ABSTRACT

BRIAN CLARK HAWS. An Assessment of Trihalomethane Levels in North Carolina Drinking Water (Under the direction of Dr. Philip C. Singer)

The objective of this investigation is to provide a current and comprehensive description of trihalomethane (THM) levels in the state's drinking water. Of particular interest is an assessment of the impact of an expected reductions in the maximum contaminant level (MCL) for THMs. The investigation involved examination of the complete THM records for all water systems in the state serving at least 10,000 persons. The data were edited and reduced to allow for calculation of a Two-Year Mean Total THM (TTHM) concentration characterizing the THM level of each system under its current operating status. Systems using a surface water source typically had higher THM levels than systems using groundwater. THM levels were observed to vary with season as well as geography. The current level of compliance with the existing MCL for THMs in North Carolina is high. In order to maintain a similar level of compliance with a lower MCL, many systems across the state will need to reduce their THM levels substantially. Lowering the MCL to 50 µg/l will affect more than half of the systems, while a 25 µg/l MCL will affect virtually all of the systems.

KEY WORDS

DRINKING WATER

TRIHALOMETHANE

CHLOROFORM

CHLORINATION

DISINFECTION BY-PRODUCTS

HUMICS

ORGANICS

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Chapter 1

INTRODUCTION

In the early 1970's, new developments in analytical technology led to the detection of several trace organic chemicals in drinking water. In response to concerns about their effects on human health, the United States Environmental Protection Agency, acting under the authority of the Safe Drinking Water Act (SDWA) of 1976, set national standards for several organic chemicals. The regulation of additional trace organics is anticipated in the near future. The SDWA Amendments of 1986 call for the promulgation of new standards for 83 contaminants by June of 1989, with 25 more standards to be added over the following three years.

One class of trace organic chemicals currently regulated under the SDWA is the trihalomethanes (THMs). Because the formation of THMs in the water treatment process is largely due to the addition of chlorine, the THMs are referred to as disinfection by-products. Chlorine addition has been a standard practice in water treatment in the United States for many years because of its strong oxidation and disinfection abilities and its relatively low cost. Because the use of chlorine is so common in water treatment, the presence of THMs in drinking water is widespead. The extent of THM formation varies significantly among water systems, depending primarily on chlorine dose and organic content of the raw water.

The regulation of THMs in drinking water began with an amendment to the National Interim Primary Drinking Water Standards on November 29, 1979. This was in response to studies which predicted an increased risk of cancer due to ingestion of chloroform, the predominant THM species in drinking water. The maximum contaminant level (MCL) for THMs in drinking water was set at 0.10 mg/l. A minimum of four samples must be taken each quarter from the distribution system and analyzed for THMs. The running annual average, computed from the four most recent consecutive quarters of data, must not exceed the MCL.

The current THM regulation applies to all water systems serving at least 10,000 persons. In North Carolina, 66 water systems are subject to the regulation, reporting their THM levels on a quarterly basis to the Public Water Supply Branch of the North Carolina Department of Human Resources, Division of Health Services, Environmental Health Section in Raleigh . Once received by the Public Water Supply Branch, the THM measurements are entered into a computer database before the report sheet is filed with other correspondence from the water system.

The purpose of this investigation was to provide an overall assessment of THM concentrations in the drinking water systems of North Carolina. While other investigations of this kind are based on data from only a portion of North Carolina water systems, this investigation involved the collection of all existing data from systems in North Carolina serving at least 10,000 persons. The data was acquired from the database and document files maintained by the Public Water Supply Branch. A value representative of the current THM concentration was computed for each system. The data were evaluated to identify variations in the THM concentrations due to season, geographic location, and raw water source. In anticipation of a lower MCL for THMs of 50 or 25 μg/l in the near future, the impact of such a revision in the standard on drinking water systems in North Carolina, based on current THM concentrations of these systems, was also addressed. Finally, the strategies available for reducing THM concentrations in North Carolina water supplies in response to a more stringent MCL are discussed.

Chapter 2

REVIEW OF CURRENT LITERATURE

Definition of Trihalomethanes

Methane

Trihalomethane

X = Cl, Br, or I

Figure 2.1
Molecular Structure of Trihalomethanes

Trihalomethanes (THMs) are a group of organic compounds, which are derivatives of methane (CH_4). While methane molecules are composed of a single carbon surrounded by four hydrogens, THM molecules contain a single carbon, only one hydrogen, and three halogens. These three halogens may consist of one or any combination of the following types: chlorine, bromine, or iodine. During the treatment of water for drinking purposes, THMs are produced by a reaction between free chlorine and natural organic material in the water. The sum of the concentrations of all the species of THMs that are measured in the water is commonly referred to as the total THM concentration (TTHM). Chloroform, also referred to as trichloromethane ($CHCl_3$), and bromodichloromethane ($CHBrCl_2$) are the species of THMs that occur most frequently in drinking water. Two other species that frequently occur are dibromochloromethane ($CHBr_2Cl$) and tribromomethane, commonly referred to as bromoform ($CHBr_3$). These species usually amount to only a small fraction of the TTHM concentration, except for cases in which the raw water contains a relatively high concentration of bromide. The remaining six species, which contain iodine, are of little significance in water treatment since they occur infrequently and at low concentration.

Formation of THMs

In recent years, a considerable amount of research effort has been devoted to learning more about the formation of THMs during water treatment. As a result, a much better understanding has been gained about the mechanism of THM formation and the extent to which various factors affect the process. Another topic of recent research has been the development of models for predicting the amount of THMs that will form in a particular water source.

Mechanism of THM Formation

During the course of treating water for drinking purposes, free chlorine reacts with natural organic material to form THMs. Because of its strong oxidation and disinfection ability, chlorination is an integral step in the processes employed by virtually all water treatment plants. The natural organic material in surface waters is composed mostly of humic substances, which are the primary source of THM precursors in natural waters. These humic substances are made up of humic and fulvic acids, with fulvic acids accounting for the larger portion. Humic substances exist in natural waters as a result of the natural decay process of vegetative materials. Other potentially significant sources of THM precursors are algae and algal extracellular metabolic products (Hoehn, et al., 1978; Morris and Baum, 1978; Briley and Williams, 1984).

In water treatment, chlorine is usually applied in the form of a gas (Cl_2). In most waters, the chlorine gas converts quickly to hypochlorous acid (HOCl). Rapid formation of chloroform occurs when the hypochlorous acid attacks the reactive sites on the natural organic material. Humic substances most often provide these reaction sites. When the bromide ion (Br^-) is present in water, the brominated THM species may be formed. Hypobromous acid (HOBr) is produced by a reaction between aqueous chlorine (HOCl) and the bromide ion. Once hypobromous acid is formed, it reacts with organic material in a manner similar to hypochlorous acid to form brominated THMs (Minear, 1980; Minear, 1983; Cooper et al, 1985).

Factors Influencing THM Formation

Recent research has shown that THM formation can be significantly influenced by several factors. The amount and type of precursor material present in the raw water, the amount of chlorine applied, and the length of time for contact between precursors and chlorine have the greatest effect on the amount of THMs formed. Other factors which may significantly influence THM formation are pH, temperature, and bromide concentration.

The existence of a direct relationship between THM production and precursor concentration in water is well established in the literature. Using several different humic acid concentrations, Stevens (1976) demonstrated that TTHM concentration increased as the humic acid concentration increased. A study by Babcock and Singer (1979) indicated a similar relationship between chloroform formation and humic acid concentration under constant reaction conditions. The same study also found that the relationship between chloroform formation and humic acid content was linear. Based on the findings of these and other similar studies, organic content, as reflected by the TOC (total organic carbon) concentration, has been established as a good indicator of the potential for THM formation.

The results of recent studies by Engerholm and Amy (1983) and Singer (1985) indicate that the amount of chlorine applied has a significant influence on the amount of THMs formed. The conclusion of earlier research was that the THM production increased with increasing chlorine dose until the demand for it was met, with further addition of chlorine having a minimal effect on THM production. Engerholm and Amy and Singer concluded from their research that a strong relationship exists between the chlorine/carbon ratio of the water and the amount of THMs formed.

Since even the most advanced treatment schemes are not capable of complete removal of THM precursors, the formation of THMs will occur for the entire length of time that free chlorine is present in the water. The THM levels at different points in the treatment process and distribution system have been measured during the course of several studies (Arguello et al., 1979; Glaze and Rawley, 1979, Young and Singer, 1979). This type of data clearly illustrates the upward progression in THM concentration that occurs with chlorine contact time (Kissinger and Fritz, 1976). THM formation begins with the first addition of free chlorine to the water and continues until the supply is depleted.

THM formation occurs more rapidly as temperature is increased, causing more THMs to form at higher temperature than at lower temperature. This effect was demonstrated in a laboratory study in which Ohio River water was chlorinated at several different temperatures (Stevens et al., 1976). Faster reaction kinetics at higher temperature cause chlorine to be utilized more rapidly, which increases the chlorine demand of the water. Several studies have observed seasonal variations in THM levels, with the highest levels typically occurring during the summer months, and the lowest levels occurring in the winter months (Arguello et al., 1979; Veenstra and Schnoor, 1980; Schreiber, 1981; Singer et al., 1981). Singer et al. (1981) concluded that the principal factors contributing to these seasonal variations were temperature and the natural organic content of the raw water.

The pH of the water can also have an impact on the concentration of THMs formed. The THM formation process is known to occur in a series of defined steps. The rate at which the process proceeds is regulated by those steps which advance more slowly than the others. Since these "slower" steps are catalyzed by the hydroxide ion (OH^-), raising the pH will cause THMs to form more rapidly. This was found to be true in laboratory studies by Stevens et al. (1976) and other researchers. This effect of a high finished water pH has resulted in elevated THM levels in treatment plants (Glaze and Rawley, 1979; Singer, 1988).

The concentration of bromide in the raw water has been shown to influence the distribution of the various species of THMs as well as the total yield of THMs. Hypobromous acid is produced by a reaction between aqueous chlorine and bromide. Organic matter may react exclusively with hypobromous acid to produce bromoform. More often, though, it reacts with both hypobromous acid and hypochlorous acid to form the mixed species such as bromodichloromethane and dibromochloromethane. The findings of several studies have indicated that the total yield of THMs increases with increasing concentration of bromide in the water (Bunn et al., 1975; Trussel and Umphres, 1978; Minear, 1980). Lange and Kawczynski (1978) observed that the fraction of the total THMs attributed to the brominated species increases with increasing bromide concentration of the water. This suggests that bromide may compete more effectively for reactive sites on the organics than chlorine and that bromine substitution is a faster reaction than chlorine substitution.

Estimating the Extent of THM Formation

One method of estimating the total concentration of THMs which may be formed after chlorination of a water sample is to determine the THM formation potential (THMFP). THMFP is defined as the difference between two THM measurements, Instantaneous THMs and Terminal THMs, which are performed on samples taken from the same source. Instantaneous THMs (Inst THMs) refer to the concentration of THMs which already exist in the water at the time of sampling. Terminal THMs (Term THMs) refer to the concentration of THMs formed after chlorination of the water sample under specific conditions. When measuring Term THMs, the chlorine dose, contact time, pH, temperature, and other conditions are chosen to simulate typical conditions in the actual treatment process.

Since the determination of THMFP involves sophisticated laboratory techniques as well as a considerable amount of time, researchers have been trying to develop accurate models to estimate final TTHM levels from simple water quality measurements. A model developed by Amy and co workers (1987, 1983) predicts TTHM levels from the parameter TOC•UVABS. TOC is the total organic carbon concentration, while UVABS is the ultraviolet absorbance measurement. They concluded that this was the best parameter for estimating TTHMs since TOC is an indicator of precursor content, while UVABS refers to the reactivity of the precursors in forming THMs. The biggest difficulty in developing accurate models has been their validation with a variety of water sources. A model may work well when applied to a single water source, but loses considerable accuracy when another source of water is used. This is because the models rely on overall measurements of organic content such as TOC, which measures all organic constituents, not all of which are THM precursors. Although TOC is a good indicator of precursor content, it has not been successfully used to quantitatively predict TTHMs in samples from a wide range of sources.

Regulation of THM Levels in Drinking Water

The health effects associated with chloroform have been studied much more than any of the other species of THMs. Because of their similarity in structure, the other species of THMs are expected to produce health effects similar to chloroform. Chloroform has been found to be carcinogenic in both rats and mice. Since metabolic patterns in humans resemble those found in mice, it is probable that chloroform is also a human carcinogen (Searle, 1976). According to the most recent studies, the predicted incremental risk of developing cancer is approximately one in 10,000 for a person consuming one liter of water each day which contains 0.10 mg/l of chloroform for a lifetime (National Research Council, 1987). The standard limiting TTHM levels in drinking water is based on findings of this type.

The development of new analytical technologies in the early 1970's resulted in the discovery of numerous organic chemicals in drinking water. This discovery caused national concern over drinking water quality, since many of these organic chemicals were suspected or known to be carcinogenic. A considerable lack of compliance and enforcement of the standards recommended by the United States Public Health Service (USPHS) was brought to the attention of the nation as drinking water quality investigations began. In an effort to protect the nation's health by insuring the quality of drinking water, Congress passed the Safe Drinking Water Act (SDWA) of 1974. This act gave the Federal government the authority to establish standards of quality for drinking water. Previously, this had been the responsibility of the state and local governments. Soon afterward, the National Interim Primary Drinking Water Regulations (NIPDWR) were published in the Federal Register. In June of 1977, these regulations went into effect. On November 29, 1979, an amendment was added to the NIPDWR which regulated THMs in drinking water.

The maximum contaminant level (MCL) for TTHMs was set at 0.10 mg/l by the 1979 amendment to the NIPDWR. The requirements for THM monitoring and for compliance with the MCL became effective one to four years later, depending on the number of persons served by the particular system. For utilities serving less than 10,000 persons, the effective dates were left to the discretion of the state or primacy agency. The regulation requires that each treatment plant take a minimum of four samples each quarter. All four samples must be taken on the same day, with one-fourth taken at the extremity of the distribution system and the other three-fourths taken at points representative of the population distribution. Analysis of the samples must be done at a certified laboratory, which uses one of the approved methods for the measurement of THMs. The average TTHM level must be reported to the state or primacy agency within 30 days. The running annual average is calculated by taking the average of the quarterly averages of the four most recent quarters. If this running annual average exceeds the MCL (0.10 mg/l), the plant is out of compliance and is required to notify its customers of the situation and take corrective action.

Some systems may exhibit THM measurements which are consistently well below the MCL. In an effort to save time, effort and expense in monitoring, the regulations include provisions which allow these systems to qualify for reduced monitoring requirements. A system qualifies for reduced monitoring if the maximum total THM potential (MTP) is less than 0.10 mg/l. The MTP is determined by a specific procedure defined by the EPA, which is similar to the procedure for determining Terminal THMs. If the criterion is met, the system is required to sample for the MTP a minimum of once per year at the extremity of the distribution system. If a system is unable to satisfy the MTP criterion, it may still qualify for reduced sampling if it demonstrates that TTHM levels are consistently below 0.10 mg/l for a period of one year. Systems satisfying this criterion are required to sample a minimum of one time per quarter, with the sample being taken at the extremity of the distribution system. Thereafter, if a TTHM measurement exceeds the 0.10 mg/l level or if the water source is modified, the system must return to the regular monitoring scheme.

Due to the fact that the regulation of THMs is relatively new in the U.S., it is difficult to provide a detailed assessment of its impact on the water treatment industry. A recent survey conducted by McGuire and Meadow (1988) focused on THMs in the U.S. Input for the survey came from a variety of systems throughout the nation, representing a wide range of capacities, source water types, and treatment process schemes. Although the survey was not comprehensive, the trends it identified are likely to be accurate. In general, smaller systems were found to have higher THM levels than larger systems, with the highest THM levels occurring in systems serving 10,000 to 25,000 customers. The authors suggested that an explanation of this trend might be that smaller systems typically do not have the personnel and resources to devote to controlling THM levels that larger systems do. Since groundwater sources are usually low in precursor content (Symons et al. 1975), it came as no surprise that systems using groundwater as their source had the lowest average THM value of all the different source types. A small percentage (4.6%) of the systems surveyed reported that they had been out of compliance with the regulation at least once between 1984 and 1986. This is an indication that the current regulation poses few major problems overall. The impact of the regulation on THM levels was shown to be significant, as the survey reported an average reduction in THMs of 40 to 50 percent. Of the systems which had to alter their treatment process to achieve compliance, most of them modified their clarification and disinfection practices. A switch to the use of chloramines was common among those systems which modified their disinfection practices. An interesting finding was that many systems that altered their disinfection practices reported a savings in operation and maintenance costs. However, the modifications did not take place without problems. Those most commonly reported were taste and odor control, microbiological quality, corrosion, biofilm control, and color.

The MCL for THMs will almost certainly be lowered in the coming years. It is not yet known, however, what the new standard will be. The authors of one recent article on the SDWA amendments mentioned that the standard may be lowered to 50 µg/l or less in the future (Dyksen et al., 1988). Lowering the standard to that level would bring it closer to the World Health Organization's recommended MCL of 30 µg/l for chloroform (Sayre, 1988). Under the SDWA Amendments of 1986, new standards for 83 contaminants are due to be promulgated by June of 1989, with 25 more standards added in the following three years. Disinfection by-products (DBPs), a category which includes THMs, are expected to be one class of contaminants addressed by the new standards. In an effort to insure that the new standards are technically and economically feasible, research is being conducted to determine which methods of water treatment are most effective in reducing the contaminant level of interest. Based on the results of the research, recommendations will be made on the best available technology (BAT) for use in complying with each new standard. This type of research is currently in progress with regard to the THM regulation. The final regulations for disinfection by-products are scheduled to be complete by January of 1991, and to become effective in June of 1992 (Dyksen et al., 1988).

Seventy five percent of those water treatment plant representatives that responded to the recent THM survey by McGuire and Meadow (1988) indicated that they are opposed to a lower standard for THMs. Many commented that the reduced health risk associated with a lower standard would not justify the complications, expenses, and effort involved. Also, they expressed concern that efforts to comply with a lower standard might interfere with disinfection effectiveness and microbiological quality, which they felt to be the highest priority in water treatment. Finally, the validity of the data used to justify such a revision was questioned. After performing a series of case studies, Singer (1988) concluded that most systems would be unable to maintain a high degree of finished water quality while complying with a 20-50 μg/l MCL for THMs using alternative oxidants along with conventional treatment techniques.

Techniques for Controlling THM Levels

Several techniques are currently used to control THM levels in finished drinking water. Most of the techniques reduce or prevent the formation of THMs, while some remove THMs once they are formed. Prevention of THM formation may be accomplished by removing the precursors before they have the opportunity to react with free chlorine to form THMs. Coagulation, flocculation, sedimentation, and filtration are used for removing turbidity and organic color in most water treatment plants, and have been shown to be effective in removing THM precursors (Singer et al., 1981; Hoehn et al., 1984; Knocke et al., 1986; Hubel and Edzwald, 1987). Additional precursor removal can be accomplished using granular activated carbon (McCreary and Snoeyink, 1977; McCarty et al., 1979; Meijers et al., 1979; Blanck, 1979; Jodellah and Weber, 1985; Semmens and Staples, 1986). However, because of concerns about its effectiveness and cost, the use of granular activated carbon for this purpose is currently not widespread. THM formation may also be controlled by minimizing the contact time between free chlorine and precursors. Moving the point of chlorination from near the head of the plant to a location downstream (such as the filter inlet) has been widely used to reduce chlorine contact time. This modification also allows for additional THM precursors to be removed prior to initial chlorine contact, resulting in reduced THM levels in the finished water.

One of the most promising technologies for minimizing chlorine contact time is the use of alternative oxidants, such as chlorine dioxide, ozone, chloramines, and potassium permanganate instead of chlorine. A substantial portion of research is being devoted to the use of alternative oxidants for oxidation and disinfection, which reduces or eliminates precursor contact with free chlorine. Many systems have eliminated THM production in the distribution system by using chloramines for disinfection in the distribution system, as opposed to free chlorine (McGuire and Meadow, 1988). This strategy can reduce THM levels significantly, since a substantial portion of the free chlorine contact time typically occurs in the distribution system. Finally, the most common technique for removing THMs after they have been formed is air stripping.

Techniques for Removing Precursors

The combination of coagulation, flocculation, sedimentation, and filtration is capable of removing THM precursors to a degree of 50 percent or more (Singer et al., 1981; Hoehn et al., 1984; Knocke et al., 1986; Hubel and Edzwald, 1987). The organic compounds that are removed most effectively by this series of processes are those of intermediate and high molecular weight (Hoehn et al., 1984; Semmens and Staples, 1986). According to Randke (1988), the portion of organic matter removed by this process is particularly significant because it is especially high in THMFP. Two controllable variables impacting the removal efficiency are the type of coagulant and pH. Alum is believed to be the best coagulant for the removal of precursors (Hubel and Edzwald, 1987). Hubel and Edzwald also found that the use of coagulant aids does not significantly improve the efficiency of alum for removing THM precursors. The use of a coagulant such as alum is also advantageous because the subsequent chlorine dosage required to maintain a residual is reduced. The pH range for optimal TOC and THM precursor removal by coagulation, flocculation, and sedimentation is 5.5 to 6.0 (Babcock and Singer, 1979; Singer, 1983; Edzwald et al., 1983; Dempsey et al., 1984).

The use of granular activated carbon (GAC) can be an effective strategy for removing THM precursors (McCreary and Snoeyink, 1977; McCarty et al., 1979; Meijers et al., 1979; Blanck, 1979; Jodellah and Weber, 1985; Semmens and Staples, 1986). In addition, it provides excellent removal of tastes and odors and is the most effective technology for removing synthetic organic chemicals (SOCs). Its principal application for THM control is to provide additional THM precursor removal following initial removal by coagulation, flocculation, sedimentation, and filtration. While providing approximately 50 percent removal of precursors, pretreatment also removes particles that would cause rapid clogging of the bed. This results in a longer bed life, which is the length of time over which a bed provides effective removal before it must be replaced with fresh GAC. With many of the higher molecular weight materials removed, the GAC column can then adsorb the materials that are lower in molecular weight and more difficult to coagulate (Semmens and Staples, 1986; Randke, 1988).

Most of the concern about the use of GAC centers on the expense involved in operating and maintaining the process. The effectiveness and economic feasibility of GAC for the removal of THM precursors are strongly influenced by the empty bed contact time (EBCT). The EBCT is defined as the volume of the empty carbon bed divided by the flowrate through the bed. GAC beds operating at longer EBCTs have demonstrated the highest percentage removals of THM precursors for longer periods of time (Symons et al., 1983). Long bed lives are desirable from an economic standpoint because regeneration of the GAC is an expensive process. However, the EBCT is also limited by economics because EBCT determines the volume of GAC used if the flowrate is constant through the bed. Because the effectiveness of GAC for removing THM precursors also varies according to the composition of the source water, the economic feasibility of the process must be determined individually for each system (Symons et al., 1983).

Techniques for Limiting Chlorine Contact Time

Moving the Point of Chlorination

Probably the most widely used method of reducing THM levels in drinking water is moving the point of chlorination. This method is simple and it provides almost immediate results. Before the discovery and subsequent concern about THMs, pre-chlorination, the practice of adding chlorine to the raw water, was used by most treatment plants. Now, most plants that had elevated THM levels have discontinued the practice of pre-chlorination because it allows THM formation to begin at the earliest stage of treatment, maximizing contact time of free chlorine with precursors. In order to reduce the amount of contact time and postpone the onset of THM formation, the point of chlorination is often moved to a stage beyond coagulation, flocculation, and sedimentation. This allows for a significant removal in the amount of precursor material before chlorine is added and THM formation begins.

The purposes served by pre-chlorination are oxidation and disinfection. Moving the point of chlorination causes a reduction in disinfection power, since the latter is controlled by contact time and concentration. This leads to potential problems with microbiological quality, algal growth in basins and tastes and odors. Maintaining strong oxidizing conditions throughout the treatment process is important for oxidizing reduced iron and manganese in the water. If these conditions are not maintained in the sedimentation basin and through the filters, iron and manganese may "bleed" from sludge on the bottom of the basin or from the filter media (Singer, 1986; Knocke et al., 1987). For this reason, the point of chlorination is often moved to the filter inlet so that oxidizing conditions will be maintained through the filters.

