statistics

N Total :	25
N Miss :	0
N Used :	25
Mean :	25.726
Variance:	3.590
Std. Dev:	1.895
% C.V. :	7.365
Skewness:	-.821
Kurtosis:	3.036
Minimum :	21.500
25th % :	24.925
Median :	26.250
75th % :	26.700
Maximum :	29.000



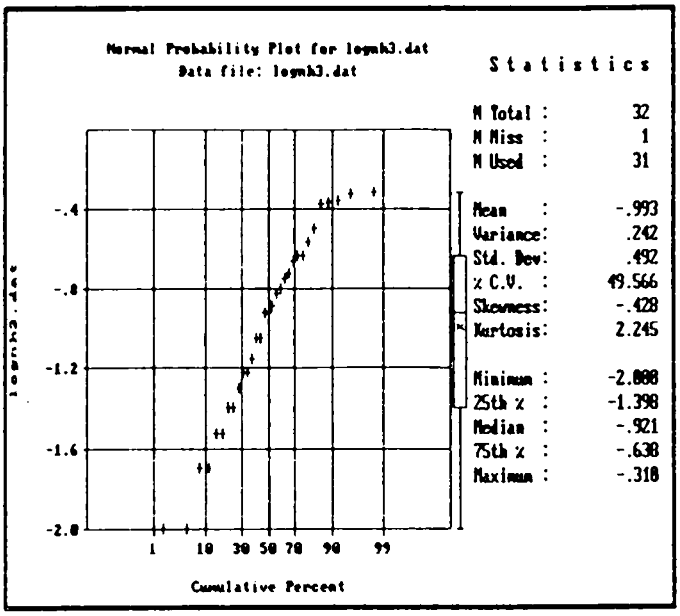
Statistics

N Total :	25
N Miss :	0
N Used :	25
Mean :	4.577
Variance:	8.574
Std. Dev:	2.928
% C.V. :	63.971
Skewness:	.511
Kurtosis:	2.200
Minimum :	.060
25th % :	1.977
Median :	4.100
75th % :	5.952
Maximum :	10.000



Statistics

N Total :	27
N Miss :	0
N Used :	27
Mean :	.848
Variance:	.000
Std. Dev:	.014
% C.V. :	1.659
Skewness:	.070
Kurtosis:	2.610
Minimum :	.823
25th % :	.837
Median :	.848
75th % :	.857
Maximum :	.881

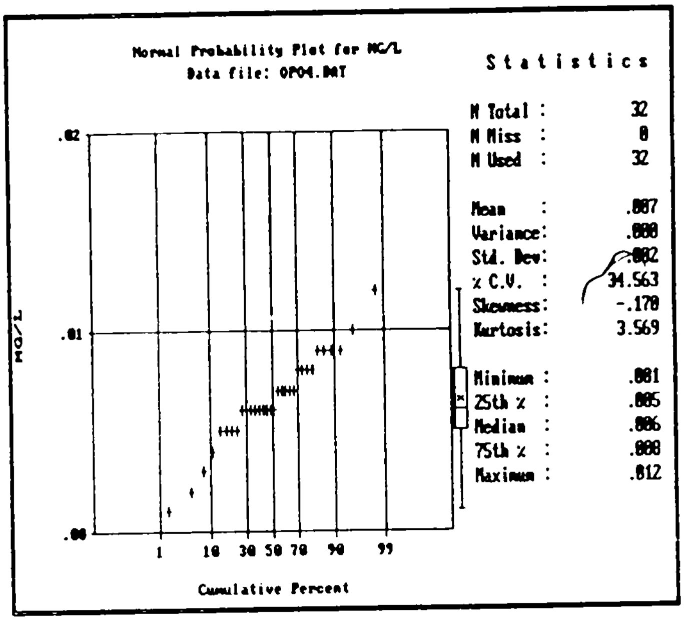

Normal Probability Plot for logmh3.dat
Data file: logmh3.dat

Statistics

N Total : 32
N Miss : 1
N Used : 31

Mean : -.993
Variance: .242
Std. Dev: .492
% C.V. : 49.566
Skewness: -.428
Kurtosis: 2.245

Minimum : -2.000
25th % : -1.398
Median : -.921
75th % : -.638
Maximum : -.310

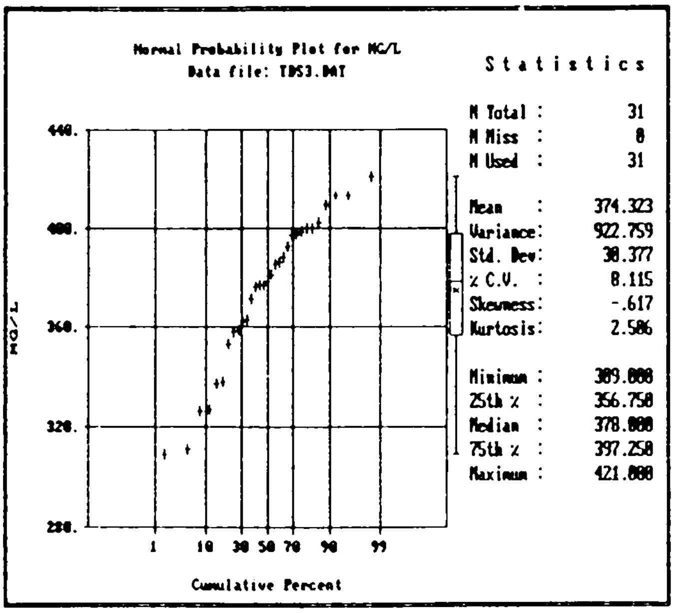

Normal Probability Plot for MG/L
Data file: OP04.DAT

Statistics

N Total : 32
N Miss : 0
N Used : 32

Mean : .007
Variance: .000
Std. Dev: .002
% C.V. : 34.563
Skewness: -.170
Kurtosis: 3.569