Application of Chlorine Dioxide

Chlorine dioxide is a strong oxidant and disinfectant that can be used effectively to control iron and manganese, THM precursors, microorganisms, algal growth, and organics responsible for undesirable tastes and odors. Its advantage over chlorine is that it forms no THMs (Werdehoff and Singer, 1987). Chlorine dioxide has been successfully applied as a pre-oxidant and disinfectant, eliminating many of the problems that result from moving the point of chlorination to a downstream location. Since no THMs result from the application of chlorine dioxide, THM formation does not begin until the point at which free chlorine is applied.

The oxidation of THM precursors by chlorine dioxide is believed to provide additional THM control beyond that accomplished by simply moving the point of chlorine addition. This makes it possible for reductions in THM levels of 50 percent or more to be achieved through the use of chlorine dioxide as a pre-oxidant (Lykins and Griese, 1986; Singer, 1988). Using chlorine dioxide as the sole oxidant and disinfectant eliminates the use of chlorine entirely, resulting in TTHM levels of essentially zero (Lykins and Griese, 1986; Singer, 1988). Unfortunately, losses in microbiological quality, as indicated by elevated standard plate counts and increased incidence of coliform bacteria, have occurred at some systems where this strategy has been applied (Singer, 1988).

The range of application of chlorine dioxide as an alternative to free chlorine for oxidation and disinfection is limited by its rapid rate of depletion. This makes it difficult to maintain a residual to insure adequate disinfection. The depletion of the chlorine dioxide dose may occur in only a few hours in high TOC waters, while in waters of higher quality, a residual may be maintained for several days.

Because of the potential hazard posed by the inorganic by-products of chlorine dioxide, there is a practical limit to the amount which may be applied. The products of chlorine dioxide are chlorite (ClO_2^-), and chlorate (ClO_3^-). They are of concern because Couri et al. (1982) found that the presence of chlorine dioxide, chlorite, and chlorate residuals in drinking water caused hemolytic anemia in rats and mice, with chlorate showing the greatest effect. In response, the EPA recommended that the sum of chlorine dioxide, chlorate, and chlorite residuals in drinking water should not exceed 1.0 mg/l (EPA, 1983). To meet this recommendation, Werdehoff and Singer (1987) suggested that chlorine dioxide dosage should be less than 2.0 mg/l and probably less than 1.5 mg/l.

Application of Ozone

Although ozone has disinfection capabilities, it is more useful as an oxidant. Like other oxidants, ozone may be used for the control of iron, manganese, and color. In addition, ozone can oxidize THM precursors and is particularly effective in controlling tastes and odors. Applied in place of chlorine as a pre-oxidant, ozone serves these purposes and decreases the demand for chlorine. Ozone is an extremely strong viricidal agent, but its usefulness as a disinfectant is limited because it does not provide a long lasting residual (Rice et al., 1981; Vogt and Regli, 1981). This may result in problems with algal growths in pre-treatment basins. Due to the lack of a residual from pre-ozonation, it is often applied at a second location where oxidative conditions are required, such as the filter inlet. This practice is called two-stage ozonation. Chang and Singer (1988) reported that pre-ozonation can improve removal of TOC, but that its effect is negligible at the dosages applied in practice, which are typically 3.0 mg/l or less. Chang and Singer (1988) determined that a slight reduction in THMFP could be achieved if the ozone to TOC ratio was in the range of 0.25 to 1.2 mg/mg.

Ozone can improve coagulation and flocculation when applied under the correct conditions. Oxidation by ozone destabilizes particles in solution, promoting their aggregation. This results in the formation of larger particles, a phenomenon called microflocculation. Since larger particles are more readily removed by filtration, the quality of filtered water is improved and the filter run length is increased. One parameter which influences the effectiveness of ozone-inducing microflocculation is the dose applied. Chang and Singer (1988) found that in order for ozone to enhance particle destabilization, a minimum hardness to TOC ratio must be present. Also, the region of optimum dosage is significantly influenced by hardness and TOC. Ozone must be carefully applied because overdosing can cause particles to restabilize. Other parameters which may affect the process are pH and alkalinity.

Replacing chlorine with ozone as a pre-oxidant, as in the case of chlorine dioxide, prevents the production of chloroform until chlorine is applied at a later stage in the process. The benefit in postponing the start of THM formation has been discussed in a previous section on moving the point of chlorination. However, formation of the brominated THM species can occur when ozone is applied. Ozone reacts with bromide to form hypobromous acid, which then can react with organic matter to produce the brominated species of THMs. Still, however, TTHM levels in the distribution system can be reduced significantly through pre-ozonation.

Application of Chloramines

Chloramines are a disinfectant that does not promote the formation of THMs (Symons, 1976). Numerous investigators have observed that the use of chloramines stops THM formation (Brodtmann et al., 1977; Norman et al., 1980; Mitcham et al., 1983; Symons et al., 1983). In a few systems, the use of chlorine as a disinfectant can be eliminated entirely, with chloramines providing adequate primary disinfection while preventing the formation of THMs in the distribution system. However, only a few systems will have contact times long enough to achieve primary disinfection with chloramines. Chloramines can also be used in combination with free chlorine and other pre-treatment oxidants and disinfectants; the latter provide oxidation and disinfection during the treatment process, with chloramines providing disinfection in the distribution system. Chloramines are also referred to as combined chlorine, since they are produced from free chlorine and ammonia. In water treatment applications, chloramines most commonly exist as monochloramine (NH_2Cl), and once formed, they are relatively stable.

There are some concerns about the use of chloramines in place of free chlorine. A common occurrence in plants switching to chloramines has been a measurable increase in finished water color (Singer, 1986; Thompson and Ameno, 1987). The best approach for achieving acceptable levels of color while minimizing THM production is to maximize the removal of the humic material which is responsible for the color prior to the addition of free chlorine. Coagulation with ferric chloride is one strategy that has been used successfully to remove color in a plant that applied chloramines (Thompson and Ameno, 1987). A second strategy involves the oxidation of the color causing material by strong oxidants such as ozone and chlorine dioxide.

The degree of disinfection is determined by the power and concentration of the disinfectant used, and the contact time. This is often specified by the CT value, which is the concentration of the disinfectant multiplied by the contact time. Because chloramines have less disinfection power than free chlorine, microbiological quality is a concern when they are used in place of chlorine. This may be compensated for by applying a higher residual of chloramines and by providing contact time with a stronger disinfectant, such as ozone or free chlorine, prior to the addition of chloramines. The presence of ammonia also introduces the potential for biological nitrification to occur. This is a concern because the nitrite produced by the process could react with amines to form nitrosamines, which are known to be a potent class of carcinogens.

Application of Potassium Permanganate

Potassium permanganate is very effective as a pre-oxidant. When the point of chlorine addition is moved to reduce THM production, permanganate can be used to provide oxidative pre-treatment. It may be applied to control iron and manganese, as well as tastes and odors. The ability of permanganate to control THMs is limited (Colthurst and Singer, 1982; Kreft et al., 1985). It has no significant impact on coagulation, flocculation, and sedimentation of THM precursors and it reduces THM formation only to a small degree. Since its strength of oxidation is limited, permanganate is not able to satisfy high oxidant demands. In these cases, permanganate is useful because it can satisfy some of the demand, which decreases the amount of chlorine required. A decrease in the amount of chlorine applied can translate to lower THM production. A good disinfectant must be used when applying permanganate, since it is not an effective disinfectant. Because of its limited abilities, permanganate's principal use is in suppport of other, more effective methods of THM control (Colthurst and Singer, 1982).

Technique of Removing THMs

THMs that already exist in the water may be removed by air stripping. Removal rates as high as 95 percent are attainable (Bilello and Singley, 1986). Although this technique is capable of removing a substantial portion of the THMs present, it does not remove precursors. This is particularly significant for high TOC waters which are likely to contain high levels of precursors after filtration. After air stripping, these precursors can combine with subsequent chlorine to form additional THMs in the distribution system. Reformation of THMs can, of course, be minimized through a high degree of precursor removal by prior processes or by the subsequent use of combined chlorine. In the future, air stripping may be less practical, since a large portion (70%) of the halogenated disinfection by-products (soon to be regulated) are non-volatile.

Incidence of THMs in North Carolina and the Southeast

The water systems of North Carolina and the southeastern United States are particularly susceptible to elevated THM levels because of raw water quality and chlorination practices. The National Organics Reconnaissance Survey (1975) found that southeastern water supplies are relatively high in humic content and TOC. To satisfy the high oxidant demands of the raw water, many systems in the southeastern United States practiced prechlorination. High THM precursor content, coupled with the application of high chlorine dosages beginning early in the treatment process creates a condition which is highly favorable for THM formation. This has resulted in average THM levels in North Carolina (Singer et al., 1981) and the southeastern United States that are substantially higher than the average for the rest of the nation (Symons et al., 1975).

A lower maximum contaminant level (MCL) for THMs will have a significant impact on the water systems of North Carolina and the southeast. Since the promulgation of the initial standard for THMs, several water systems in North Carolina have modified their treatment process to reduce their THM levels. Many systems have achieved significant reductions in THM levels by reducing chlorine dosage or by discontinuing prechlorination. In the event of a lower THM standard, additional systems will require modification to achieve compliance. Those systems which have already reduced their chlorine dosage or moved their point of chlorine addition will be forced to employ other technologies to reduce their THM levels to an acceptable level.

Chapter 3

METHODS

Collection of Data

The primary objective of the data collection was to obtain complete and current records of THM measurements for every water system serving at least 10,000 persons in the State of North Carolina. This information was available from the primacy agency, which is the Public Water Supply Branch of the North Carolina Department of Human Resources, Division of Health Services, Environmental Health Section in Raleigh.

In North Carolina, THM measurements are performed by state-certified laboratories. Each quarter, the utilities collect their own samples from the distribution system, send them to a state-certified laboratory for analysis, and then send their report of measured THMs to the Public Water Supply Branch in Raleigh. The Public Water Supply Branch maintains records of most water quality measurements on a computer database for easy access. Once the information is recorded in the appropriate THM file of the database, the lab report sheet is stored in a folder with other records and correspondence for that system. Although some of the data collected for this study were obtained from the individual lab report sheets, most came from computer printouts of water system files accessed from the database.

The records collected for this study include all THM reports stored in the database before June, 1988. At that time, there were 66 water systems in North Carolina serving at least 10,000 persons. Complete THM records were obtained for 62 of these systems. THM records are not kept for the systems at Garner and Union County because their water is purchased from larger systems. Records for the Brookwood and Pamlico County systems could not be found in the database. Although the system at Dunn serves less than 10,000 persons, its record was collected for the purpose of evaluating the use of chlorine dioxide for reducing THM levels.

Additional information for each system was obtained from monthly operating reports and water supply data sheets for the individual utilities, which were also available from the Public Water Supply Branch in Raleigh. Yearly folders of monthly operating reports are maintained for each system. The examination of these records focused primarily on the type and amount of chemicals added and the volume of water treated. The water supply data sheets provided a general description of each system; they are updated yearly. Information of particular interest on these sheets was the type and location of the raw water source and the types of treatment processes employed. However, the information regarding the treatment processes was often found to be vague and out-of-date. As a result, specific information about each system was acquired from the Regional Director of the Public Water Supply Branch for the district in which the utility was located, or directly from the plant superintendent.

Analysis of Data

Using Microsort Works software, a spreadsheet was created for each water system to present the complete THM record in an organized fashion. Several computations were performed to reduce the data to a useful form for purposes of making comparisons.

The THM record for each system was carefully examined to detect possible errors. Once a value was recognized as being erroneous, it was excluded from the data set. The most common types of errors found in the records were groups of duplicate values. Often, two groups of identical measurements appeared in the record only a few days apart, indicating that the same measurements had been recorded twice. This was attributed to an error in reading the date of sampling from the report sheet. This was a common occurrence in the records, accounting for a majority of the values that were discarded. Another common error observed was a misplaced decimal point. This error was often easily detected by observing that one measurement in a group differed from the others by one or more orders of magnitude.

Before a representative average THM concentration was calculated for each system, it was necessary to eliminate some questionable measurements from the record. For example, in some cases, a group of four THM measurements would contain three values which were similar in concentration, while the fourth value was close to zero. In other cases, one measurement was much higher than the other three values. The THM regulation requires that three samples be taken from representative points in the distribution system, while the fourth sample is taken at the extremity of the system. All of the water enters the distribution system from the treatment plant at a common point, with the same THM concentration. THM concentrations vary in the distribution system, depending on how much chlorine contact time has occurred between the entrance of the water into the distribution system and the point of sample collection. The three samples taken at representative points in the distribution system are expected to have similar THM concentrations because the chlorine contact time is similar. The sample taken at the extremity of the distribution system will have a higher THM concentration, due to a longer chlorine contact time. Since there was no practical way to confirm which measurements were valid and which might have been erroneous, a systematic approach was adopted to determine which values should be discarded as being non-representative.

The following procedure was established to designate as outliers those measurements which were deemed not to be representative of the entire group. The data from each system were grouped by the quarter of the year in which the measurement appeared in the record. In most cases, this produced a more normal distribution of values with a smaller variance than would have been possible if the data were analyzed as a whole. This allowed for extreme values in each quarter to be exposed. The 95 percent confidence interval was calculated for the group of measurements for each quarter. All measurements which fell outside this interval were designated as outliers and were discarded. Some system records did not contain enough data to make such an analysis meaningful. In these cases, no values were discarded.

The following computations were performed on the data set from each system record.

1. Unadjusted Average - average of all measurements taken on a given sampling date.
2. Adjusted Average - same as Unadjusted Average except that outliers were excluded from the computation.
3. Quarterly Average - average of all the measurements (excluding outliers) taken during the quarter.
4. Running Annual Average - average of the four most recent quarterly averages.
5. Two-Year Mean - average of the eight most recent quarterly averages.
6. Percentage of Brominated Species - average percentage of brominated species for the eight most recent quarters.

Because several of the THM records had gaps (quarters for which no data were recorded), a method of substituting reasonable values for these quarters was necessary in order to calculate a meaningful Two-Year Mean THM concentration. The value chosen for substitution was the Quarterly Average from the same quarter of the previous year. If the Quarterly Average value from the previous year was also missing, the most recent previous value available for that quarter was used. If no previous value was available, a subsequent Quarterly Average from the same quarter was used.

The terms "unadjusted" and "adjusted" were used to distinguish between computations that included outliers and those that did not. With the exception of the computation of Unadjusted Averages, outliers were excluded from all other calculations.

The purpose of calculating the Two-Year Mean THM concentration was to get an indication of the utility's current performance with regard to THM production. A period of two years was chosen as opposed to a one-year period in order to establish confidence in the value as a true indicator of current system performance. A longer period of time was not chosen because of a desire for the value to be based on the most current data.

The results of all the computations appear in columns of the spreadsheet. Most of the computations were performed using spreadsheet functions. These computations were carried out to two significant figures.

A graph of Quarterly Average values versus the quarter sampled was prepared for the entire record of each system using Microsoft Works software.

Chapter 4

RESULTS AND DISCUSSION

Results

The THM record for each system was organized using a spreadsheet. The format used for each record is shown in Tables 4.1, 4.2, 4.3 and 4.4, which are the THM records for the Pasquatank County, Richmond County, Reidsville, and Goldsboro systems. The name of the plant, the Public Water Supply Branch identification number, and the number of persons served is indicated in the first few rows of the spreadsheet. The records are arranged by the sampling date, which appears in the first column, beginning with the most recent data entry. The second column is used to designate those measurements which were discarded, such as outliers, errors, and duplicates. These are identified by an omega (Ω) in the second column. Column 3 contains the individual total trihalomethane measurements.

In Table 4.1, the first measurement on the 9/25/87 sampling date satisfied the criteria for classification as an outlier, so it was discarded and an omega appears next to it. The group of measurements appearing on the 9/1/87 sampling date in Table 4.1 were identified as duplicates, since they were identical to those measurements appearing on 8/31/87. Accordingly, they were discarded. The same is true for the 6/22/87 entries, which were duplicates of the 6/18/87 entries. With the exception of one measurement, the 5/7/86 entries are identical to the 2/13/86 entries. Because it is unlikely that three identical measurements could occur on two different sampling dates, the 5/7/86 entries were assumed to be duplicates and were discarded. Since the

TABLE 4.1

Pasquatank County THM Record

Plant: Pasquatank County			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0470015						
Population Served: 13000						
Date of Sampling		TTHM's ug/l	Unadjusted Average Reading ug/l	Adjusted Average Reading ug/l	Quarterly Average Reading ug/l	
01/11/88		20				
"		37				
"		60				
"		67	46		46	
09/25/87	Ω	144				
"		70				
"		33				
"		30	69	45		
09/01/87	Ω	106				
"	Ω	76				
"	Ω	49				
"	Ω	30	65			
08/31/87		30				
"		49				
"		106				
"		76	65		56	Σ
06/22/87	Ω	73				
"	Ω	53				
"	Ω	42				
"	Ω	21	47			
06/18/87		21				
"		73				
"		42				
"		53	47		47	
10/20/86		29				
"		42				
"		20				
"		137	57		57	

TABLE 4.1 (cont'd)

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
08/29/86		23				
		8				
		70				
		88	47			
07/07/86		30				
"		51				
"		61				
"		75	55		51	
05/07/86	Ω	66				
"	Ω	51				
"	Ω	51				
"	Ω	11	45			
02/13/86		11				
"		51				
"		44				
"		66	43		43	
07/26/85	Ω	14				
"	Ω	48				
"	Ω	50				
"	Ω	87	50			
07/15/85		48				
"		14				
"		50				
"		87	50		50	

TABLE 4.2

Richmond County THM Record

Plant: Richmond County			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0377109						
Population Served: 13000						
			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
05/12/88		92				
"		44				
"		51				
"		56	61		61	
02/18/88		35				
"		24				
"		25				
"		35	30		30	
12/08/87		59				
"		71				
"		60				
"		72	65			
10/20/87		45				
"		73				
"	Ω	147				
"		122	97	80	72	Σ
07/01/87		79				
"		88				
"		103				
"		90	90		90	
03/31/87		97				
"		36				
"		56				
"	Ω	114	76	63	63	Σ
12/10/86		52				
"		47				
"		84				
"		69	63		63	

TABLE 4.2 (cont'd)

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
09/16/86		80				
"		101				
"	Ω	207				
"		132	130	104	104	Σ
06/23/86		59				
"		71				
"	Ω	123				
"		65	79	65	65	Σ
03/21/86		49				
"		39				
"		50				
"		77	54		54	
12/19/85		67				
"		49				
"		70				
"		94	70		70	

TABLE 4.3

Reidsville THM Record

Plant: Reidsville			Ω-measurement discarded for adjusted average calculation		
			Σ-some measurements(Ω) discarded before calculating average		
PWID: 0279020					
Population Served: 13000					
			Unadjusted	Adjusted	Quarterly
Date of Sampling		TTHM's µg/l	Average Reading µg/l	Average Reading µg/l	Average Reading µg/l
03/16/88		30			
"		35			
"		34			
"		41	35		35
12/08/87		34			
"		34			
"		44			
"		38	37		37
09/28/87	Ω	62			
"	Ω	65			
"	Ω	75			
"	Ω	78	70		
09/03/87		62			
"		65			
"		75			
"		78	70		
07/31/87	Ω	76			
"	Ω	76			
"	Ω	77			
"	Ω	73	75		70
06/04/87		73			
"		76			
"		77			
"		76	75		75
03/19/87		36			
"		28			
"		26			
"		23	28		28

TABLE 4.3 (cont'd)

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
11/25/86		33				
"		28				
"		33				
"		32	31		31	
08/27/86		43				
"		39				
"		42				
"		49	43		43	
05/29/86		46				
"		39				
"		52				
"		54	48			
04/03/86		43				
"		52				
"		50				
"		42	47		47	
12/03/85		45				
"		55				
"		25				
"		51	44		44	
09/03/85		77				
"		80				
"		89				
"		72	79		79	
05/21/85		63				
"		71				
"		70				
"		50	63		63	
03/19/85		32				
"		29				
"		42				
"		36	35		35	

TABLE 4.3 (cont'd)

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
08/02/84		65				
"		77				
"		57				
"		69	67		67	
05/15/84		52				
"		48				
"		46				
"		49	49		49	
01/10/84		21				
"		32				
"		25				
"		23	25		25	
10/14/83		73				
"		101				
"		88				
"		87	87		87	
06/15/83		123				
"		140				
"		132				
"		139	133		133	
02/09/83		88				
"		79				
"	Ω	104				
"		69	85	79	79	Σ

TABLE 4.4

Goldsboro THM Record

Plant: Goldsboro		Ω-measurement discarded for adjusted average calculation		
		Σ-some measurements(Ω) discarded before calculating average		
PWID: 0496010				
Population Served: 32900				
		Unadjusted	Adjusted	Quarterly
Date of	TTHM's	Average Reading	Average Reading	Average Reading
Sampling	µg/l	µg/l	µg/l	µg/l
03/16/88	53			
"	60			
"	46			
"	41	50		50
11/17/87	51			
"	61			
"	44			
"	42	49		49
09/01/87	99			
"	124			
"	97			
"	86	101		101
05/27/87	98			
"	108			
"	86			
"	78	92		92
03/11/87	91			
"	90			
"	84			
"	80	86		86
12/04/86	59			
"	79			
"	62			
"	48	62		62
09/25/86	100			
"	92			
"	108			
"	85	96		96

TABLE 4.4 (cont'd)

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
06/03/86		97				
"		109				
"		95				
"		88	97		97	
03/19/86		74				
"		87				
"		71				
"		68	75		75	
12/05/85	Ω	113				
"		65				
"		58				
"		68	76	64	64	Σ
09/20/85		83				
"		95				
"		85				
"		65	82		82	
04/16/85		59				
"		92				
"		68				
"		63	70		70	
02/07/85		50				
"		58				
"		53				
"		46	52		52	
12/18/84		58				
"		71				
"		50				
"		52	58		58	
09/18/84		96				
"		112				
"		94				
"		85	97		97	

TABLE 4.4 (cont'd)

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
05/03/84		96				
"		114				
"		73				
"		88	93		93	
03/06/84		100				
"		100				
"		100				
"		100	100		100	
11/22/83		73				
"		80				
"		75				
"		62				
"	Ω	73				
"	Ω	80				
"	Ω	75				
"	Ω	62	72	72	72	Σ
06/21/83		50				
"		93				
"		75				
"		84	75		75	
03/10/83		124				
"		111				
"		116				
"	Ω	162	128	117		
01/18/83		112				
"		142				
"		94				
"		81	107		111	Σ

7/26/85 entries were identical to the 7/15/85 entries, these were also identified as duplicates and discarded.

In Table 4.2, outliers were identified on the 10/20/87, 3/31/87, 9/16/86, and 6/23/86 sampling dates. These measurements, designated by an omega (Ω) appearing next to them, were discarded.

In Table 4.3, the entries appearing on the 9/28/87 sampling date were discarded since they were identified as duplicates of the entries appearing on 9/3/87. The entries appearing on 7/31/87 were also discarded as duplicates because they were identical to the entries appearing on 6/4/87. One of the entries on the 2/9/83 sampling date satisfied the criteria for classification as an outlier, so it was discarded.

In Table 4.4, the 12/5/85 and the 3/10/83 sampling dates each had one entry which was discarded after it was identified as an outlier. Two identical sets of four entries appear on the 11/22/83 sampling date, so four of the entries were discarded as duplicates.

The Unadjusted Average, which is the average of all measurements taken on the indicated sampling date, appears in column 4. The average of measurements taken on a given sampling date, excluding all discarded measurements, appears in column 5. This is the Adjusted Average and is computed only for those sampling dates where outliers have been discarded. For example, on the 1/11/88 sampling date on Table 4.1, no outliers were discarded, so an Adjusted Average did not have to be computed. An Adjusted Average is computed for the 9/25/87 sampling date, since one of the values was discarded as an outlier. A comparison of the Adjusted and Unadjusted Averages gives an indication of the impact of discarded outliers.

Out of 4573 entries, only 132 were identified as outliers. This represents only

2.9 percent of the total number of entries. The number of low outliers and high outliers was fairly evenly distributed, with 61 low outliers and 71 high outliers identified.

The Quarterly Average, appearing in column 6, is the average of all measurements taken in a given quarter, excluding measurements discarded as outliers. If any measurements taken during the quarter were discarded as outliers, a sigma (Σ) appears in column 7, next to the Quarterly Average. For example, one of the twelve measurements taken during the third quarter (months 7, 8, and 9) of 1987 in the Pasquatank County record (Table 4.1) was discarded as an outlier. The Quarterly Average was computed for the remaining eleven measurements.

The Quarterly Average values were used for further analysis in computing the Two-Year Mean THM concentrations for each system and for preparing graphical representations of the data. Substitute Quarterly Average values were used for quarters in which there was no data. The Pasquatank County record can be used to demonstrate the method of substitution. It can be seen from Table 4.1 that no data exists in the Pasquatank County record for the fourth quarter of 1987, the first quarter of 1987, and the fourth quarter of 1985. The second quarter of 1986 was also considered to have no data since all entries for the quarter were discarded because they were identified as duplicates. In order to provide a continuous sequence of Quarterly Average values, these gaps in the record were filled by reasonable substituted values. When these gaps occurred, the Quarterly Average value for the same quarter of the previous year was substituted. For instance, the Quarterly Average from the fourth quarter of 1986 was substituted for the missing value in the fourth quarter of 1987. Similarly, the gap in the first quarter of 1987 was filled by the Quarterly Average value from the first quarter of 1986. The second quarter of 1986 had no data representing it since all of the measurements were discarded as duplicate values. No data from the second quarter of a previous year was available, so the Quarterly Average from the same quarter of the following year (second quarter of 1987) was used.

Once the eight values representing the Quarterly Average TTHM concentrations of the most recent two years of data were assembled, the Two-Year Mean TTHM concentration was computed by taking the average of the eight values.

A plot of the Quarterly Average TTHM concentrations versus the quarter sampled for the Pasquatank County water system is shown in Figure 4.1. This graph represents the adjusted data from Table 4.1. The substituted Quarterly Averages are designated by a different symbol which appears in the legend. Figure 4.1 indicates that Quarterly Average values did not vary substantially over the course of the year. By contrast, Figure 4.2 for the Richmond County system, illustrates a substantial variation in Quarterly Average TTHM concentrations and a more distinct seasonal pattern to the variations, with peak values occurring in the third quarter, and minimum values occurring in the first quarter. The Quarterly Average TTHM concentration plots for the Reidsville and Goldsboro systems are shown in Figure 4.3 and 4.4.

Speadsheets and graphs of the Quarterly Average TTHM concentrations were prepared for all 63 of the systems for which TTHM data were available. The spreadsheets and graphs appear in Appendix A. The Two-Year Mean TTHM concentrations do not appear on the individual spreadsheets, but are tabulated in Table 4.5 (see below).

Summary of Two-Year Mean TTHM Concentrations

The average of the eight most recent quarterly THM averages, which is referred to as the Two-Year Mean TTHM concentration, is presented in Table 4.5 for each water system. Because a few systems lacked sufficient data, the Two-Year Mean was computed

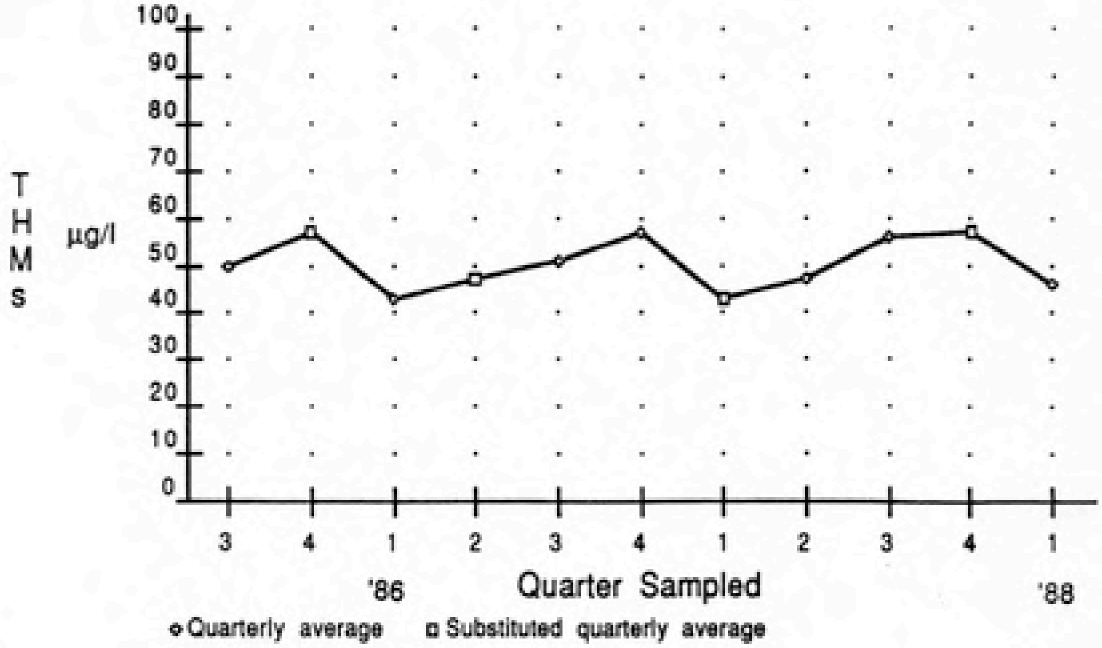

Figure 4.1
Quarterly Average TTHM Concentrations for the Pasquatank County System

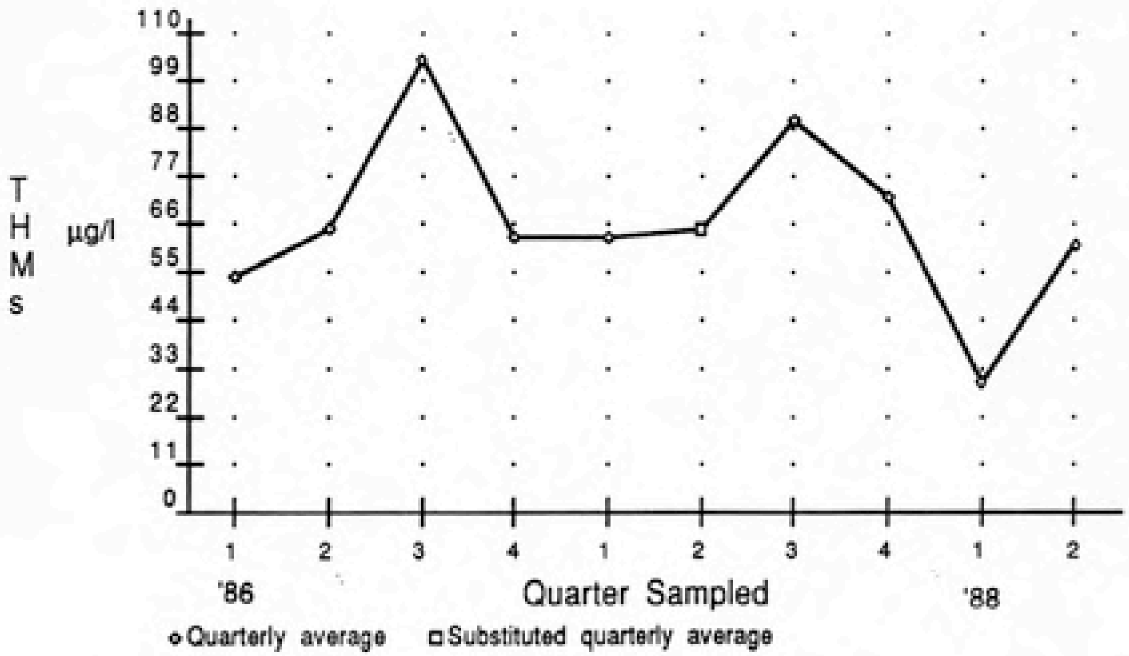

Figure 4.2
Quarterly Average TTHM Concentrations for the Richmond County System

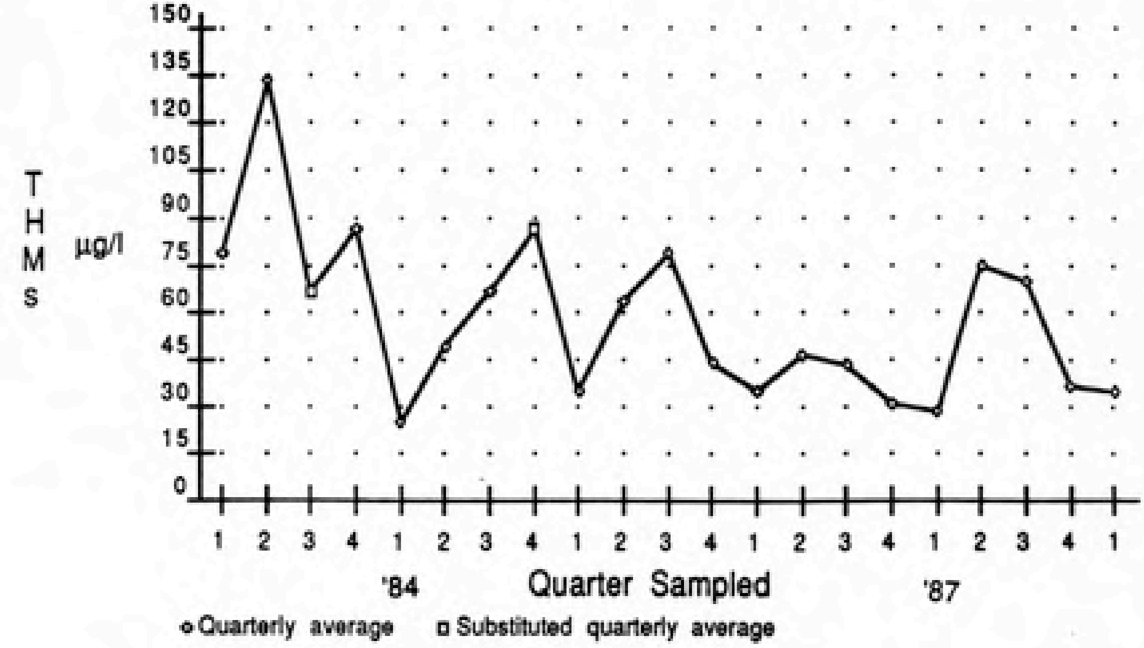

Figure 4.3
Record of Quarterly Average TTHM Concentrations for the Reidsville System

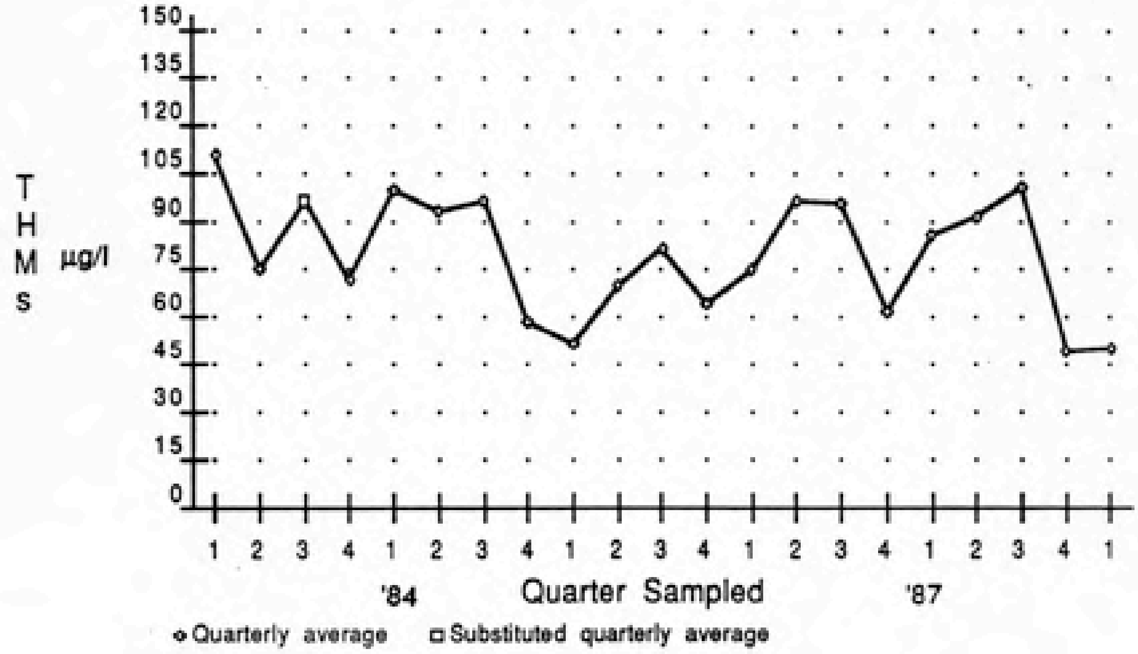

Figure 4.4
Record of Quarterly Average TTHM Concentrations for the Goldsboro System

TABLE 4.5

Average TTHM Concentrations in North Carolina Water Systems

System Location	Two-Year Mean TTHM Concentration (µg/l)	Type of Source
Elizabeth City	314	Surface & Ground
Rocky Mount	154	Surface
USMC-Cherry Point	101	Ground
Raleigh	94	Surface
Fayetteville	93	Surface
Southern Pines	93	Surface
Cary	91	Surface & Ground
Wilson	91	Surface
Wilmington	88	Surface
Sanford	87	Surface
Davidson	83	Surface
Goldsboro	82	Surface
King District	81	Surface
Durham	78	Surface
Lexington	78	Surface
Thomasville	78	Surface
OWASA	77	Surface
Asheboro	75	Surface
Roxboro	74	Surface
USMC-New River Air Station	74	Ground
High Point	70	Surface
Richmond County	68	Surface
Winston-Salem	67	Surface
Anson County	65	Surface
Kannapolis	64	Surface
Monroe	64	Surface
Henderson-Kerr	63	Surface
Belmont	62	Surface
Burlington	62	Surface
Dunn	62	Surface
Morganton	62	Surface
Charlotte	60	Surface
Shelby	59	Surface
Davie County	58	Surface
Tarboro	55	Surface
Greenville	52	Surface & Ground
Albemarle	51	Surface
Greensboro	51	Surface

(continued)

TABLE 4.5 (cont'd)

System Location	Two-Year Mean TTHM Concentration (µg/l)	Type of Source
Reidsville	51	Surface
Concord	50	Surface
Fort Bragg	50	Surface
Pasquatank County	50	Ground
Salisbury	49	Surface
Lenoir	46	Surface
Gastonia	45	Surface
Hickory	45	Surface
Statesville	45	Surface
Eden	44	Surface
Marion	44	Surface
Roanoke Rapids	43	Surface
Cape Fear Water Co.	42	Ground
Hendersonville	42	Surface
Jacksonville	38	Ground
Lumberton	38	Surface & Ground
Asheville	34	Surface
Waynesville	34	Surface
New Bern	27	Ground
USMC-Hadnot Point (*)	26	Ground
Boone	25	Surface
Robeson County (*)	6	Surface & Ground
Laurinburg	2	Ground
Onslow County	2	Ground
Brookwood	ß	Ground
Garner	∞	Purchased
Kinston	§	Ground
Pamlico County	ß	Ground
Union County	£	Purchased

(*) - Two Year Mean is based on less than two years of data.
ß - Record was not found in the database.
∞ - Water is purchased from Raleigh system; no THM values reported.
§ - Less than one year of data was available.
£ - Water is purchased from Monroe system; no THM values reported.

for only 61 of the systems. The values range from a high of 314 μg/l at Elizabeth City to a low of 2 μg/l for the Onslow County and Laurinburg systems. The average Two-Year Mean TTHM concentration for the 61 systems is 64 μg/l, with a standard deviation of 41 μg/l. The average of the Two-Year Mean values without consideration of the value for Elizabeth City, which is more than twice the next highest value, is 60 μg/l, with a standard deviation of 26 μg/l. In Table 4.5, the systems are listed according to their Two-Year Mean TTHM concentrations, from highest to lowest.

Examination of the data without discarding any outliers revealed that excluding outliers had little impact on the Two-Year Mean TTHM concentrations for most systems. Calculating the average Two-Year Mean TTHM concentration for the systems with the outliers yielded the same result as calculating the average Two-Year Mean concentration without the outliers. The two systems whose Two-Year Mean TTHM concentrations were affected most significantly by discarding outliers were Elizabeth City and Raleigh. However, after examination of their THM records (see Appendix), it appears that the entries that were discarded were indeed not representative values.

The distribution of the Two-Year Mean values among the 62 systems is illustrated by Figure 4.5. The abscissa is divided into TTHM ranges of 10 μg/l. The ordinate represents the number of systems having a Two-Year Mean (X) in the given range. Some observations that can be made from Figure 4.5 are: 1) the Two-Year Mean TTHM concentration of 38 of the systems falls in the 40 to 80 μg/l range, accounting for the majority of the facilities studied; 2) only three systems have Two-Year Means that exceed the current MCL of 100 μg/l.; 3) the number of systems on either side of the mean value (64 μg/l) is relatively evenly distributed.

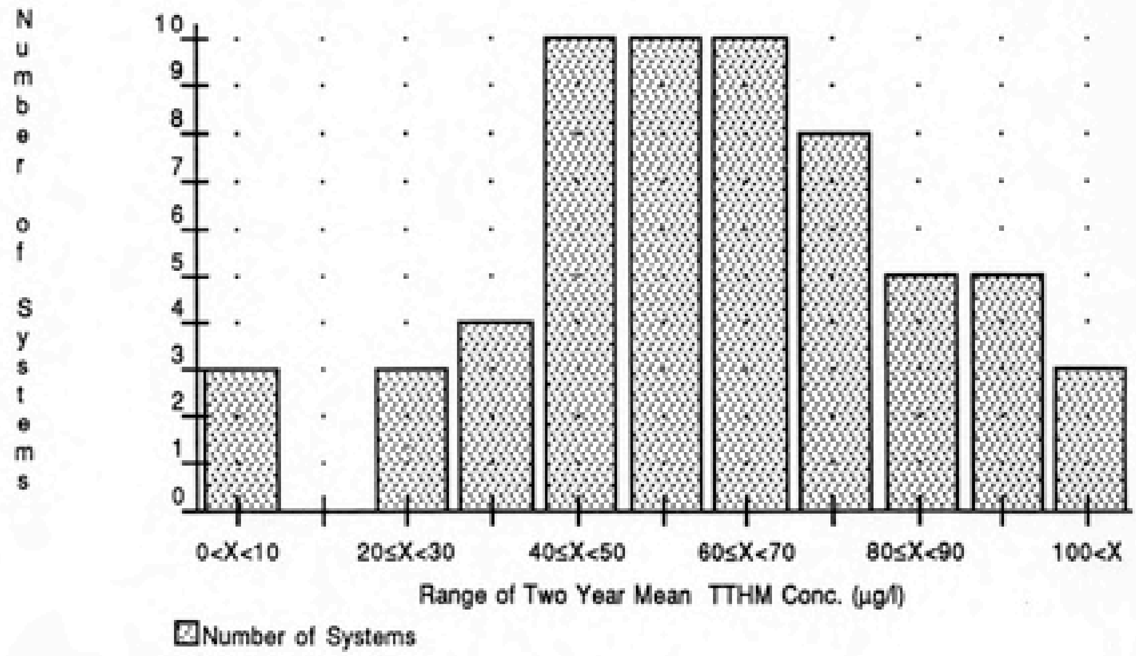

Figure 4.5
Distribution of Two-Year Mean THM Concentrations

Influence of Raw Water Source on THM Levels

Table 4.5 indicates the type of raw water source used by each system. Most of the systems use either a surface or a groundwater source, while a few purchase their water from other systems or use a mixture of both surface and groundwater. Figure 4.6 illustrates the distribution of these source types among the North Carolina systems included in this study. Clearly, the water supply systems of the state rely heavily on rivers and lakes for raw water.

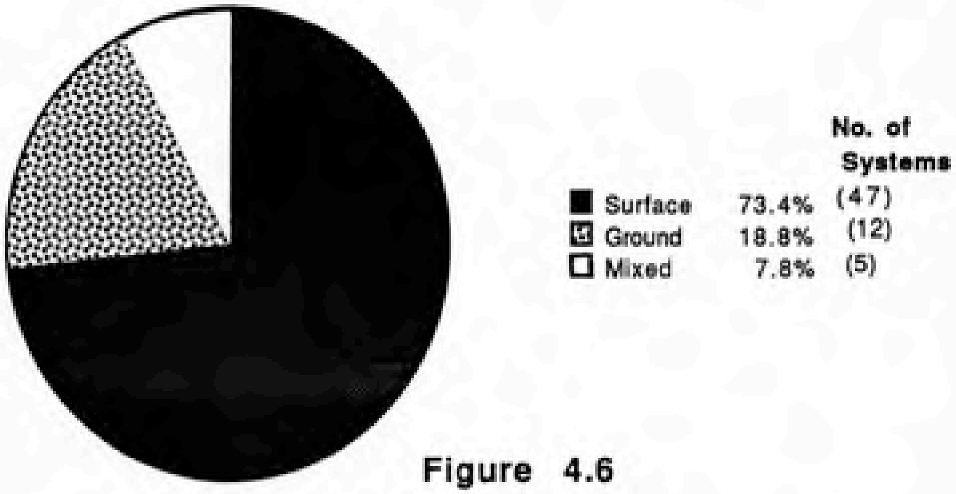

Figure 4.6

Sources of Raw Water in North Carolina

The effect of the raw water source on THM levels in the state was examined by comparing the Two-Year Mean TTHM concentrations for systems using only surface water and systems using only groundwater. The systems using a mixture of both surface and groundwater were not considered. The distribution of systems with a Two-Year Mean TTHM concentration in each 10 µg/l range for surface water and groundwater is shown in Figure 4.7. It can be seen that systems using groundwater as a source account for most of the systems with a Two-Year Mean less than 40 µg/l, while systems using surface water sources account for the majority of all systems with a Two-Year Mean greater than 40 μg/l. These findings are not surprising, since groundwater generally is expected to contain fewer THM precursors than surface water (Symons et al., 1975, Schreiber, 1981). The average of the Two-Year Mean TTHM concentrations for surface water systems is 65 μg/l, while the average Two-Year Mean for groundwater systems is 40 μg/l.

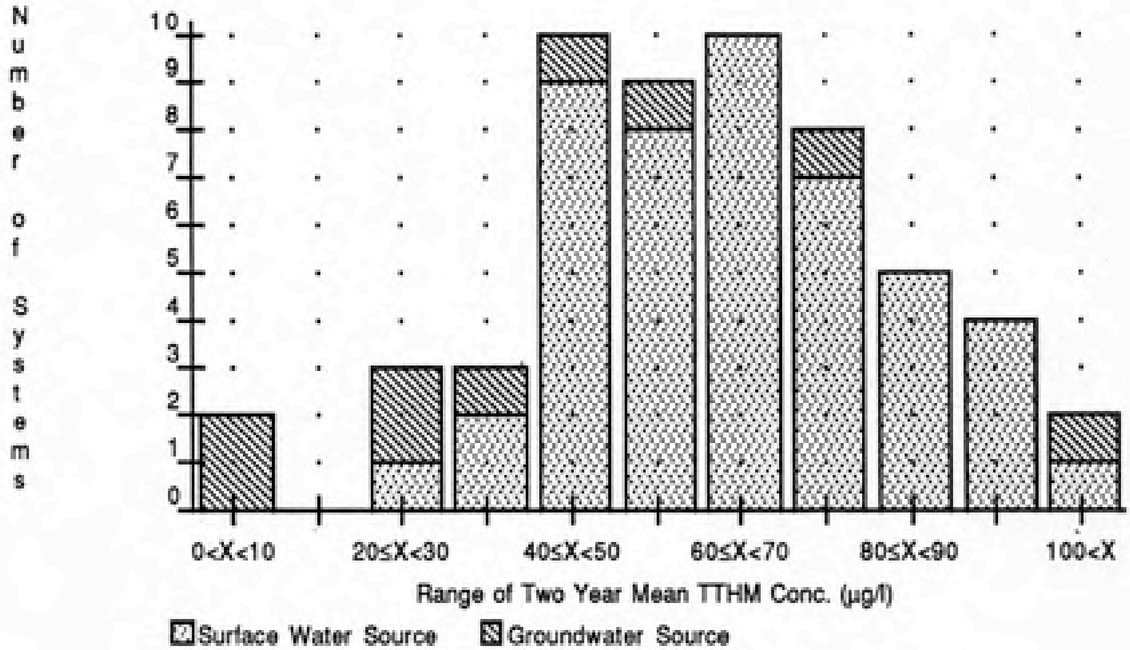

Figure 4.7
Distribution of Two-Year Mean THM Concentrations By Raw Water Source

Distribution of THM Species

The distribution among the four THM species comprising the TTHM measurement was available for only 38 of the system records collected. The average percentage of brominated THM species was computed from the eight most recent quarters of data. The percentage of brominated THM species is shown in Table 4.6. These systems are arranged according to their percentage, in descending order. The raw water source type and the Two-Year Mean TTHM concentration of each system are also indicated in the table. The highest percentage of brominated THMs among the systems examined was 91 percent at the United States Marine Corps - New River Air Station system. The system at Fort Bragg had the lowest percentage at 5 percent.