Minimum : .001
25th % : .005
Median : .006
75th % : .008
Maximum : .012

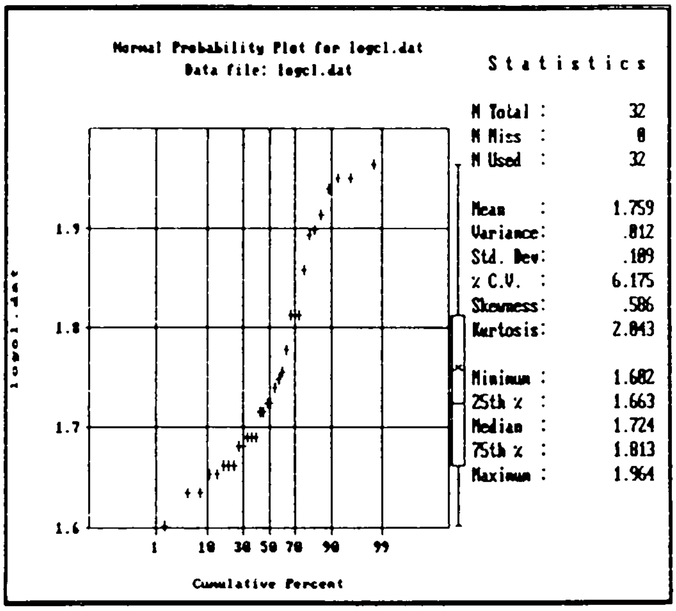

Normal Probability Plot for MG/L
Data file: TDS3.DAT

Statistics

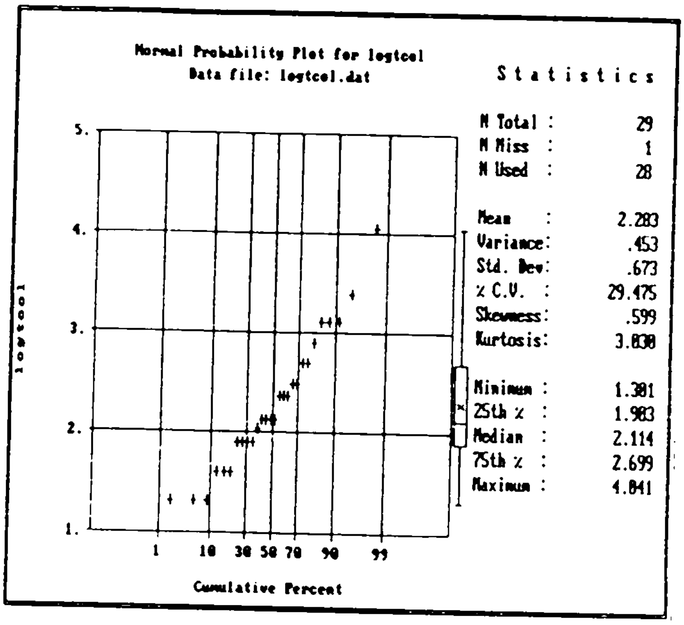
N Total : 31
N Miss : 0
N Used : 31

Mean : 374.323
Variance: 922.759
Std. Dev: 30.377
% C.V. : 8.115
Skewness: -.617
Kurtosis: 2.586

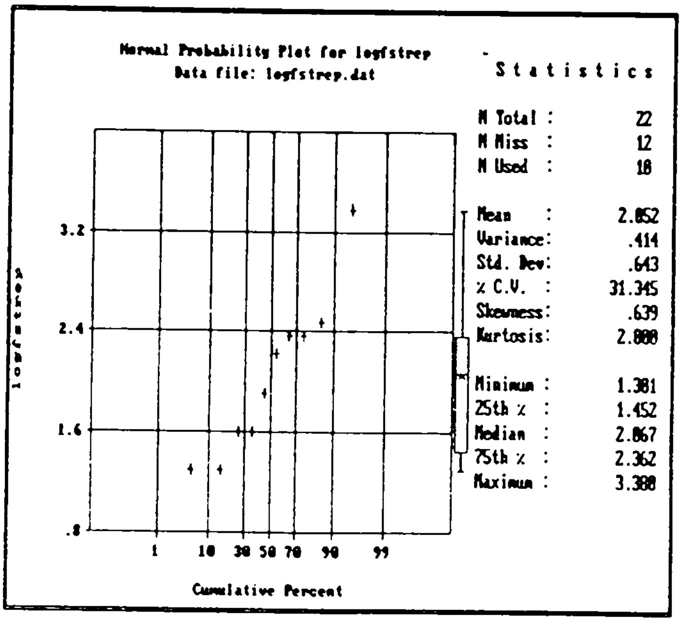
Minimum : 309.000
25th % : 356.750
Median : 378.000
75th % : 397.250
Maximum : 421.000



```
Normal Probability Plot for logcl.dat
Data file: logcl.dat

S t a t i s t i c s

N Total :        32
N Miss  :         0
N Used  :        32

Mean    :     1.759
Variance:      .012
Std. Dev:      .109
% C.V.  :     6.175
Skewness:      .586
Kurtosis:     2.043

Minimum :     1.602
25th %  :     1.663
Median  :     1.724
75th %  :     1.813
Maximum :     1.964
```