The distribution of brominated THM percentage among North Carolina water systems is shown in Figure 4.8. One-half of the systems (19) have a brominated percentage of 20 or less, while only five of the systems have a percentage of 50 or greater. The average value for the 38 systems is 26 percent. This value is somewhat misleading, since the values are not distributed evenly about the mean. More than 70 percent of the systems examined have a percentage which is less than the average value of 26.

The most significant observation that can be made from Table 4.6 is that all of the systems with percentages of brominated THMs of 50 or greater are served by groundwater. The average percentage for the systems served by groundwater is 54, compared to an average percentage of 19 for surface water sources. These averages were computed without consideration of the systems which use both surface and groundwater. These findings suggest that raw water bromide levels are generally higher in the groundwater than in the surface water, a common occurrence (Symons et al., 1983).

TABLE 4.6

Percentage of Brominated THM Species

System Location	Percentage of Brominated THMs	Type of Source	Two-Year Mean TTHM Concn. (µg/l)
USMC - N. River AS	91	Ground	74
Cape Fear Water Co.	71	Ground	42
Jacksonville	66	Ground	38
Pasquatank County	62	Ground	50
USMC - Hadnot Point	50	Ground	26
Hendersonville	42	Surface	42
Sanford	33	Surface	87
Kinston	32	Ground	§
Wilmington	31	Surface	88
Elizabeth City	29	Sur. & Gnd.	314
Belmont	26	Surface	62
Cary	24	Sur. & Gnd.	91
Fayetteville	23	Surface	93
Asheville	22	Surface	34
Charlotte	21	Surface	60
Greenville	21	Sur. & Gnd.	52
Tarboro	20	Surface	55
Kannapolis	20	Surface	64
Salisbury	20	Surface	49
Lenoir	18	Surface	46
Wilson	18	Surface	91
Raleigh	18	Surface	94
OWASA	17	Surface	77
High Point	17	Surface	70
Marion	17	Surface	44
Lumberton	16	Sur. & Gnd.	38
Lexington	16	Surface	78
Winston-Salem	15	Surface	67
Morganton	15	Surface	62
Thomasville	15	Surface	78
Greensboro	15	Surface	51
Asheboro	14	Surface	75
Roxboro	14	Surface	74
Durham	12	Surface	78
Rocky Mount	12	Surface	154
Eden	10	Surface	45
USMC - Cherry Point	7	Ground	101
Fort Bragg	5	Surface	50

§ - less than one year of data was available.

Geographic Distribution of THM Levels

The Two-Year Mean TTHM concentrations for water supplies in North Carolina are presented geographically in Figure 4.9. The figure shows a general trend of increasing THM concentrations from west to east across the state. The THM concentrations tend to be lowest in the western, or mountainous region, are higher in the Piedmont area, with the maximum levels occurring in the eastern region near the coast. Studies by Singer et al. (1981) and Barry (1980) indicated this same trend. They suggested that the trend could be due to the accumulation of humic materials in surface waters as they flow across the state or to differences in vegetation of the watersheds. Of course, these explanations are more applicable to systems using a surface water source.

Close examination of Figure 4.9 reveals that most of the systems having low THM levels in the eastern part of the state rely on groundwater sources. It should also be noted that the four lowest Two-Year Mean TTHM concentrations for surface water systems (see Table 4.5) are all located in the western part of the state.

The geographic distribution of the percentage of brominated THM species is illustrated in Figure 4.10. Most of the higher percentages of brominated species occur in the eastern part of the state. The systems with the highest percentages are groundwater systems along the coast, which suggests that these waters have higher bromide levels as a result of ocean water intrusion. The most surprising finding is that the USMC - Cherry Point system, served by groundwater and located along the coast, has one of the lowest percentages (7%) of brominated species and one of the highest Two Year Means (101).

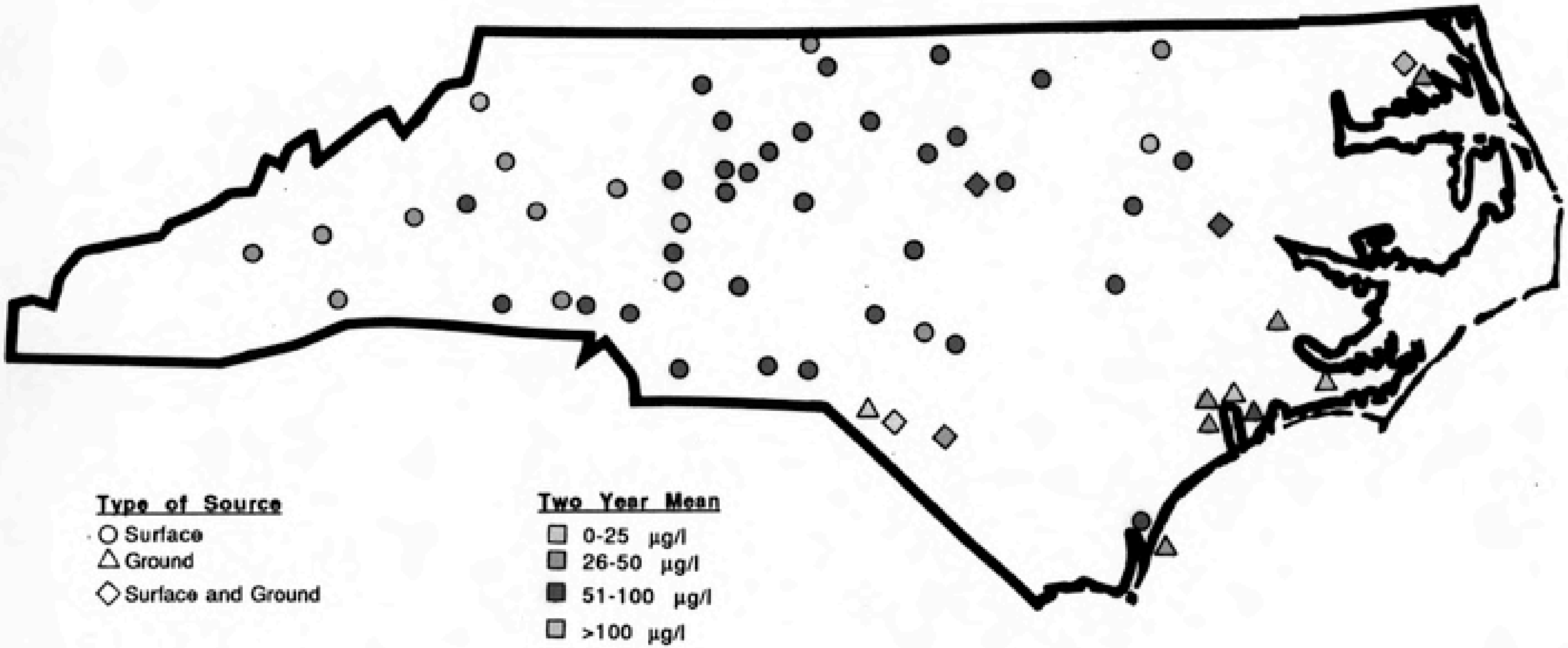

Figure 4.9
Geographic Distribution of Two-Year Mean THM Concentrations

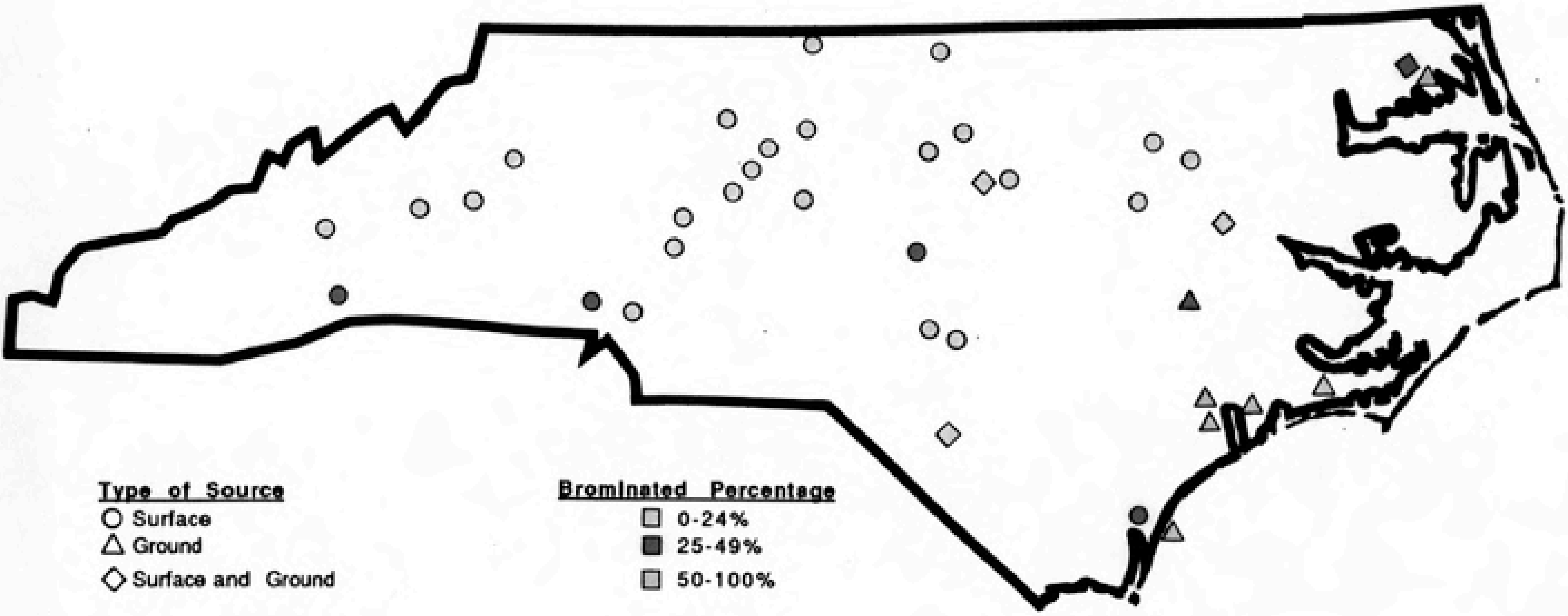

Figure 4.10
Geographic Distribution of Brominated THM Percentage

Seasonal Variations in THM Concentrations

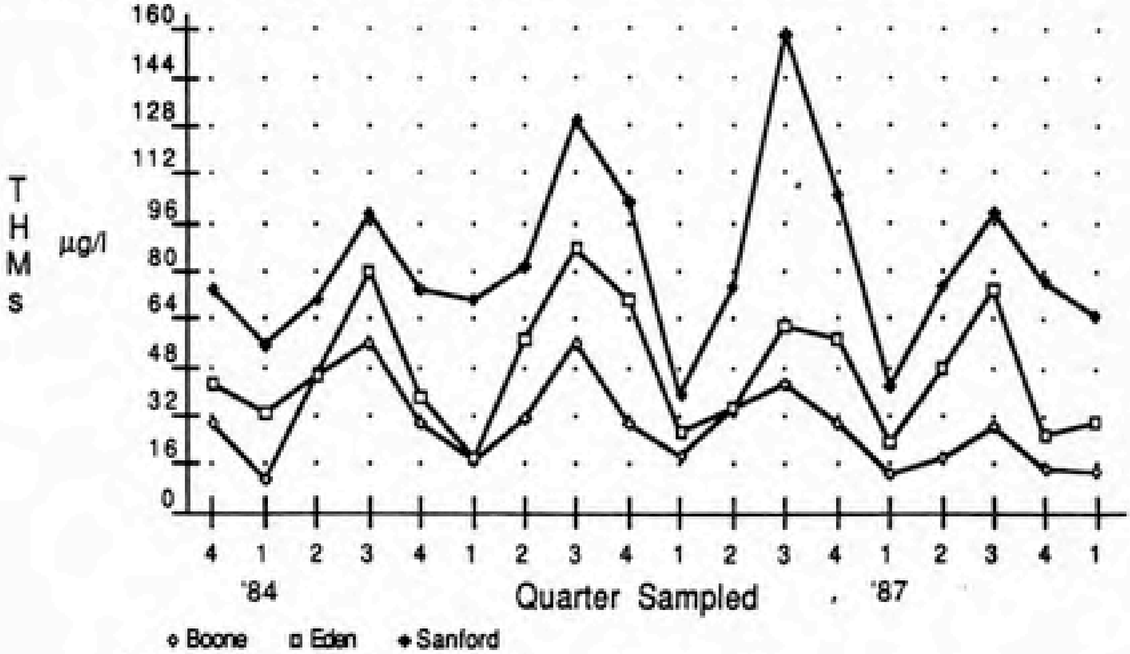

Figure 4.11
Seasonal Variation in THM Concentrations

Many of the North Carolina water systems studied exhibit pronounced seasonal variations in THM concentrations. Figure 4.11 shows these variations in the Quarterly-Average graphs for three facilities from across the state. Additional examples may be found by looking through the graphs prepared individually for each system, appearing in Appendix A. Many other investigators have observed similar trends, suggesting that such fluctuations are due to changes in temperature and variations in THM precursor concentrations in the water source during the year (Barry 1980; Veenstra and Schnoor, 1980; Schreiber, 1981; Singer et al., 1981). THM concentrations are expected to peak during late summer and early fall, when temperatures and precursor concentrations are highest. The lowest THM concentrations are expected to occur during the winter months, when temperatures and vegetative activity are low.

The eight most recent quarterly averages for 60 of the plants studied were examined to determine the quarters in which the highest and lowest values most often occurred. The systems which had relatively constant THM concentrations throughout the year were not considered. The distribution of high and low values among the quarters is shown in Figures 4.12 and 4.13. These results are consistent with those of other researchers, with the peak level typically occurring in the third quarter (July-August-September) and the lowest level most frequently occurring in the first quarter (January-February-March). An interesting observation is that the peak quarter varied more among the four quarters than the lowest quarter.

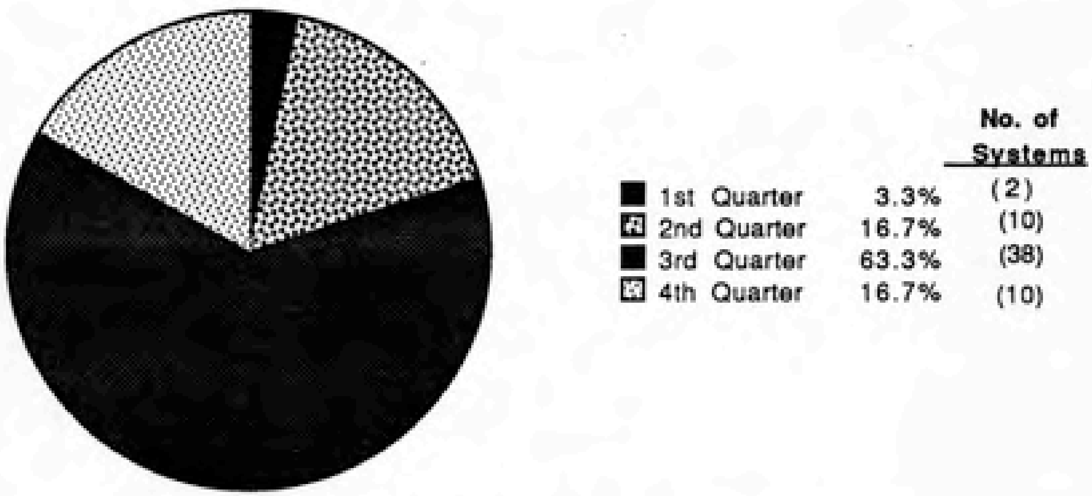

Figure 4.12
Occurrence of Highest THMs: Distribution by Quarter

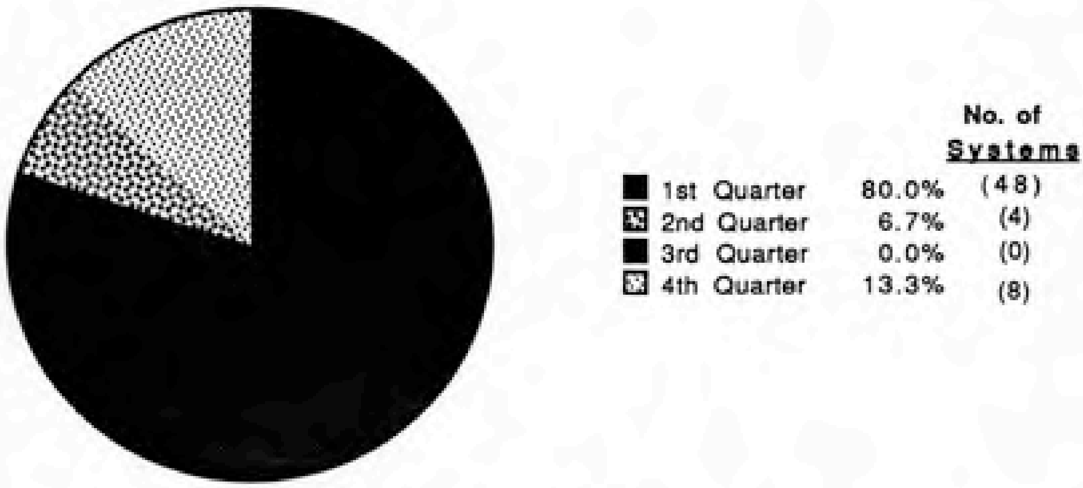

Figure 4.13
Occurrence of Lowest THMs: Distribution by Quarter

Strategies Currently Used in North Carolina to Reduce THM Levels

Many of the water systems in North Carolina have reduced their THM concentrations by reducing their prechlorination doses substantially or discontinuing prechlorination entirely and applying chlorine at a later stage of treatment. Most of the systems in the state with elevated THM concentrations have already made this modification to their treatment process scheme in an attempt to achieve compliance with the MCL. Verification of this conclusion was difficult since examination of monthly operating reports did not always clearly indicate the point of chlorine addition. Pre-chlorination is shown on the monthly operating reports, but several phone calls to utilities verified that pre-chlorination often referred to the addition of chlorine just ahead of filtration.

Young and Singer (1979) and Singer et al. (1981) measured THM concentrations at different stages of treatment in several North Carolina treatment plants. The data from the OWASA, Durham, and Wilmington plants indicated that the percentage of finished water THMs formed before filtration in prechlorinated waters ranged from 40 to 85 percent. Young and Singer (1979) concluded that by discontinuing the practice of prechlorination and applying chlorine at a later stage of the treatment process, THM concentrations in the finished water could be reduced by about 50 percent. The evaluation of data from previous studies (Young and Singer, 1979; Ohio River Valley Sanitary Commission, 1979; Singer et al., 1981; Symons et al., 1983) indicates that 65 percent is a reasonable estimate for the portion of TTHMs formed within the treatment plant, with the remaining 35 percent formed in the distribution system. Using this assumption, discontinuation of the practice of prechlorination and applying chlorine later in the process can reduce THM concentrations at the tap by approximately 30 percent. This is consistent with the reported reduction of 25 to 30 percent noted by the City of Durham (Bruce, 1988). This value is difficult to confirm using the data collected in this study because most of the systems that have moved their point of chlorination did so prior to the first THM measurements in the record.

Several of the state's water systems have incorporated alternative oxidants into their strategy for reducing THM concentrations. Some systems have adopted the use of alternative oxidants on a permanent basis, while other systems have used them only on an experimental basis. Those systems which have incorporated alternative oxidants on a permanent basis have done so only recently. Although some of the data collected since the modifications look promising, it is still too early to make an overall determination of the effectiveness of alternative oxidants for reducing THM concentrations in North Carolina drinking waters.

The treatment facility at Dunn has incorporated the use of chlorine dioxide as a pre-oxidant into the treatment process on a full-time basis. It is seen from the flow diagram in Figure 4.14 that chlorine dioxide is added prior to the flash mix basin, while

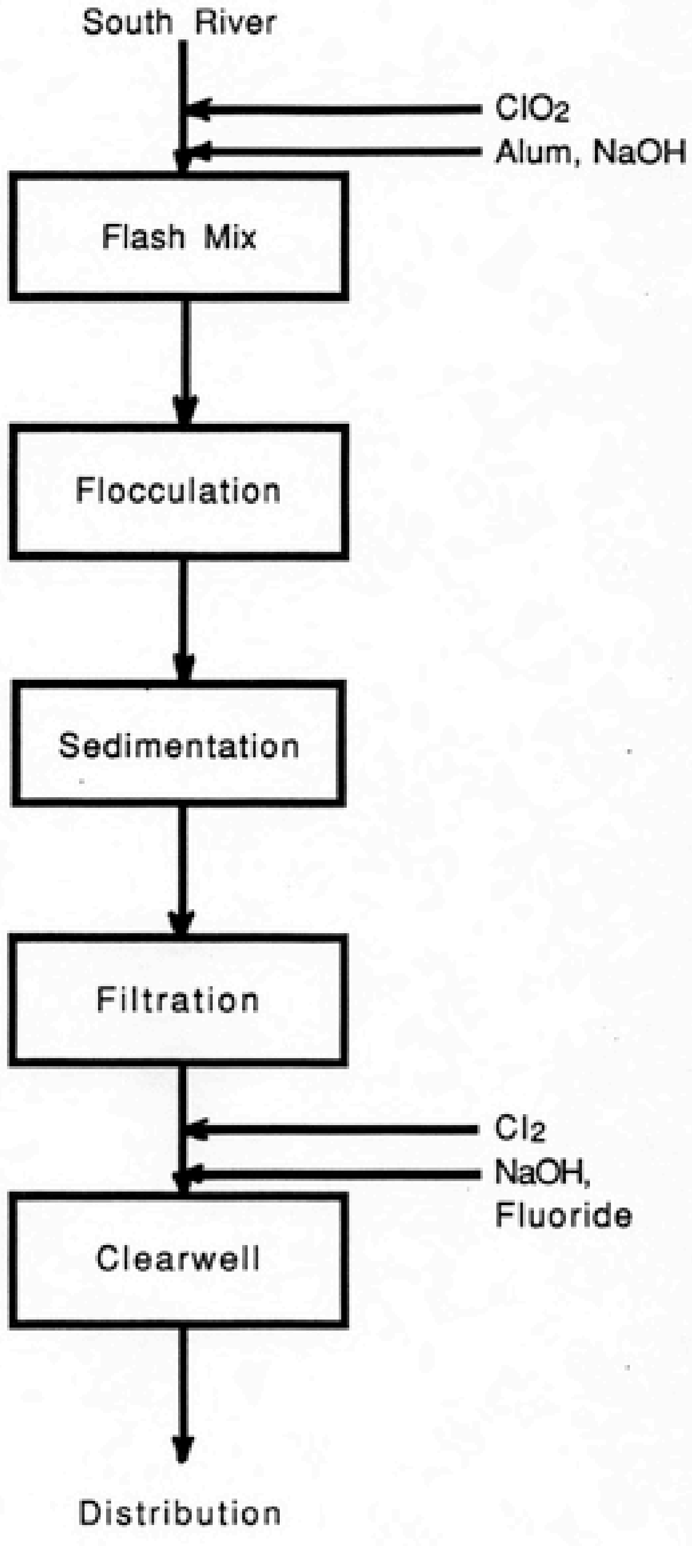

Figure 4.14
Process Flow Diagram for the Dunn Water Treatment Plant

chlorine is applied only after filtration. The monthly operating reports indicate that the typical dosage of chlorine dioxide is 2-3 mg/l.