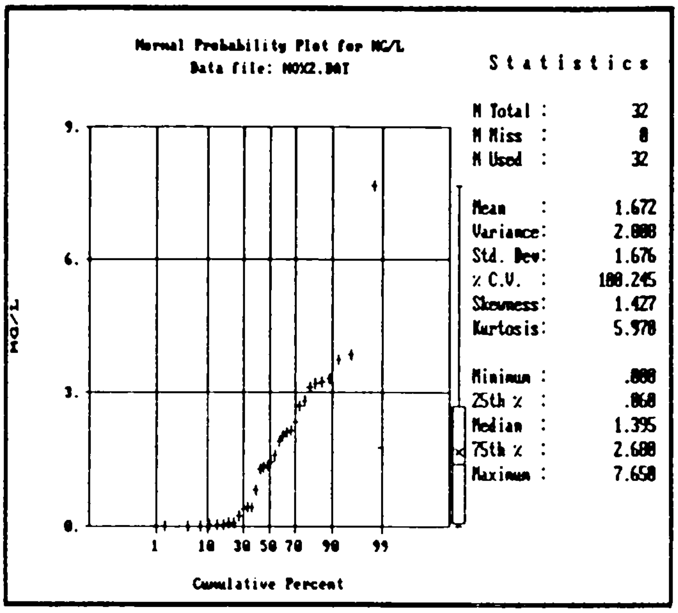


```
Normal Probability Plot for logtcol
Data file: logtcol.dat

S t a t i s t i c s

N Total :        29
N Miss  :         1
N Used  :        28

Mean    :     2.283
Variance:      .453
Std. Dev:      .673
% C.V.  :    29.475
Skewness:      .599
Kurtosis:     3.030

Minimum :     1.301
25th %  :     1.983
Median  :     2.114
75th %  :     2.699
Maximum :     4.041
```



```
Normal Probability Plot for logfstrep
Data file: logfstrep.dat

S t a t i s t i c s

N Total :        22
N Miss  :        12
N Used  :        10

Mean    :     2.052
Variance:      .414
Std. Dev:      .643
% C.V.  :    31.345
Skewness:      .639
Kurtosis:     2.000

Minimum :     1.301
25th %  :     1.452
Median  :     2.067
75th %  :     2.362
Maximum :     3.300
```

PARAMETERS EXHIBITING NON-NORMAL DATA SETS

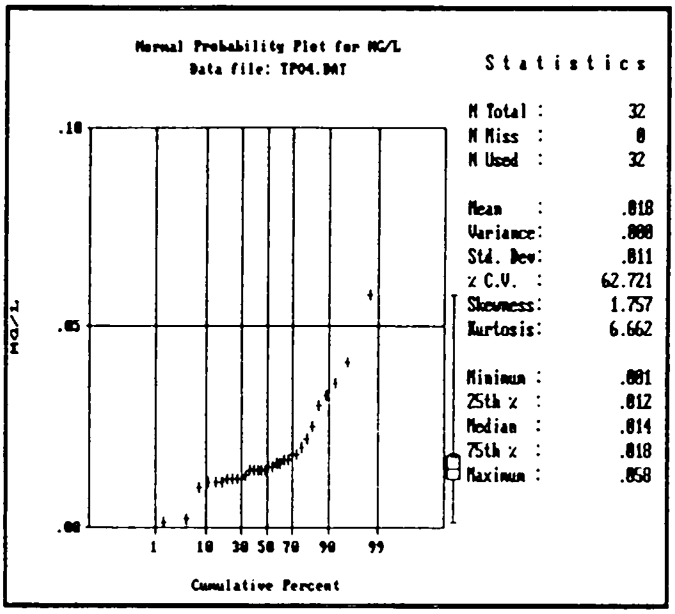

Normal Probability Plot for MG/L
Data File: NOX2.DAT

Statistics

N Total : 32
N Miss : 0
N Used : 32

Mean : 1.672
Variance: 2.000
Std. Dev: 1.676
% C.V. : 100.245
Skewness: 1.427
Kurtosis: 5.970

Minimum : .000
25th % : .060
Median : 1.395
75th % : 2.600
Maximum : 7.650

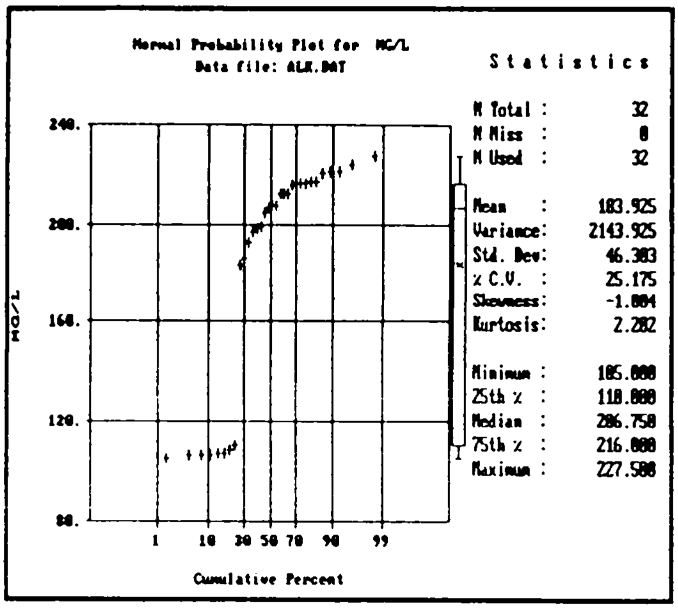

Normal Probability Plot for MG/L
Data File: TPO4.DAT

Statistics

N Total : 32
N Miss : 0
N Used : 32

Mean : .018
Variance: .000
Std. Dev: .011
% C.V. : 62.721
Skewness: 1.757
Kurtosis: 6.662

Minimum : .001
25th % : .012
Median : .014
75th % : .018
Maximum : .058

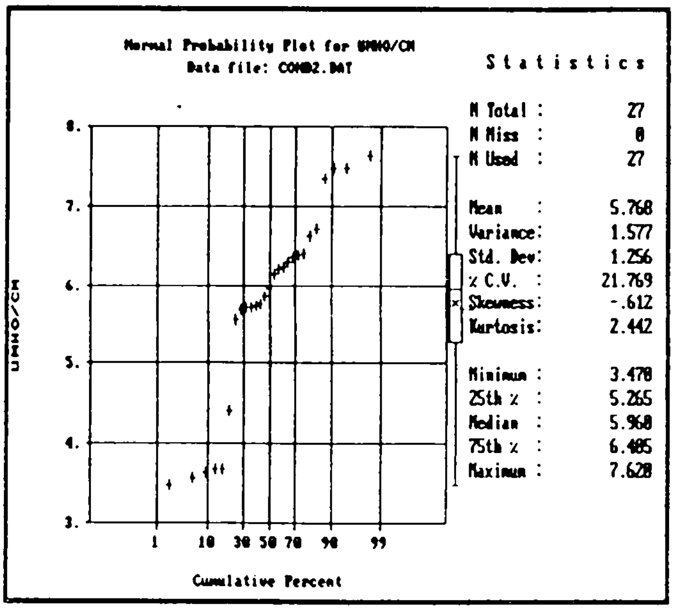

Normal Probability Plot for MG/L
Data File: ALK.DAT

Statistics

N Total : 32
N Miss : 0
N Used : 32

Mean : 183.925
Variance: 2143.925
Std. Dev: 46.303
% C.V. : 25.175
Skewness: -1.004
Kurtosis: 2.202

Minimum : 105.000
25th % : 110.000
Median : 206.750
75th % : 216.000
Maximum : 227.500