The addition of chlorine dioxide began at the Dunn facility in March of 1987. At this same time, the practice of prechlorination was discontinued. The Quarterly Average THM concentrations for the Dunn facility are shown in Figure 4.15. This graph shows that the Quarterly Average THM concentrations have decreased since the adoption of chlorine dioxide. However, the Quarterly Average THM concentrations have been on a steady downward trend since the third quarter of 1984. Clearly, other factors such as improved water quality and reduced chlorine dosages have also played a role in decreasing THM concentrations at the Dunn facility. Without additional data, it is difficult to determine what portion (if any) of the reduction in THM formation is attributable to the use of chlorine dioxide.

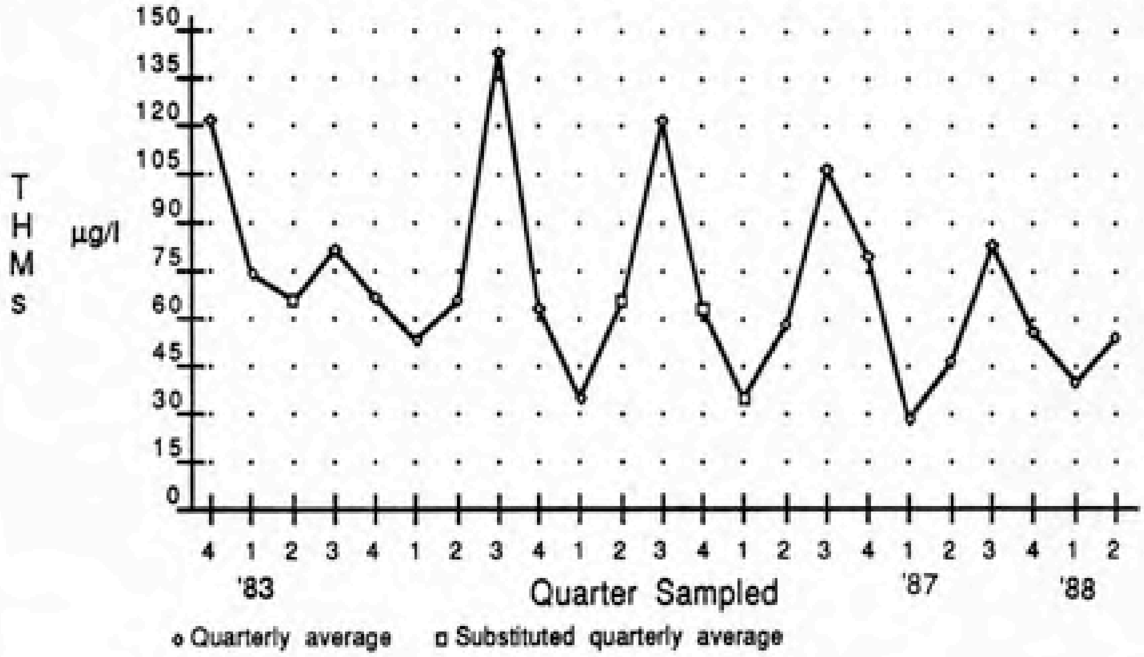

Figure 4.15
Record of Quarterly Average TTHM Concentrations for the Dunn System

At the Wilson water treatment facility, pre-oxidation with chlorine dioxide began in July of 1987. Chlorine dioxide is applied at the flash mix basin, while chlorine is added after filtration, as shown by the flow diagram in Figure 4.16. According to the superintendant of the facility, chlorine is occasionally added prior to filtration in order to maintain oxidative conditions through the filters. This is sometimes necessary for the control of manganese. Before chlorine dioxide was incorporated into the treatment process, chlorine was also added at the flash mix basin. Currently, all oxidative pretreatment is provided by chlorine dioxide. Pre-oxidation is not necessary during the winter months, so the addition of chlorine dioxide is discontinued during this part of the year. The average dosage of chlorine dioxide is 1 mg/l.

Only three quarters of data have been collected since the switch to chlorine dioxide, so its effectiveness for reducing THM concentrations at the Wilson facility cannot be ascertained yet. The graph of Quarterly Average THM concentrations, shown in Figure 4.17, does not indicate a significant reduction thus far. However, it has been an effective oxidant, according to the superintendant, providing control of tastes and odors as well as manganese (Parks, 1988).

In an effort to bring its THM concentrations below the MCL, the facility at Rocky Mount has adopted ozone as a pre-oxidant. As shown by the flow diagram in Figure 4.18, the flash mix chamber has been converted to an ozone contact chamber. The practice of prechlorination was discontinued when ozone was first applied in October of 1986. Since that time, ozone has not been used consistently. Monthly reports show that when ozone is applied, additional oxidation and disinfection is provided by chlorine applied before and after filtration. This is shown in Figure 4.18.

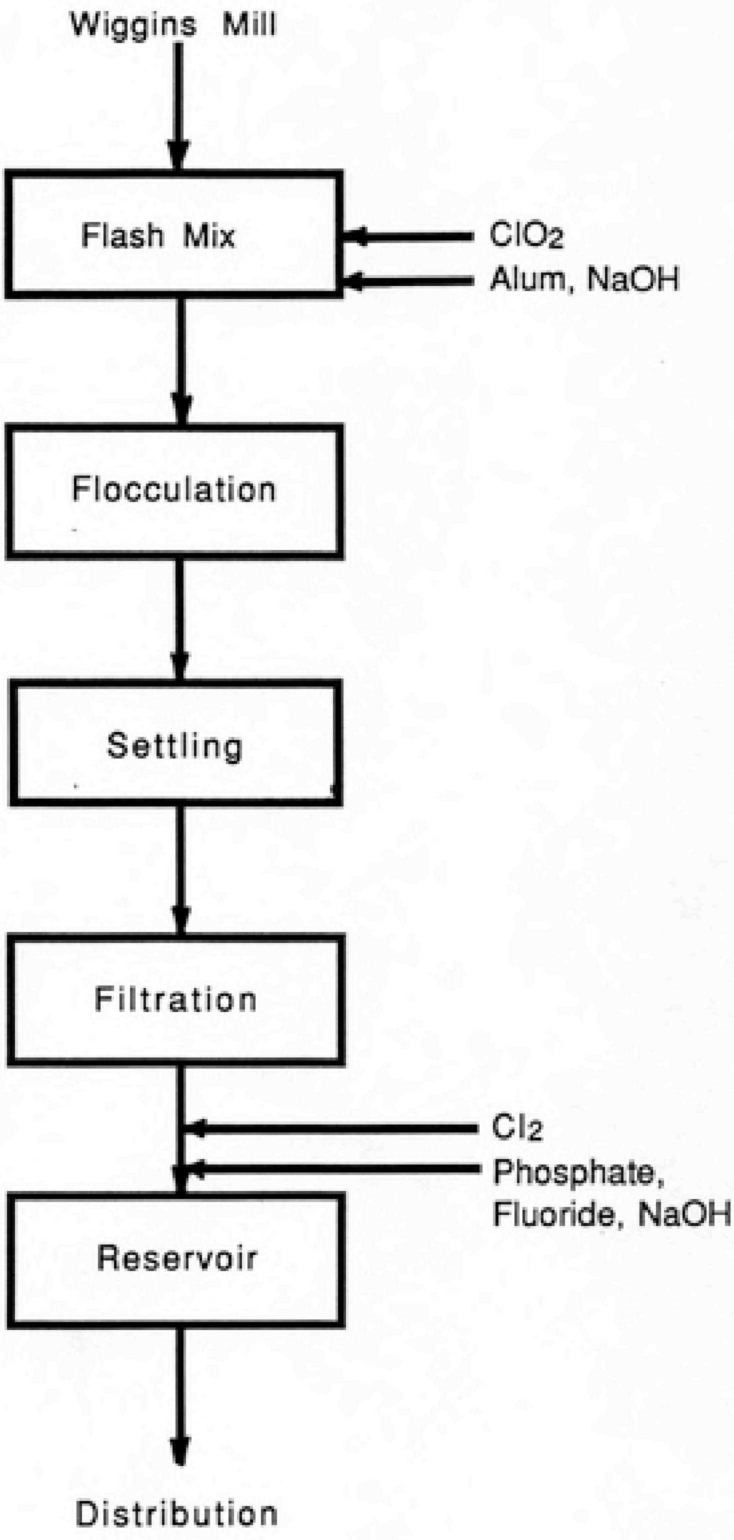

Figure 4.16
Process Flow Diagram for the Wilson Water Treatment Plant

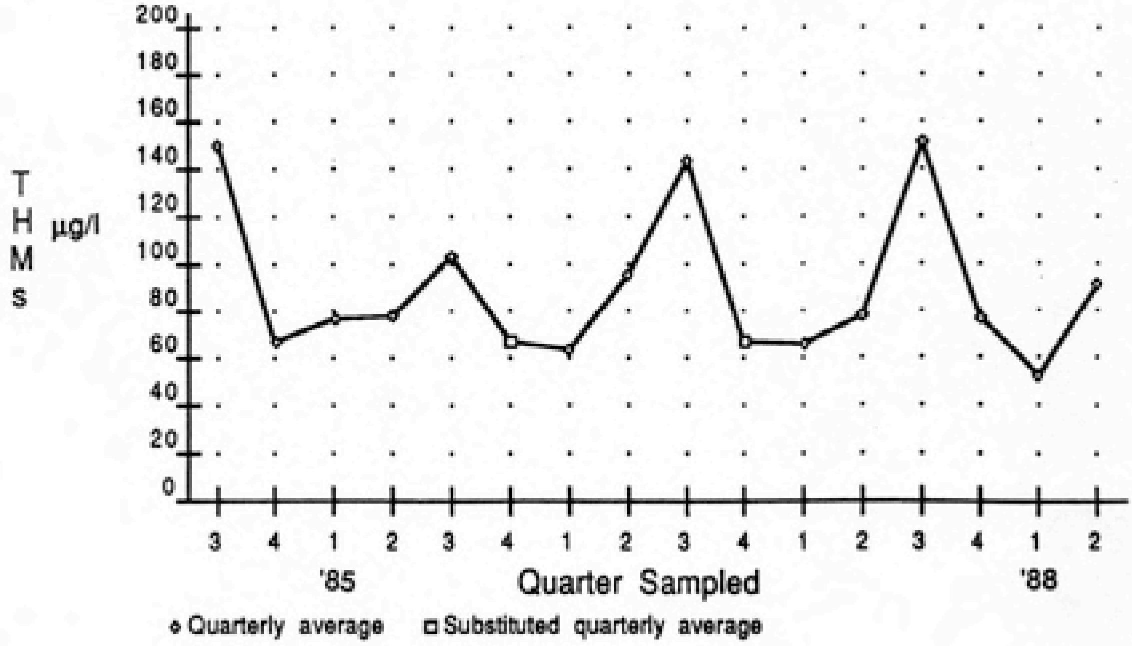

Figure 4.17
Record of Quarterly Average TTHM Concentrations for the Wilson System

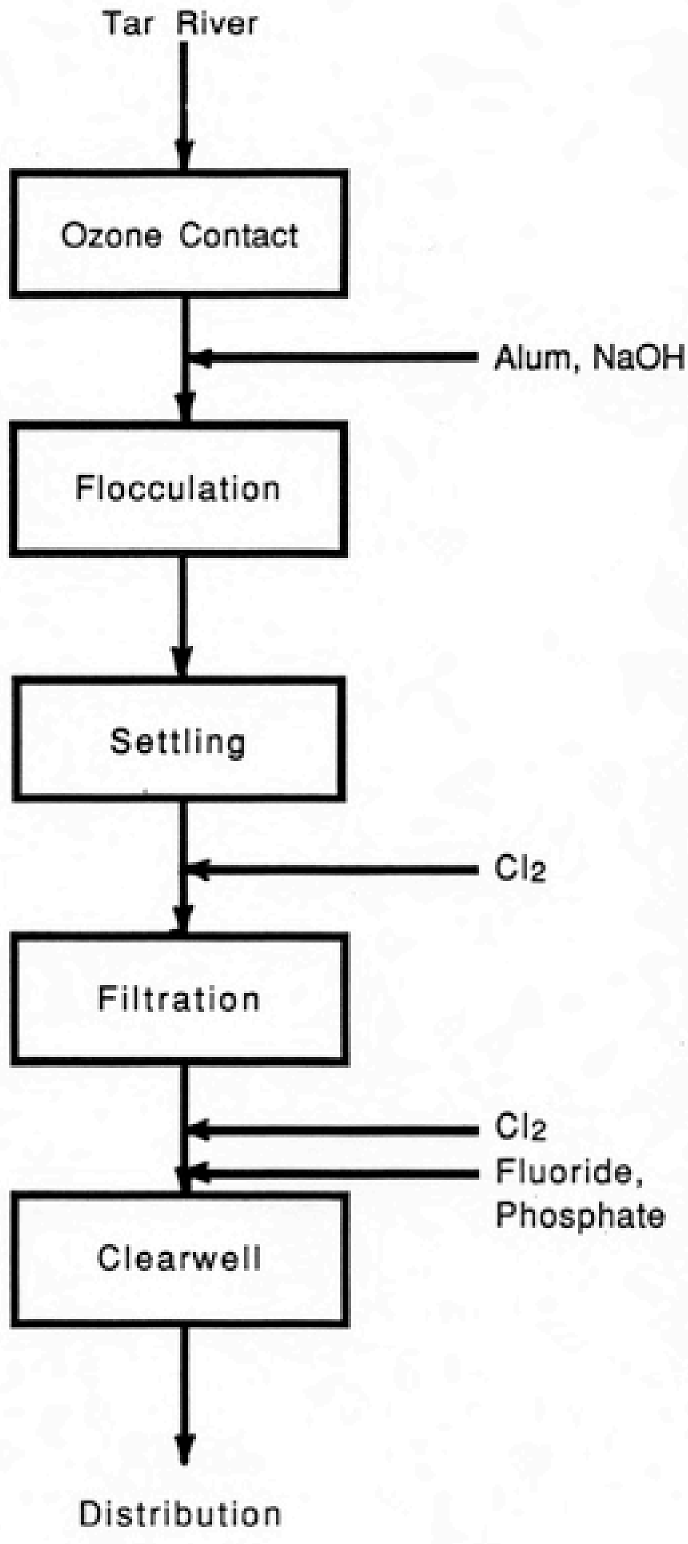

Figure 4.18
Process Flow Diagram for the Rocky Mount Water Treatment Plant

The graph of Quarterly Average THM concentrations for the Rocky Mount facility is shown in Figure 4.19. Ozone was first applied in the fourth quarter of 1986. Of the five data points plotted since that time, two are substituted values, as indicated by the square symbol on the graph. The three quarters of data actually collected since the modification are not enough to provide a strong basis for evaluating the effectiveness of ozone use for reducing THM levels at the Rocky Mount facility.

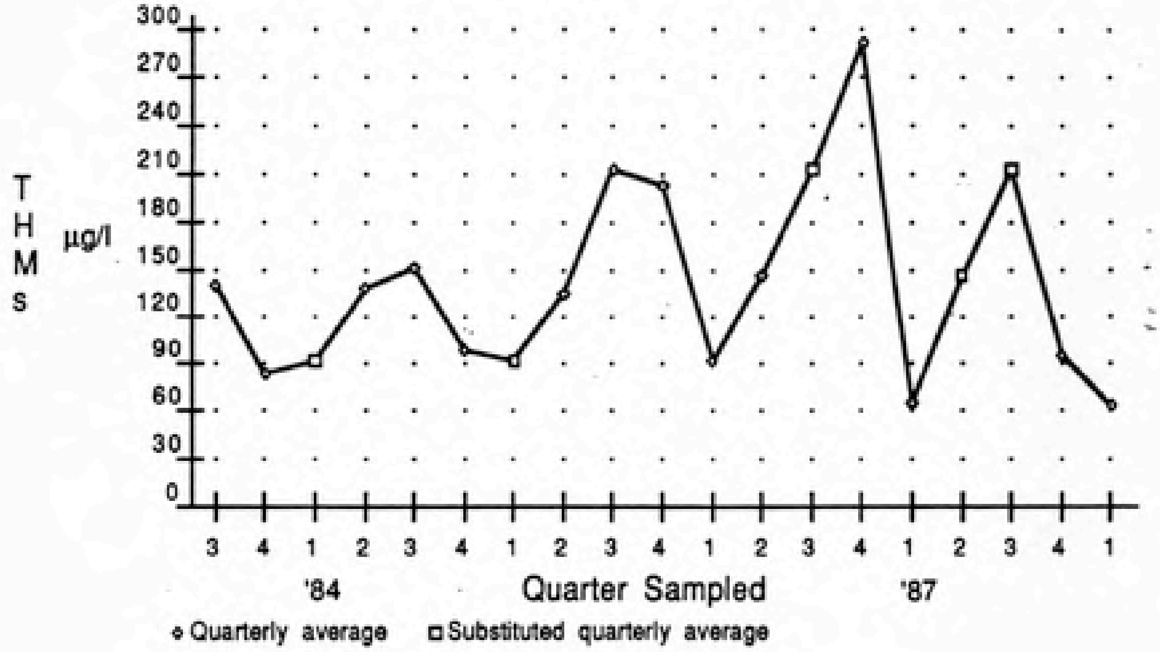

Figure 4.19
Record of Quarterly Average TTHM Concentrations for the Rocky Mount System

Impact of a Lower THM Standard

Because the MCL for THMs may be lowered in the next few years, it is important to assess the impact of a lower standard on the North Carolina water systems given their current operating status. The impact of lowering the MCL to 25 µg/l or 50 µg/l was asessed by examining the distribution of Two-Year Mean THM concentrations shown in Figure 4.20. These lower MCL values were selected for examination because these are the most likely values to be chosen for the lower MCL (Dyksen, Hiltebrand, and Raczko, 1988).

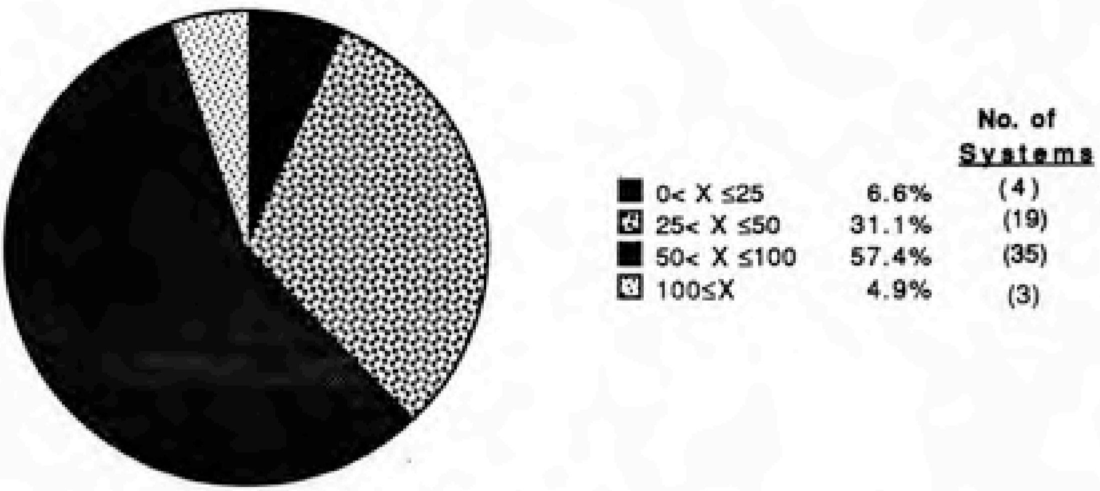

Figure 4.20
Distribution of Two-Year Mean THM Concentrations

Only 3 systems have a Two-Year Mean THM concentration which exceeds the current MCL of 100 µg/l. This represents less than 5 percent of the total number of public water systems in North Carolina serving at least 10,000 persons. Figure 4.20 indicates that lowering the standard to 50 µg/l would put an additional 35 systems out of compliance, affecting about 57 percent of all water systems. Under this 50 µg/l MCL, the total percentage of systems out of compliance would exceed 60 percent. A change in the standard to 25 µg/l would affect virtually all of the systems. An additional 19 systems would be out of compliance, bringing the total to 57, which represents more than 93 percent of the systems. Accordingly, a revision of the MCL for THMs to either level would result in the need for a substantial number of systems needing to modify their operations to reduce THM formation.

Various degrees of THM reduction would be required for the water systems in North Carolina if the MCL for THMs were to be lowered to 50 or 25 µg/l. The average Two-Year Mean TTHM concentration for the state's water systems, not counting Elizabeth City, is 60 µg/l. This value suggests that the average system would require a reduction of almost 20 percent in its level of THM formation to comply with a 50 µg/l standard. An MCL of 25 µg/l would require a reduction of nearly 60 percent for the average system.

The Two-Year Mean THM concentrations for the water systems in North Carolina indicate a high level of compliance with the current THM standard. In order to maintain this same level of compliance with a 50 µg/l MCL, reductions in THM concentrations of nearly 50 percent would be required for many systems. Considerably higher degrees of reduction would be required to maintain the current level of compliance in the event that a 25 µg/l MCL is adopted, with some systems needing reductions in their THM concentrations approaching 75 percent. Clearly, many of the North Carolina water systems would need to modify their treatment processes significantly if the MCL for THMs is lowered to 50 or 25 µg/l.

THM Reduction Strategies for North Carolina

The most widely used technique for reducing finished water THM concentrations in North Carolina water systems is moving the point of chlorination. The simplicity of the modification at most plants, as well as the positive results, make this approach particularly popular. The technique involves discontinuing the practice of prechlorination, which delays the initial addition of chlorine until a later stage of treatment, typically at a point before or after filtration. The reduction in chlorine contact time and the addition of free chlorine after a substantial fraction of the THM precursors have been removed by coagulation, flocculation, and sedimentation results in the production of fewer THMs. A savings in chemical costs is also likely to result from the decrease in chlorine use.

The extent of THM reduction resulting from moving the point of chlorination varies among water systems. These variations may occur because of differences in chlorine dosage, precursor content of the raw water, coagulation effectiveness in the removal of precursors, and the amount of contact time between the point of prechlorination and subsequent chlorination. Using data from several studies (Glaze and Rawley, 1979; Ohio River Valley Sanitary Commission, 1979; Young and Singer, 1979; Singer et al., 1981; Singer, 1988), a typical reduction in THM formation is estimated to be 30 percent by moving the point of chlorination. Most of the systems in North Carolina with elevated THM levels have already made this modification to their treatment process, so that other techniques will have to be used to achieve further reductions in THM levels.

When the application of chlorine at the head of the plant is discontinued, its strong oxidation and disinfection ability is no longer provided during the initial stages of treatment. Lack of adequate oxidation at this stage can result in problems with the control of iron and manganese, and tastes and odors. Another concern is the potential for algal growths in the pre-treatment basins, which can be unsightly and cause maintenance problems.

The degree of oxidation and disinfection needed during the initial stages of treatment varies among water systems, depending primarilary on the quality of the raw water entering the system. Some systems using a high quality raw water may be able to satisfy all oxidation and disinfection demands through the addition of chlorine only at a later stage in the treatment process; for example, after sedimentation. Other systems may use a raw water which requires significant oxidative pretreatment, which may be provided by potassium permanganate, chlorine dioxide, or ozone.

Potassium permanganate is a good oxidant that does not promote THM formation. It is not effective for disinfection, however, so its application must be coupled with a good disinfectant. Manganese removal must be insured when potassium permanganate is used, since a lack of manganese control can cause problems in the sedimentation basins and filters.

The application of chlorine dioxide is an attractive alternative to prechlorination because it can provide strong oxidation and disinfection without promoting the formation of THMs. Chlorine dioxide also forms very few total organic halogens (TOX) (Werdehoff and Singer, 1987). Chlorine dioxide's rapid rate of depletion, especially in waters with high oxidant demands, makes it more practical in most cases for oxidative pretreatment purposes than for disinfection, since difficulty may be experienced in maintaining a residual.

In addition to the reduction in THM concentrations resulting from discontinuing prechlorination, chlorine dioxide is believed to provide further reduction in THM formation through the oxidation of THM precursors. In some systems, this has resulted in overall reductions in THM concentrations of 50 percent or more (Lykins and Griese, 1986; Singer, 1988). However, in response to concerns over the potential health effects of the inorganic by-products of chlorine dioxide, the EPA has recommended that the sum of chlorate, chlorite, and chlorine dioxide concentrations in the distribution system not exceed 1.0 mg/l. To insure that this recommendation is met, chlorine dioxide dosages should not exceed 2.0 mg/l, with a preferred dosage of less than 1.5 mg/l (Werdehoff and Singer, 1987).

Reduced THM levels may also be achieved by replacing pre-chlorination with pre-ozonation, which can satisfy pretreatment demands for oxidation and disinfection. Ozone is especially useful as an oxidant and, like potassium permanganate and chlorine dioxide, is noted for its particular success in controlling tastes and odors. It is also a very strong disinfectant, the strongest of all disinfectants used in water treatment. Because the ability of ozone to maintain a residual is limited, pre-ozonation may allow for undesirable algal growth to occur in the basins. In some cases, a second application of ozone is applied at a later stage of the treatment process, such as at the filter inlet. Although ozone is an extremely strong viricide, it requires the use of a secondary supplimentary disinfectant because of its inability to produce a lasting residual.

Overall reductions in THM concentrations through the use of ozone have exceeded 50 percent in some cases (Rice et al., 1986; Lykins and Griese, 1986; Singer, 1988). This is due principally to the elimination of pre-chlorination and moving the point of chlorine addition from the raw water inlet to pre- or post-filtration. The remainder of the reduction is due to the oxidation of THM precursors by ozone, amounting to 10 to 20 percent destruction of THM precursors (Singer, 1988). In some cases, ozone has been shown to enhance THM production, since it can oxidize bromide to hypobromous acid, resulting in the formation of bromoform. Accordingly, ozone may be applied most successfully at systems whose THMs are composed primarilary of chloroform.

THM concentrations may be reduced to a significant degree through optimization of the coagulation, flocculation, sedimentation, and filtration processes to achieve maximum removal of THM precursors. The optimum conditions may be determined from bench-scale studies examining the performance of different types and dosages of chemicals under various conditions. When alum is used as a coagulant, the optimum pH is in the 5.5 to 6.0 range (Randtke, 1988). Most modifications can be made at little or no cost. In North Carolina, most utilities already operate near the optimal pH for precursor removal.

Granular activated carbon (GAC) can also be used to remove THM precursors. However, a high degree of THM precursor removal requires a high empty bed contact time (EBCT) and frequent regeneration of the GAC for waters of high TOC as found in North Carolina, which makes the process expensive.

Using chloramines or combined chlorine instead of free chlorine as a secondary disinfectant for disinfection in the distribution system can reduce THM levels significantly. Chloramines are produced by simultaneous addition of chlorine and ammonia or by applying ammonia at a later stage to convert the free chlorine residual in the water to combined chlorine. The ratio of ammonia to chlorine most often used for chloramination is 1 to 4 on a mg/mg basis. Adding the ammonia separately gives the process flexibility in the amount of contact allowed with free chlorine. This approach is particularly attractive because the demand for oxidation or primary disinfection can be provided by the free chlorine before it is converted to combined chlorine, which is a weaker oxidant and disinfectant.

Once free chlorine is converted to combined chlorine, THM production essentially stops because the free chlorine residual no longer exists. The amount of THM reduction achieved depends on the amount of free chlorine contact time eliminated through the conversion of free chlorine to chloramines. The amount of residence time in the distribution system is different for each plant, depending on the flowrate and the distance traveled in the distribution system. Examination of the data from studies by the Ohio River Valley Sanitation Commission (1979), Glaze and Rawley (1979), Young and Singer (1979), Singer et al. (1981), and Singer (1988) indicates that the typical portion of the total THMs formed in the distribution system averages about 35 percent. This estimate is conservative, as some systems have reduced their THM levels as much as 80 percent through the use of chloramines (Norman et al., 1980; Mitcham et al., 1983).

Chloramines are not as strong a disinfectant as free chlorine, causing some concern about their ability to maintain bacteriological quality in the finished water. Chloramines are not used in any of the water systems in North Carolina because of concerns by the Public Water Supply Branch about their ability to provide adequate protection of the distribution system. A minimum free chlorine residual in the distribution is currently required by the Public Water Supply Branch (Chen, 1988). However, the application of chloramines is currently under consideration for the Raleigh and Elizabeth City systems (Chen, 1988).

Although North Carolina has no operating experience with chloramines at the present time, their effectiveness for reducing THM concentrations while maintaining bacteriological quality has been demonstrated in systems across the country (Norman et al., 1980; Kreft et al., 1985; Dice, 1985; Singer, 1988). The successful application of chloramines has been demonstrated at the Metropolitan Water District of Southern California, which is one of the largest water utilities in the United States (Kreft et al., 1985), and at the Denver Water Department, where they have been used for over 70 years (Dice, 1985). Chloramines are able to provide adequate disinfection for the Metropolitan Water District of Southern California because of the unusually long contact time in the distribution system. However, this amount of contact time is not typical of most systems. The Denver Water Department credits its success with chloramines to careful study of the source water, quality control monitoring to recognize and respond to unusual conditions, and attention to system maintenance.

Although chloramines are not in use in North Carolina at the present time, the possibility of a lower MCL for THMs in the future suggests that they should be given strong consideration. In the event of a 50 µg/l or 25 µg/l THM standard, many of the state's water systems will require substantial reductions in their THM production. Since most of the systems with elevated THM concentrations have already stopped prechlorinating, pretreatment with chlorine dioxide or ozone is not likely to provide significant additional reductions in THM formation. The use of chloramines in conjunction with a strong primary disinfectant may be the most feasible technique for providing the degree of additional THM reduction required.

It must be emphasized that any changes in oxidation and disinfection practice must not jeopardize the ability of the system to provide good biological disinfection. This is especially true in light of the proposed surface water treatment rule and its more stringent requirements for disinfection (EPA, 1987). The proposed rule includes a requirement for removal or inactivation of 99.9 percent of Giardia cysts and 99.99 percent of enteric viruses. Minimum CT (concentration of disinfectant multiplied by contact time) values for each type of disinfectant are recommended by the rule. Because the recommended CT values for chloramines are very high, most systems will not provide enough contact time in their distribution system to achieve adequate disinfection using chloramines as the sole disinfectant. However, chloramines may still be applied as the secondary disinfectant, with primary disinfection accomplished with free chlorine, ozone or chlorine dioxide.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1) The Two-Year Mean TTHM concentration was computed for 61 of the 66 water systems in North Carolina which serve at least 10,000 persons. The THM records for the other five systems were either unavailable or insufficient to perform such a calculation. The values ranged from 314 µg/l in Elizabeth City to 2 µg/l for Laurinburg and Onslow County, with an average value of 64 µg/l. Only three of the systems had Two Year Means in excess of 100 µg/l, which is the current MCL. The majority of the systems, 38 of the 61 studied, had a Two-Year Mean TTHM concentration in the 40 to 80 µg/l range.

2) The majority of the 61 water systems studied used a surface supply as the source of raw water. Systems using surface water accounted for most of the systems with Two-Year Mean TTHM concentrations greater than 40 µg/l, while those systems with TTHM concentrations less than 40 µg/l were typically groundwater systems. The surface water systems studied had an average Two-Year Mean TTHM concentration of 65 µg/l, while the systems served by groundwater had an average TTHM concentration of 40 µg/l.

3) The THM records for 38 of the systems collected contained the concentration of each THM species making up the total THM measurement. The percentage of brominated species ranged from 91 percent at the United States Marine Corps - New River Air Station to 5 percent at Fort Bragg. Seventy percent of the systems reporting this

information had a percentage of brominated THM species of less than 26 percent, the average value for all 38 systems. All five of the systems with a brominated THM percentage of 50 or greater were systems served by groundwater, supporting the observations of others that bromide levels tend to be higher in groundwaters than in surface waters. The geographic distribution of the brominated THM percentages showed that the highest percentages occurred in groundwater systems located along the Atlantic coast of North Carolina, suggesting that these waters contain high levels of bromide as a result of intrusion by ocean water.

4) A geographic trend of increasing Two-Year Mean TTHM concentrations from west to east was observed. Several exceptions to this trend were systems served by groundwater, the quality of which is not expected to be affected by geography as dramatically as surface water. The lowest Two-Year Mean TTHM concentrations for systems served by surface water were found in the extreme western part of the state, indicating a high quality of surface water in that region.

5) The record of quarterly averages for many of the systems exhibited pronounced seasonal trends in THM levels. In most systems, the peak THM values occurred in the third quarter (July-August-September), with the lowest THM values occurring in the first quarter (January-February-March). These trends are believed to be a result of seasonal changes in temperature, which influence reaction kinetics, and precursor content in the water.

6) The water systems in North Carolina presently show limited use of alternative oxidants and disinfectants. Ozone or chlorine dioxide has been incorporated into the treatment process of only a few systems on a permanent basis. Because the implementation of alternative oxidants and disinfectants in these systems has occurred

only recently, there is not enough data to assess how effective they have been in reducing THM concentrations.

7) A revision of the MCL for THMs to 50 or 25 µg/l will have a significant impact on the water utilities of North Carolina. The magnitude of the impact will depend on how much the standard is lowered. A reduction of the MCL to 50 µg/l will make significant modifications necessary for more than half of the systems, based on their current Two-Year Mean TTHM concentrations. The degree of compliance with the current MCL among North Carolina systems is very high. To maintain a similar level of compliance with a 50 µg/l standard, some systems will require reductions in THM formation by as much as 50 percent. An MCL of 25 µg/l will affect virtually all of the systems in the state and require degrees of THM reduction much higher than 50 percent to achieve a level of compliance comparable to the current level.

Recommendations

1) Because of the likelihood of a lower MCL for THMs in the coming years and the promulgation of MCLs for other disinfection by-products, it is recommended that each water system in the state begin planning a strategy for reducing THM formation. In situations where it is feasible, this should include pilot-scale and full-scale experimentation with methods of THM control.

2) The use of chlorine dioxide and ozone should be investigated further in systems across the state to determine their effectiveness for reducing THM levels.

3) Since some systems which have already moved their point of chlorination to reduce THM formation will require additional reductions of 50 percent or more in order to comply with a 50 µg/l or 25 µg/l MCL, the use of chloramines as a method of controlling THM formation in the state should be given strong consideration. The

application of chloramines should be studied in systems across the state to determine their effectiveness in reducing THMs concentrations, while still maintaining satisfactory degrees of disinfection. This will involve the conjunctive use of chloramines as a secondary disinfectant, with free chlorine, ozone, or chlorine dioxide as a primary disinfectant.

4) The MCL for THMs should not be lowered to 25 µg/l because it would require, in many cases, degrees of THM reduction which are beyond the cabilities of current technology.

5) Consideration should also be given to statewide monitoring of total organic carbon (TOC) concentrations in the raw water supplies used by the water utilities. As a measure of precursor content, TOC measurements could be used to evaluate the relationship between raw water quality and THM formation.

6) The point of chlorine addition should be clearly indicated on the montly operating reports submitted to the Public Water Supply Branch by each water system. Under the current system, "pre-chlorination" is used to by some utilities in reference to chlorine applied in pre-treatment, while other utilities use the term in reference to chlorine applied prior to filtration.

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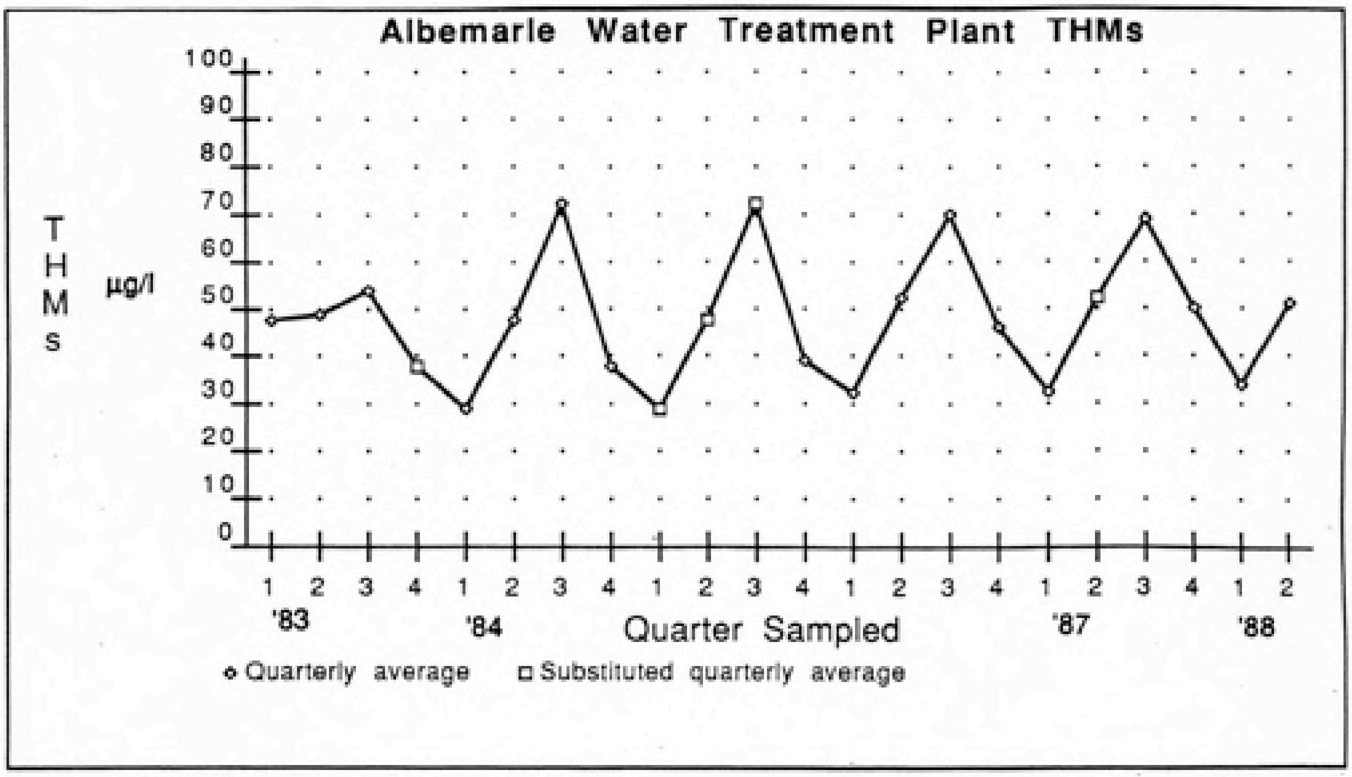
APPENDIX A

THM RECORDS FOR NORTH CAROLINA WATER SYSTEMS


Albemarle Water Treatment Plant THMs
100
90
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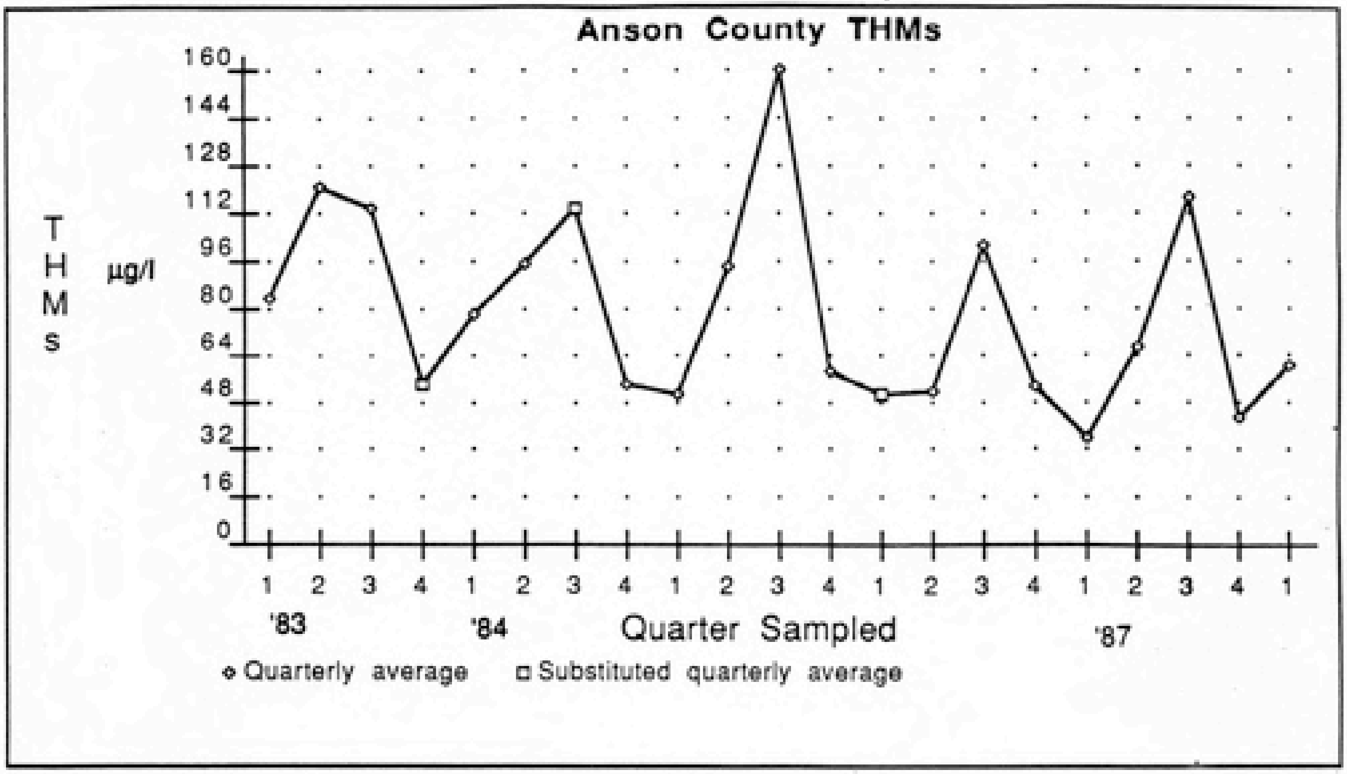
THMs
µg/l
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'83
'84
Quarter Sampled
'87
'88
Quarterly average
Substituted quarterly average

Plant: Albemarle			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0184010						
Population Served: 17500						
			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
05/10/88		51	51		51	
02/11/88		34	34		34	
12/08/87		41	41			
10/20/87		60	60		50	
07/06/87		69	69		69	
03/02/87		32	32		32	
11/21/86		46	46		46	
08/13/86		70	70		70	
05/16/86		52	52		52	
02/26/86		32	32		32	
12/23/85		39	39		39	
12/20/84		34				
"		41				
"		43				
"		30				
"		43	38		38	
07/25/84		70				
"		72				
"		73				
"		73	72		72	
04/27/84		48				
"		46				
"		54				
"		46	48		48	

Albemarle THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
01/04/84		29				
"		30				
"		28				
"		29	29		29	
09/27/83		53				
"		62				
"		57				
"		44	54		54	
06/22/83	Ω	65				
"		47				
"		53				
"		48	53	49	49	Σ
03/09/83		45				
"		44				
"		48				
"		44	45			
01/11/83		60				
"		53				
"		52				
"		40	51		48	

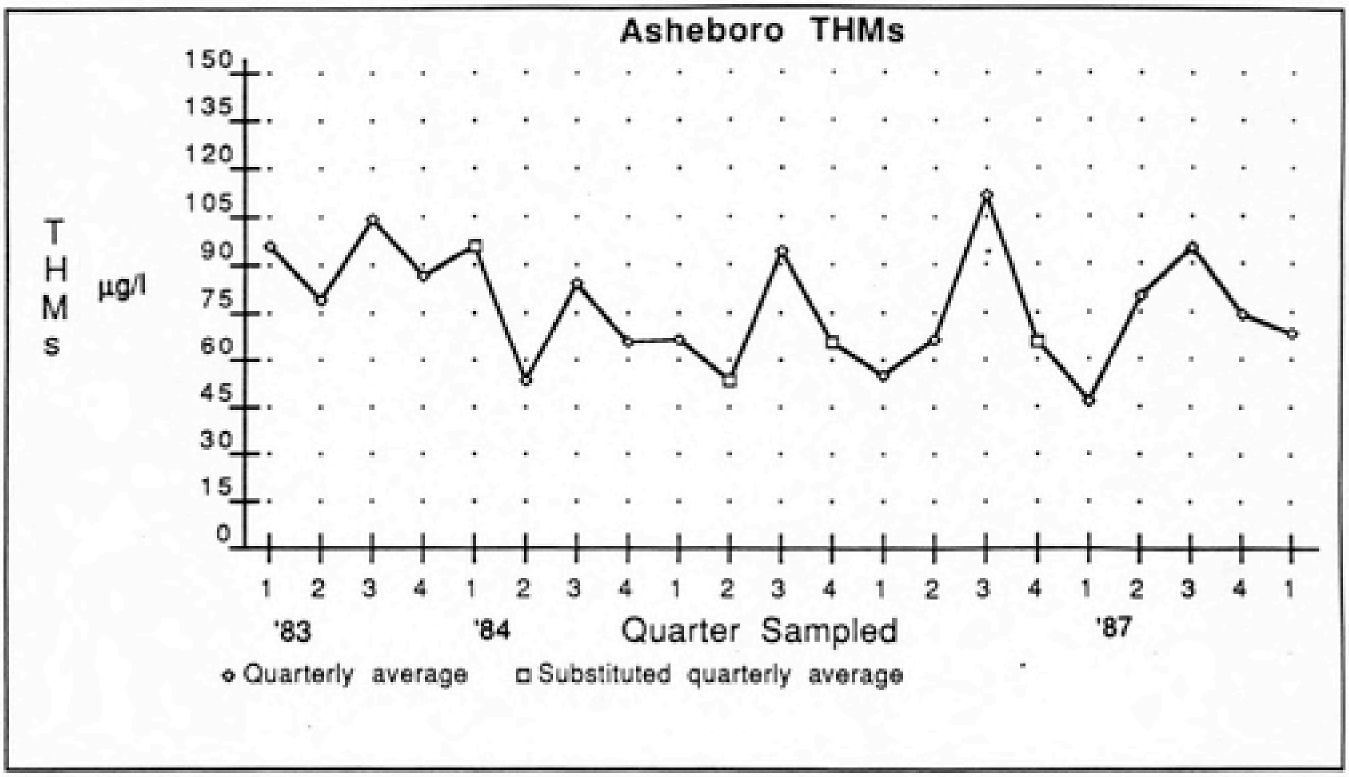

Anson County THMs
160
144
128
112
96
80
64
48
32
16
0
THMs
µg/l
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
Quarter Sampled
'87
◇ Quarterly average
□ Substituted quarterly average

Plant: Anson County			Ω-measurement discarded for adjusted average calculation		
			Σ-some measurements(Ω) discarded before calculating average		
PWID: 0304010					
Population Served: 28000					
			Unadjusted	Adjusted	Quarterly
Date of		TTHM's	Average Reading	Average Reading	Average Reading
Sampling		µg/l	µg/l	µg/l	µg/l
03/31/88		51			
"		64			
"		53			
"		74	60		60
12/18/87		27			
"		26			
"		63			
"		57	43		43
09/11/87		92			
"		133			
"		114			
"		128	117		117
06/18/87		68			
"		93			
"		38			
"		68	67		67
03/19/87		36			
"		28			
"		49			
"		33	36		36
11/13/86		34			
"		82			
"		51			
"		44	53		53
09/09/86		138			
"		81			
"		111			
"		74	101		101
05/28/86		63			
"		61			
"		88			
"		40	63		

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
04/07/86		53				
"		31				
"		45				
"		33	40		52	
12/02/85		79				
"		38				
"		57				
"		63	59		59	
09/06/85		182				
"		180				
"		156				
"		121	160		160	
06/14/85		98				
"		92				
"		78				
"		108	94		94	
03/29/85		68				
"		41				
"		49				
"		45	51		51	
12/21/84		30				
"		54				
"		34				
"		58	44			
10/04/84		77				
"	Ω	134				
"		73				
"	Ω	123	102	75	54	Σ
06/22/84		100				
"		77				
"		87				
"		116	95		95	
03/27/84		76				
"		65				
"		104				
"		66	78		78	