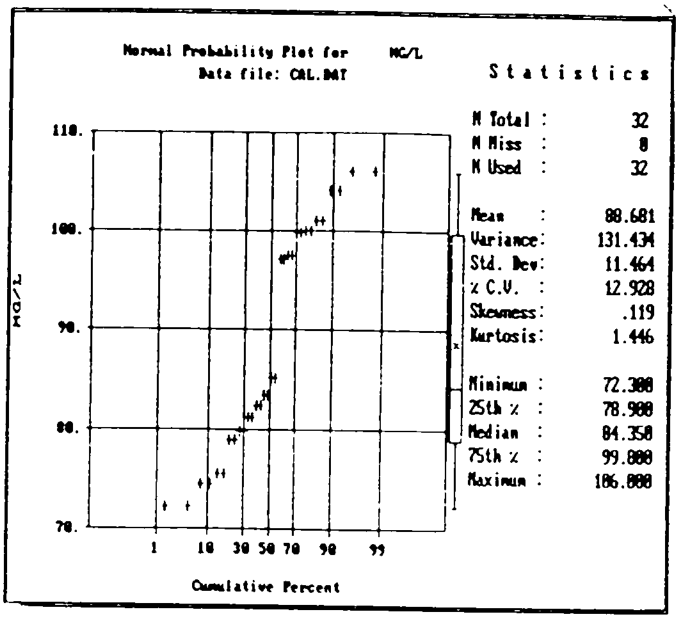

Normal Probability Plot for UMHO/CM
Data File: COND2.DAT

Statistics

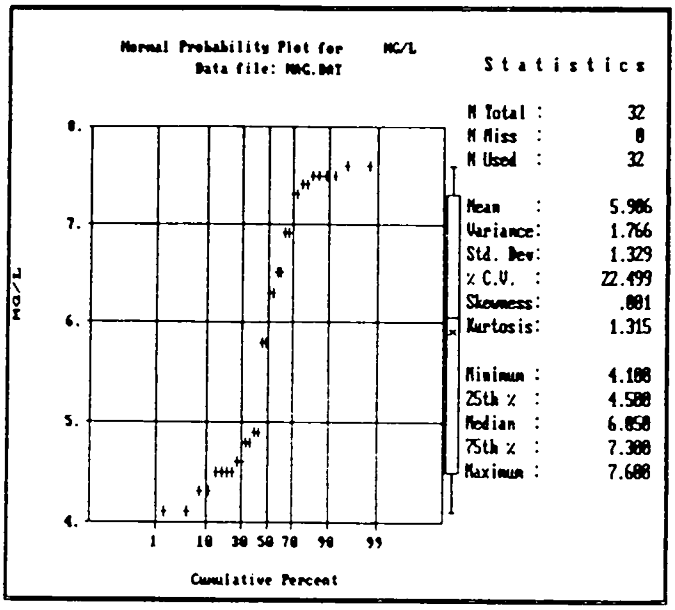
N Total : 27
N Miss : 0
N Used : 27

Mean : 5.768
Variance: 1.577
Std. Dev: 1.256
% C.V. : 21.769
Skewness: -.612
Kurtosis: 2.442

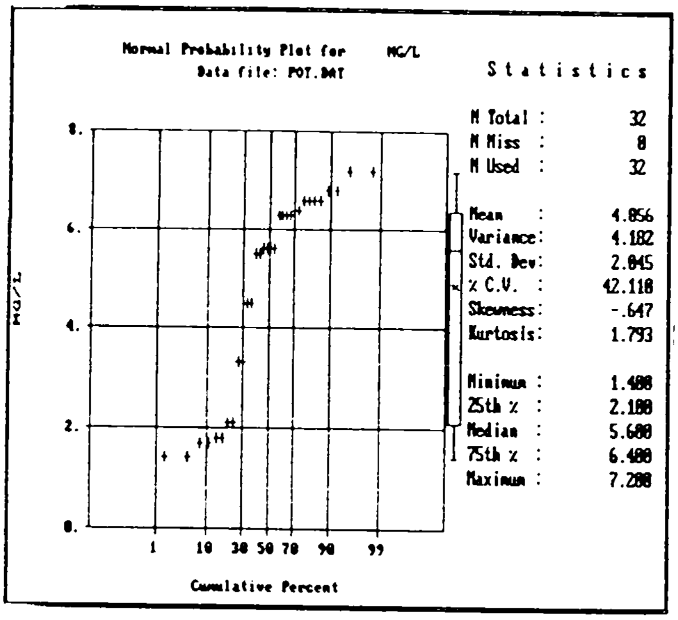
Minimum : 3.470
25th % : 5.265
Median : 5.960
75th % : 6.405
Maximum : 7.620