Anson County THM Records

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
09/08/83	102			
"	127			
"	104			
"	122	114		114
05/17/83	126			
"	119			
"	107			
"	131	121		121
03/01/83	106			
"	82			
"	75			
"	85	87		
01/11/83	94			
"	86			
"	69			
"	77	81		84


Asheboro THMs
THMs µg/l
150
135
120
105
90
75
60
45
30
15
0
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
Quarter Sampled
'87
Quarterly average
Substituted quarterly average

Plant: Asheboro

Ω-measurement discarded for adjusted average calculation

Σ-some measurements(Ω) discarded before calculating average

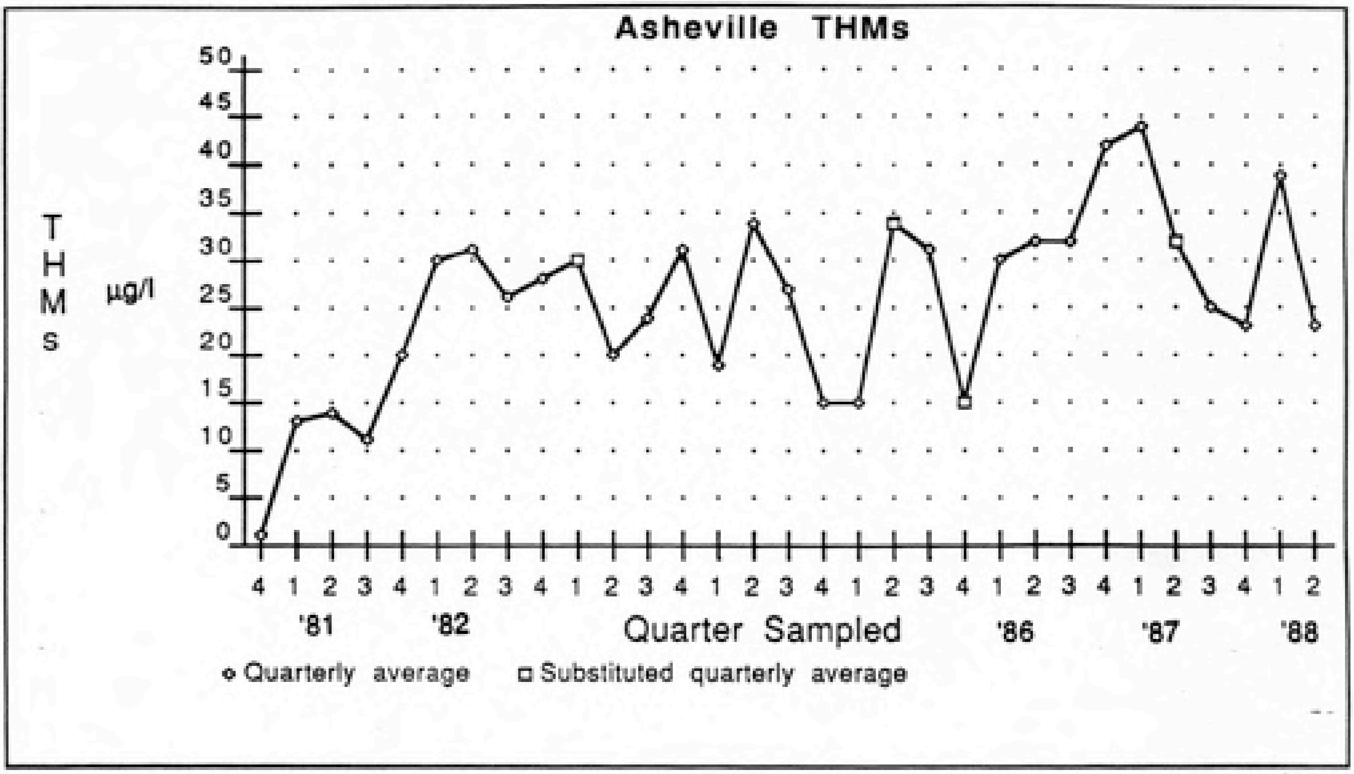
PWID: 0276010

Population Served: 20000

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
03/23/88		68	68		68
12/22/87		74	74		74
09/23/87		95	95		95
06/23/87		80	80		80
03/12/87		47	47		47
08/07/86		110			
"		110			
"		117	112		112
04/09/86		67	67		67
01/19/86		46	46		
01/08/86		64	64		55
09/26/85		86	86		
08/08/85		103	103		
07/24/85	Ω	2	2		94
03/26/85		67	67		67
12/13/84		66	66		66
09/19/84		89			
"		77			
"		73			
"		98	84		84
05/25/84		53			
"		50			
"		51			
"		66	55		

Asheboro THM Records

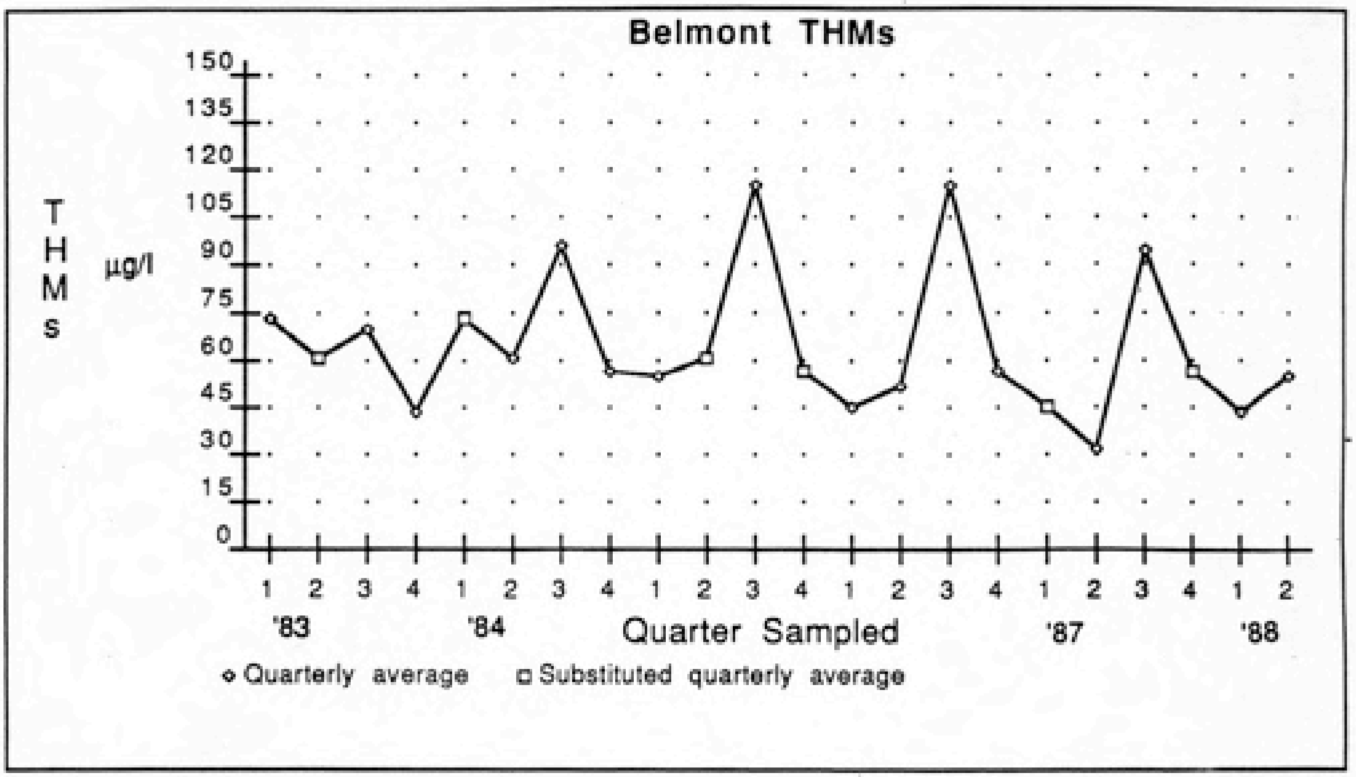
Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
04/03/84	45			
"	46			
"	46			
"	67	51		53
12/27/83	100			
"	70			
"	89			
"	88	87		87
08/12/83	111			
"	101			
"	101			
"	104	104		104
06/24/83	75			
"	75			
"	84			
"	84	79		79
03/10/83	104			
"	88			
"	95	96		96


Asheville THMs
T H M s µg/l
50
45
40
35
30
25
20
15
10
5
0
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'81
'82
Quarter Sampled
'86
'87
'88
◇ Quarterly average
□ Substituted quarterly average

Plant: Asheville		Ω-measurement discarded for adjusted average calculation		
		Σ-some measurements(Ω) discarded before calculating average		
PWID: 0111010				
Population Served: 114900				
		Unadjusted	Adjusted	Quarterly
Date of Sampling	TTHM's µg/l	Average Reading µg/l	Average Reading µg/l	Average Reading µg/l
04/07/88	23	23		23
1/11/88	39	39		39
10/19/87	23	23		23
07/23/87	25	25		25
03/27/87	38	38		
01/29/87	50	50		44
12/22/86	42	42		42
09/18/86	31	31		
07/08/86	33			
07/07/86	33	33		32
04/03/86	32	32		32
03/20/86	32	32		
01/02/86	28	28		30
09/25/85	28	28		
07/01/85	34	34		31
03/13/85	15	15		15
12/10/84	15	15		15
09/24/84	27	27		27
06/28/84	34	34		34
03/06/84	19	19		19
12/14/83	31	31		31

Asheville THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
09/26/83		28	28			
07/21/83		20	20		24	
04/11/83		20	20		20	
12/22/82		28	28		28	
09/14/82		26	26		26	
06/09/82		31	31		31	
02/20/82		30				
"		30	30		30	
11/25/81		31				
"		18				
"		16				
"		16	20		20	
08/06/81		21				
"		9				
"		9				
"		6	11		11	
05/05/81		16				
"		14				
"		14				
"		11	14		14	
02/06/81		30				
"		9				
"		5				
"		7				
"	Ω	30				
"	Ω	9				
"	Ω	5				
"	Ω	7	13	13	13	Σ
10/30/80		1				
"		1				
"		1				
"		1	1		1	


Belmont THMs
THMs µg/l
150
135
120
105
90
75
60
45
30
15
0
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'83
'84
Quarter Sampled
'87
'88
◇ Quarterly average
□ Substituted quarterly average

Plant: Belmont

Ω-measurement discarded for adjusted average calculation

Σ-some measurements(Ω) discarded before calculating average

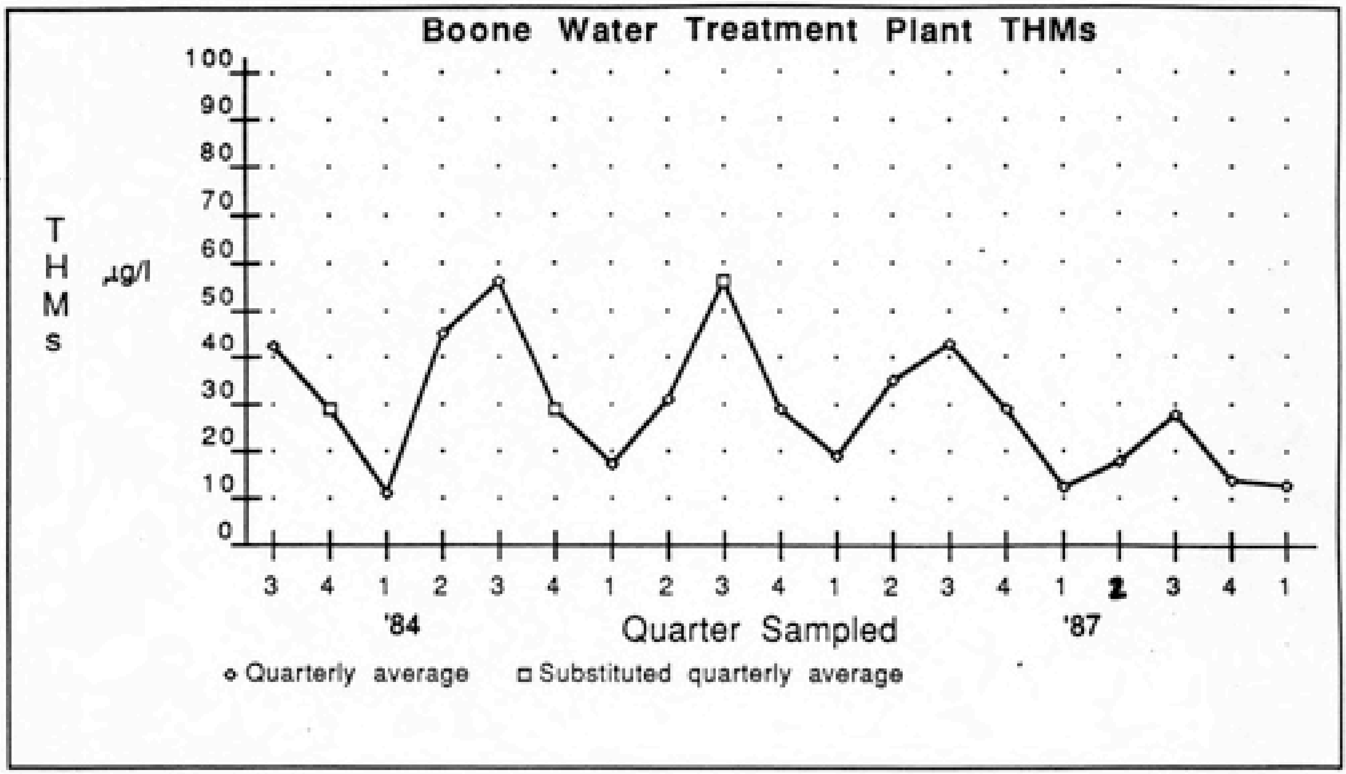
PWID: 0136015

Population Served: 15100

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
04/14/88		62				
"		50				
"		63				
"		47	55		55	
01/11/88		33				
"		55				
"		35				
"		49	43		43	
09/25/87		102				
"		65				
"		92				
"		64	81			
07/01/87		114				
"		127				
"		106				
"		85	108		94	
04/16/87		33				
"		28				
"		40				
"		25	32		32	
12/31/86		34				
"		39				
"		35				
"		27	34			
10/09/86		64				
"		98				
"	Ω	128				
"		103	98	88	57	Σ
08/26/86		104				
"		83				
"		158				
"		117	115		115	

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
04/11/86		42				
"		52				
"		63				
"		50	52		52	
01/10/86		29				
"		47				
"		54				
"		49	45		45	
09/23/85		63				
"		88				
"		101				
"		92	86			
07/02/85		125				
"		149				
"		150				
"		153	144		115	
03/15/85		58				
"		61				
"		57				
"		43	55		55	
12/11/84		50				
"		49				
"		65				
"		63	57		57	
09/12/84		93				
"		78				
"		100				
"		113	96		96	
06/20/84		88				
"		95				
"	Ω	117				
"	Ω	111	103	91		

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
04/02/84		42				
"		63				
"		64				
"		43				
"		42				
"		43				
"		64				
"		63	53		61	Σ
12/30/83		32	32			
12/20/83		36				
"		54				
"		52	47		43	
09/23/83	Ω	15				
"		71				
"		70				
"		70	56	70	70	Σ
03/29/83		64				
"		85				
"		79				
"		64	73		73	



Boone Water Treatment Plant THMs
THMs µg/l
100
90
80
70
60
50
40
30
20
10
0
3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'84
Quarter Sampled
'87
o Quarterly average
□ Substituted quarterly average

Boone Water Treatment Plant THM Records

Plant: Boone

Ω-measurement discarded for adjusted average calculation

Σ-some measurements(Ω) discarded before calculating average

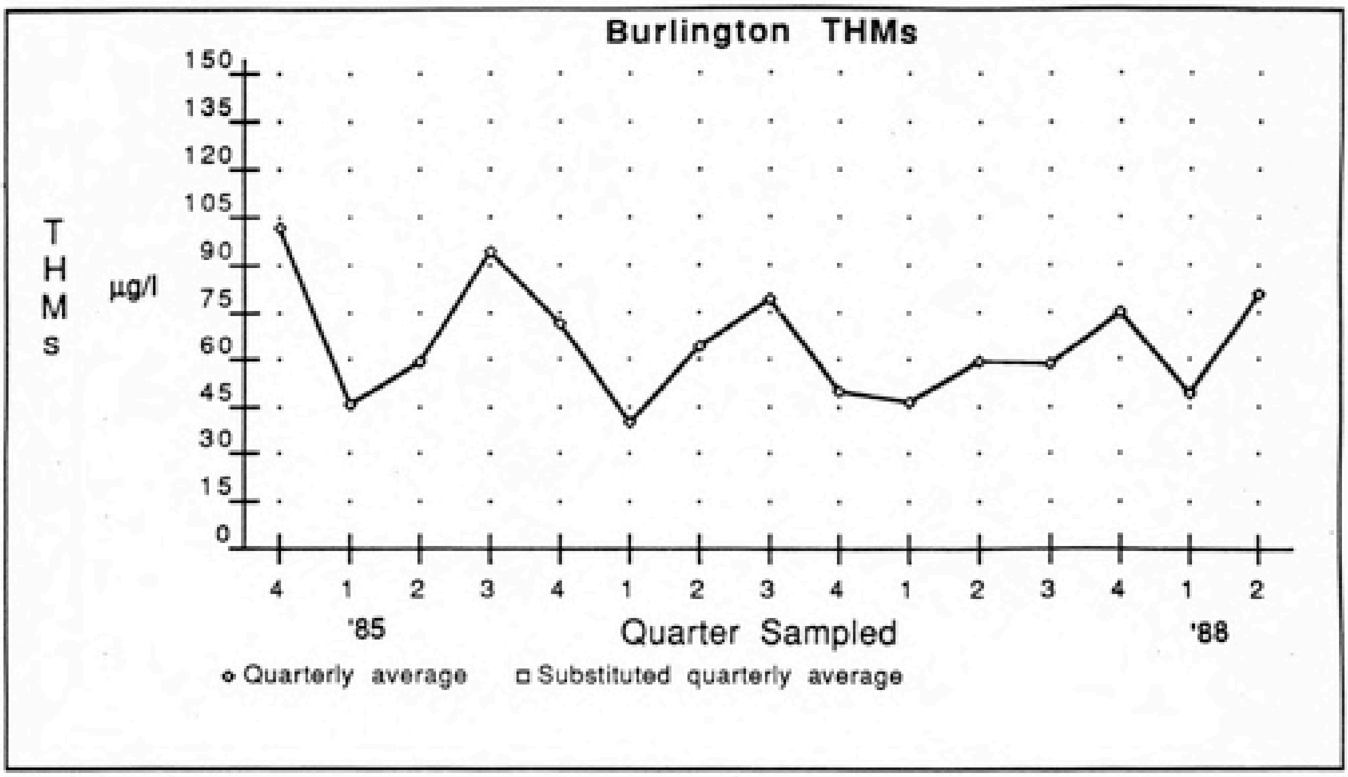
PWID: 0195010

Population Served: 13250

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
03/22/88	13	13		13
11/24/87	14	14		14
08/26/87	28	28		28
06/11/87	18	18		18
03/18/87	12	12		12
10/30/86	29	29		29
08/14/86	43	43		43
05/21/86	35	35		35
03/18/86	19	19		19
10/11/85	29	29		29
06/13/85	48	48		
04/12/85	14	14		31
02/25/85	17	17		17
08/01/84	53			
"	55			
"	54			
"	62	56		56
05/22/84	32			
"	49			
"	51			
"	48	45		45
01/10/84	12			
"	11			
"	12			
"	10	11		11

Boone Water Treatment Plant THM Records

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
07/22/83	43			
"	40			
"	40			
"	47	42		42


Burlington THMs
150
135
120
105
90
75
60
45
30
15
0
THMs
µg/l
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'85
Quarter Sampled
'88
Quarterly average
Substituted quarterly average

Plant: City of Burlington		Ω-measurement discarded for adjusted average calculation		
		Σ-some measurements(Ω) discarded before calculating average		
PWID: 0201010				
Population Served: 38145				
Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
05/12/88	75			
"	94			
"	83			
"	70			
"	83			
"	92			
"	88			
"	83	83		
04/22/88	69			
"	69	69		81
02/12/88	40			
"	48			
"	47			
"	45			
"	47			
"	61			
"	48			
"	55	49		49
10/20/87	67			
"	66			
"	77			
"	69			
"	80			
"	98			
"	69			
"	77	75		75
07/15/87	55			
"	53			
"	79			
"	51			
"	63			
"	51			
"	53			
"	62	58		58

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
04/27/87		53				
"		47				
"		70				
"		58				
"		58				
"		67				
"		64				
"		63	60			
04/24/87		53	53		59	
02/12/87		43				
"		41				
"		43				
"		36				
"		50				
"		34				
"		42				
"		40				
"		41	47		47	
10/17/86		51				
"		52				
"		38				
"		50				
"		56				
"		52				
"		52				
"		52	50		50	
07/23/86		84				
"		83				
"		80				
"		80				
"		60				
"		88				
"		79				
"		82	79		79	
05/05/86		59				
"		60				
"		63				
"		50	58			

Burlington THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
05/02/86		62				
"		81				
"		64				
"		72	70		64	
02/20/86		31				
"		41				
"		36				
"		44				
"		44				
"		44				
"		40				
"		41	40		40	
11/15/85		74				
"		85				
"		67				
"		82				
"		62				
"		67				
"		69				
"		72	72		72	
08/06/85		81				
"		103				
"		71				
"		89				
"		122				
"		108				
"	Ω	139				
"		84	100	94	94	Σ
04/30/85		61				
"		60				
"		46				
"		63				
"		61				
"		70				
"		57				
"		57	59		59	

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/21/85		38				
"		45				
"		48				
"		46				
"		37				
"	Ω	69				
"		51				
"		55				
"	Ω	38				
"	Ω	45				
"	Ω	48				
"	Ω	46				
"	Ω	37				
"	Ω	69				
"	Ω	51				
"	Ω	55	49	46	46	Σ
12/17/84		69				
"		52	60			
11/16/84	Ω	132				
"		108				
"		115				
"		124				
"		122				
"		123	121	118	102	Σ

Plant: Cape Fear Water Co.			Ω-measurement discarded for adjusted average calculation		
			Σ-some measurements(Ω) discarded before calculating average		
PWID: 0465107					
Population Served: 13584					
			Unadjusted	Adjusted	Quarterly
Date of		TTHM's	Average Reading	Average Reading	Average Reading
Sampling		µg/l	µg/l	µg/l	µg/l
01/11/88	Ω	16			
"	Ω	19			
"	Ω	58			
"	Ω	20	28		
01/04/88		16			
"		19			
"		58			
"		20	28		28
10/15/87	Ω	94			
"	Ω	80			
"	Ω	28			
"	Ω	16	54		
10/08/87		94			
"		80			
"		28			
"		16	54		54
06/01/87	Ω	9			
"	Ω	79			
"	Ω	12			
"	Ω	59	40		
05/29/87		9			
"		79			
"		12			
"		59	40		40