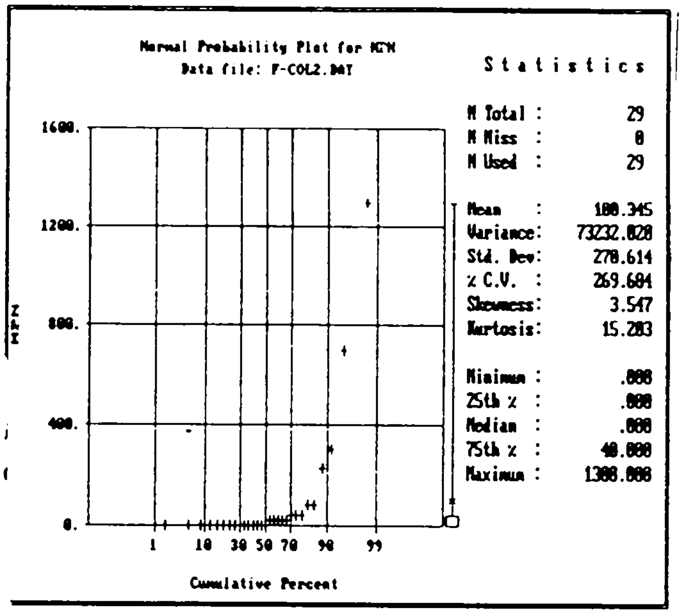
```
Statistics

M Total :        32
M Miss  :         0
M Used  :        32

Mean    :    88.681
Variance:   131.434
Std. Dev:    11.464
% C.V.  :    12.928
Skewness:      .119
Kurtosis:     1.446

Minimum :    72.300
25th %  :    78.900
Median  :    84.350
75th %  :    99.800
Maximum :   106.000
```



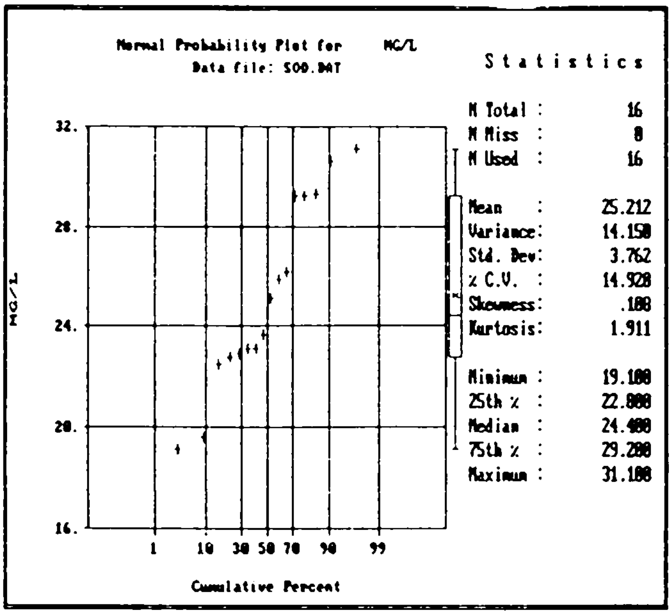
```
Statistics

M Total :        32
M Miss  :         0
M Used  :        32

Mean    :     5.906
Variance:     1.766
Std. Dev:     1.329
% C.V.  :    22.499
Skewness:      .001
Kurtosis:     1.315

Minimum :     4.100
25th %  :     4.500
Median  :     6.050
75th %  :     7.300
Maximum :     7.600
```



```
Statistics

M Total :        32
M Miss  :         0
M Used  :        32

Mean    :     4.856
Variance:     4.182
Std. Dev:     2.045
% C.V.  :    42.110
Skewness:     -.647
Kurtosis:     1.793

Minimum :     1.400
25th %  :     2.100
Median  :     5.600
75th %  :     6.400
Maximum :     7.200
```



```
Statistics

M Total :        29
M Miss  :         0
M Used  :        29

Mean    :   100.345
Variance: 73232.020
Std. Dev:   270.614
% C.V.  :   269.684
Skewness:     3.547
Kurtosis:    15.203

Minimum :      .000
25th %  :      .000
Median  :      .000
75th %  :    40.000
Maximum :  1300.000
```



```
Statistics

M Total :        16
M Miss  :         0
M Used  :        16

Mean    :    25.212
Variance:    14.150
Std. Dev:     3.762
% C.V.  :    14.920
Skewness:      .100
Kurtosis:     1.911

Minimum :    19.100
25th %  :    22.800
Median  :    24.400
75th %  :    29.200
Maximum :    31.100
```

APPENDIX 3

EPA ANALYTES AND METHOD DETECTION LIMITS

EPA Analytes and Detection Limits - Water Samples

EPA 601s - Halogenated Volatiles, detection limit 1 µg/l

Bromobenzene
Bromochloromethane
Bromodichloromethane
Bromoform
Bromomethane
Carbon tetrachloride
Chlorobenzene
Chloroethane
2-Chloroethylvinyl ether
Chloroform
o-Chlorotoluene
m-Chlorotoluene
p-Chlorotoluene
1,2-Dibromoethane
Dibromoethane
Dibromomethane
Dibromochloromethane
Dichlorodifluoromethane
1,1-Dichloroethene (Vinylidene chloride)
cis-1,2-Dichloroethene
trans-1,2-Dichloroethene
1,2-Dichloropropane
1,3-Dichloropropane
2,2-Dichloropropane
1,1-Dichloropropene
cis-1,3-Dichloropropene
trans-1,3-Tetrachloroethane
1,1,1,2-Tetrachloroethane
1,1,2,2-Tetrachloroethane
Tetrachloroethene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethene (1,1,2-Trichloroethene)
Trichlorofluoromethane
1,2,3-Trichloropropane
1,1,2-Trichloro-1,2,2-trifluoroethane
Methylene chloride
Vinyl chloride

EPA 602s - Aromatic volitiles (detection limit 1.0 µg/l)

Benzene
Toluene
e-Benzene
p-Xylene
m-Xylene
p/m-dichlorobenzene
o-dichlorobenzene

EPA 608s - Organochlorine Pesticides and PCBs

Parameter	Sample Date 4/88	11/88
	µg/l	
Aldrin	.010	.004
alpha-BHC	.006	.003
beta-BHC	.015	.006
delta-BHC	----	.009
gamma-BHC	.007	.004
Chlordane	.104	.014
4,4'-DDD	.040	.011
4,4'-DDE	.018	.004
4,4'-DDT	.050	.012
Dieldrin	.020	.002
Endosulfan I	.018	.014
Endosulfan II	.034	.004
Endosulfan sulfate	.105	.066
Endrin	.033	.006
Endrin aldehyde	.057	.023
Heptachlor	.010	.003
Heptachlor epoxide	.014	.083
Toxaphene	.527	.24
PCB-1016	.142	----
PCB-1221	.264	----
PCB-1232	.313	----
PCB-1242	.186	.065
PCB-1248	.251	----
PCB-1254	.190	----
PCB-1260	.221	----

EPA Analytes and Detection Limits - Sediment Samples

EPA 608s - Organochlorine Pesticides and PCBs

Parameter	Detection Limit	
	4/88	11/88
	µg/g	µg/kg
Aldrin		0.04
alpha-BHC		0.03
beta-BHC		0.06
delta-BHC		0.09
gamma-BHC		0.04
Chlordane		0.14
4,4'-DDD		0.11
4,4'-DDE		0.04
4,4'-DDT		0.12
Dieldrin		0.02
Endosulfan I		0.14
Endosulfan II		0.04
Endosulfan sulfate		0.66
Endrin		0.06
Endrin aldehyde		0.23
Heptachlor		0.03
Heptachlor epoxide		0.83
Toxaphene		2.4
PCB-1016		---
PCB-1221		---
PCB-1232		---
PCB-1242		0.65
PCB-1248		---
PCB-1254		---
PCB-1260		---

EPA 610s - Volatile Organic Compounds

Acenaphthene
Acenaphthylene
Anthracene
Benzoanthracene
Benzo(a)pyrene
Benzo(b)fluoroanthene
Benzo(k)fluoroanthene
Benzo(ghi)perylene
Chrysene
Dibenzo(ah)anthracene
Fluoroanthene
Fluorene
Ideno(1,2,3-cd)pyrene
Napthalene
Phenanthrene
Pyrene

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