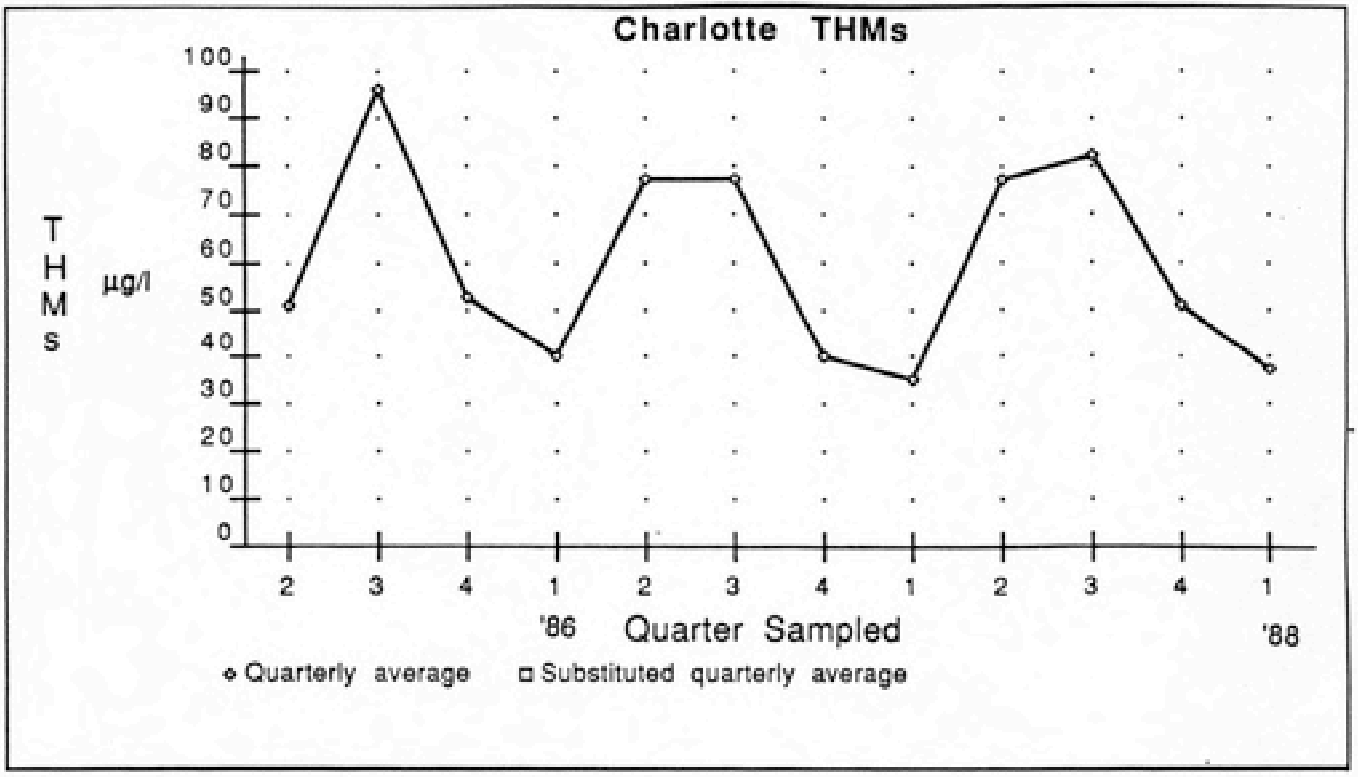
Plant: Town of Cary			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0392020						
Population Served: 41876						
			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
03/01/88		48				
"		49				
"		55				
"		48				
"		65				
"		66				
"		69				
"		58				
"		86				
"		65				
"		64				
"		63				
"		105				
"		88				
"		66				
"		64				
"		75				
"		91				
"		68				
"		65	68		68	

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
07/13/87		136				
"		194				
"		151				
"		158				
"		169				
"		149				
"		128				
"		149				
"		151				
"		128				
"		149				
"		171				
"		176				
"		139				
"		147				
"		136				
"		171				
"		171				
"		150				
"		162				
"		184				
"		165				
"		154				
"		174				
"		161				
"		172				
"	Ω	20				
"		181				
"		148				
"		146				
"		142				
"		91	151	155		

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
07/08/87		105				
"		128				
"		119				
"		116				
"		133				
"		115				
"		100				
"		119				
"		135				
"		103				
"		141				
"		135				
"		129				
"		85				
"		126				
"		66				
"		124				
"		112				
"		135				
"		132				
"		115				
"		128				
"		102				
"		136				
"		107				
"	Ω	55				
"		137				
"		112				
"		84				
"		83				
"		108				
"		117	114	116	135	Σ

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/24/87		104				
"		115				
"		111				
"		106				
"		72				
"		107				
"		153				
"		135				
"		151				
"		86				
"		128				
"		117				
"		120				
"		34				
"		81				
"		60				
"		123				
"		88				
"		90				
"		40				
"		94				
"		92				
"		125				
"		116				
"		112				
"		119				
"		124				
"		124				
"		125				
"		83				
"	Ω	5				
"		49	100	103	103	Σ

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
12/31/86		93				
"		104				
"		109				
"		103				
"		61				
"		54				
"		37				
"		37				
"		38				
"		33				
"		46				
"		67				
"		65				
"		25				
"		36				
"		41				
"		30				
"		103				
"		66				
"		79				
"		25				
"		60				
"		76				
"		63				
"		75				
"		83				
"		78				
"		39				
"		70				
"		78				
"		87	63		63	


Charlotte THMs
100
90
80
70
60
50
40
30
20
10
0
THMs µg/l
2 3 4 1 2 3 4 1 2 3 4 1
'86 Quarter Sampled '88
Quarterly average
Substituted quarterly average

Plant: Charlotte

Ω-measurement discarded for adjusted average calculation

Σ-some measurements(Ω) discarded before calculating average

PWID: 0160010

Population Served: 340000

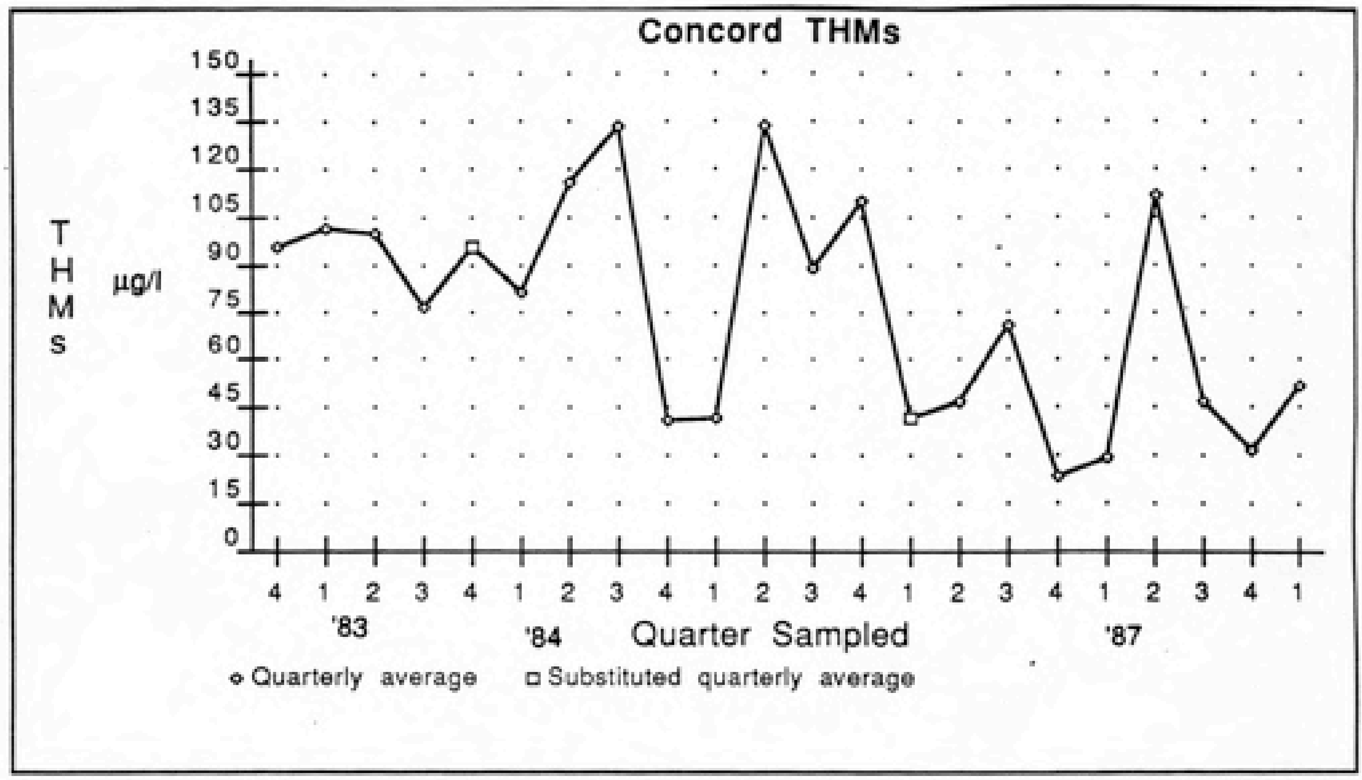
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/26/88		39				
"		35				
"		35				
"		41				
"		38				
"		37				
"		37				
"		37	37		37	
11/23/87		51				
"		48				
"		66				
"		57				
"		50				
"		45				
"		46				
"		46	51		51	
09/23/87	Ω	86				
"	Ω	88				
"	Ω	76				
"	Ω	79				
"	Ω	87				
"	Ω	80				
"	Ω	74				
"	Ω	87				
"	Ω	86	82			
09/14/87		88				
"		76				
"		79				
"		87				
"		80				
"		74				
"		87				
"		86	82		82	Σ

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
06/01/87	Ω	82				
"	Ω	65				
"	Ω	70				
"	Ω	88				
"	Ω	84				
"	Ω	70				
"	Ω	78				
"	Ω	78	77			
05/29/87		82				
"		65				
"		70				
"		88				
"		84				
"		70				
"		78				
"		78				
"	Ω	36	72	77	77	Σ
03/06/87	Ω	31				
"	Ω	39				
"	Ω	35				
"	Ω	36				
"	Ω	40				
"	Ω	35				
"	Ω	32				
"	Ω	34	35			
03/05/87		34				
"		32				
"		31				
"		39				
"		35				
"		36				
"		40				
"		35	35		35	Σ

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
12/04/86	Ω	30				
"	Ω	29				
"	Ω	45				
"	Ω	33				
"	Ω	34				
"	Ω	54				
"		37				
"	Ω	30				
"	Ω	29				
"		45				
"		40				
"		33				
"		34				
"		54	38	40	40	Σ
09/04/86	Ω	81				
"	Ω	72				
"	Ω	76				
"	Ω	93				
"	Ω	80				
"	Ω	67				
"	Ω	71				
"	Ω	74	77			
08/29/86		81				
"		72				
"		76				
"		93				
"		80				
"		67				
"		71				
"		74	77		77	Σ
05/29/86		78				
"		85				
"		69				
"		76				
"		78				
"		62				
"		77				
"		88	77		77	

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/26/86		43				
"		38				
"		35				
"		39				
"	Ω	49				
"		40				
"	Ω	21				
"		42	38	40	40	Σ
12/16/85		51				
"		59				
"		49				
"		50				
"		54				
"		52				
"		52				
"		51	52			
11/20/84		46				
"		46				
"		46				
"		57				
"		58				
"		51				
"		65				
"		59	53		53	
08/09/84		99				
"		101				
"		84				
"		96				
"		102				
"		90				
"		100				
"		93	96		96	

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
05/08/84	62			
"	58			
"	61			
"	66			
"	75			
"	49			
"	47			
"	48			
"	33			
"	31			
"	31	51		51


Concord THMs
THMS µg/l
150
135
120
105
90
75
60
45
30
15
0
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
Quarter Sampled
'87
Quarterly average
Substituted quarterly average

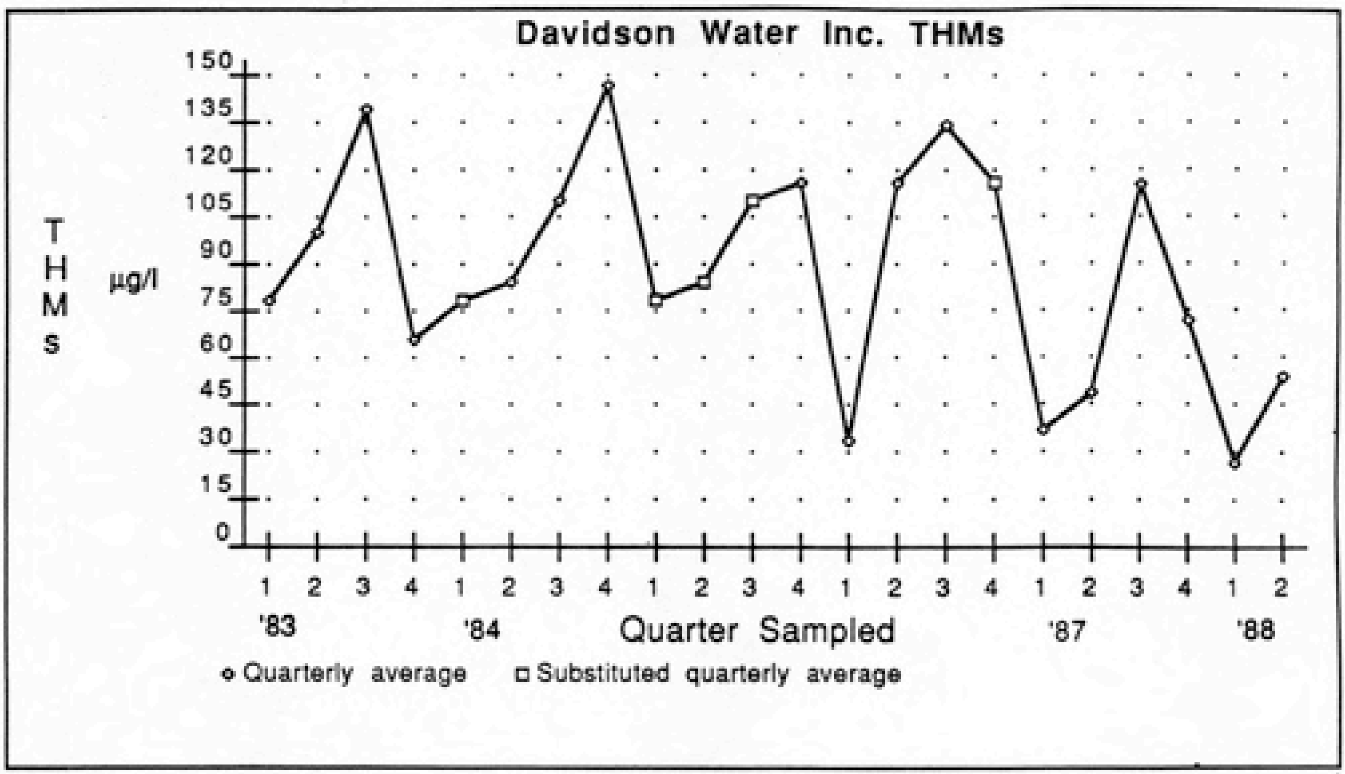
Plant: Concord			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0113010						
Population Served: 16000						
			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
03/14/88		51				
"		54				
"		50				
"		54	52		52	
12/16/87		28				
"		33				
"		27				
"		41	32		32	
09/11/87		34				
"		58				
"		34				
"		64	47		47	
06/19/87		118				
"		124				
"		104				
"		103	112		112	
03/20/87		25				
"		32				
"	Ω	2				
"		30	22	29	29	Σ
12/10/86		21				
"		24				
"		24				
"		22	23		23	
09/15/86		46				
"		70				
"		65				
"		104	71		71	
06/06/86		50				
"		50				
"		47				
"		57	51			

Concord THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
04/07/86		41				
"		43				
"		46				
"		40	42		47	
12/02/85		115				
"		109				
"		94				
"		121	110		110	
09/10/85		74				
"		95				
"		95				
"		94	89		89	
06/12/85		118				
"		134				
"		135				
"		144	133		133	
03/18/85		26				
"		33				
"		28				
"		82	42		42	
12/04/84		41				
"		42				
"		38				
"		44	41		41	
09/05/84		136				
"		141				
"		122	133		133	
06/12/84		114				
"		117				
"	Ω	18				
"		118	92	116	116	Σ
03/15/84		75				
"		83				
"		88				
"		84	82		82	

Concord THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
07/26/83		83				
"		73				
"		68				
"		84	77		77	
04/22/83		88				
"		98				
"		95				
"		121	100		100	
02/10/83		84				
"		124				
"		109				
"		91	102		102	
12/14/82		89				
"		107				
"		107				
"		82	96		96	


Davidson Water Inc. THMs
150
135
120
105
90
75
60
45
30
15
0
THMs
µg/l
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'83
'84
Quarter Sampled
'87
'88
Quarterly average
Substituted quarterly average

Plant: Davidson Water Inc.

Ω-measurement discarded for adjusted average calculation

Σ-some measurements(Ω) discarded before calculating average

PWID: 0229025

Population Served: 79984

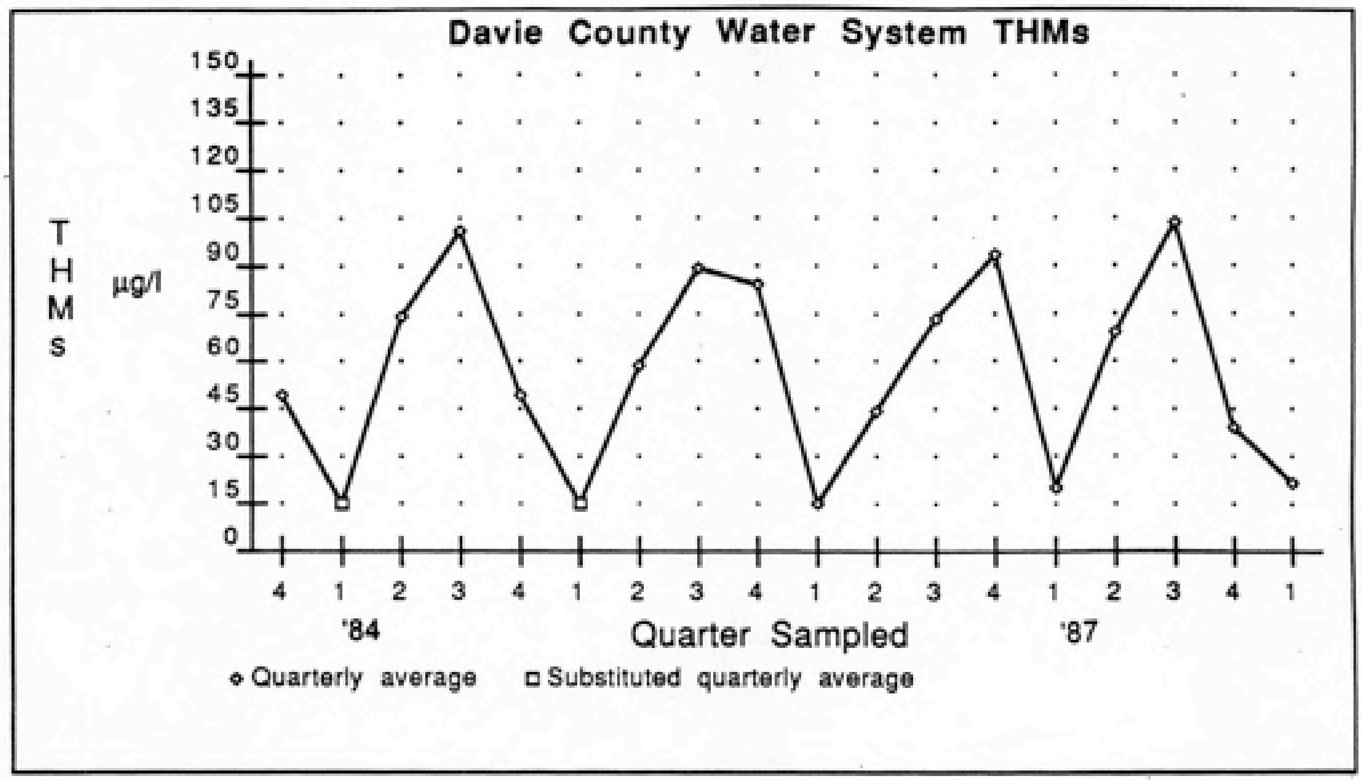
Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
04/12/88	53			
"	57			
"	54			
"	48	53		53
01/21/88	24			
"	31			
"	29			
"	25	27		27
11/17/87	76			
"	72			
"	66			
"	73	72		72
08/24/87	102			
"	118			
"	117			
"	125	115		115
04/24/87	61			
"	53			
"	55			
"	59	57		
04/01/87	34			
"	38			
"	42			
"	45	40		48
01/14/87	29			
"	35			
"	38			
"	46	37		37
09/30/86	130			
"	119			
"	127			
"	161	134		134

Davidson Water Inc. THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
06/13/86		106				
"		134				
"		111				
"		114	116		116	
03/18/86		39				
"		43				
"		48				
"		39	42			
01/08/86		30				
"		26				
"		24				
"		19	25		33	
10/01/85		84				
"		128				
"		134				
"		119	116		116	
11/01/84		138				
"		163				
"		142				
"		145	147		147	
08/23/84		103				
"		121				
"		108				
"		108	110		110	
05/18/84		87				
"		84				
"		81				
"		83	84		84	
12/21/83		69				
"		69				
"		64				
"		64	66		66	
09/21/83		115				
"		148				
"		141				
"		151	139		139	

Davidson Water Inc. THM Records

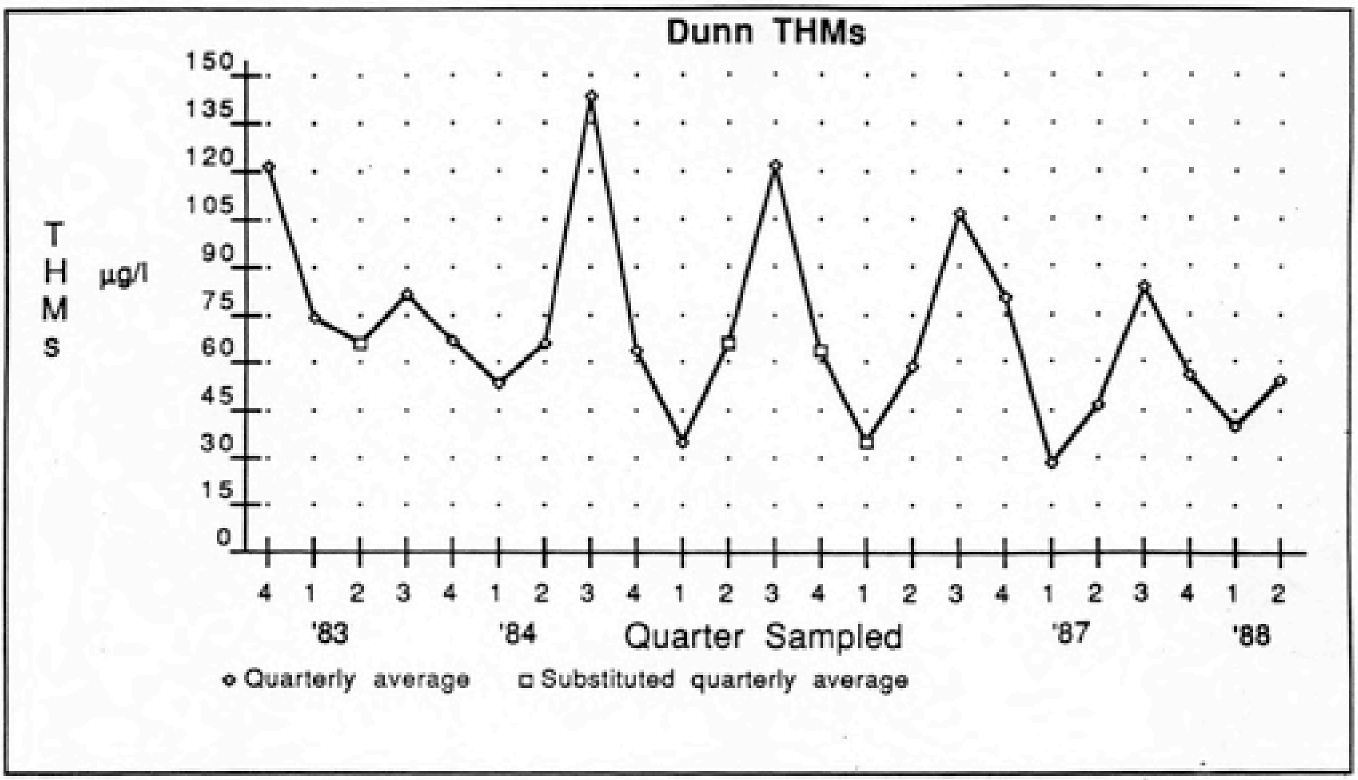
			Unadjusted	Adjusted	Quarterly	
Date of Sampling		TTHM's µg/l	Average Reading µg/l	Average Reading µg/l	Average Reading µg/l	
05/06/83		105				
"		103				
"		97				
"		94	100		100	
03/02/83		87				
"		78				
"		93				
"		83	85			
01/03/83		79				
"		60				
"		73				
"		68	70		78	


Davie County Water System THMs
150
135
120
105
90
75
60
45
30
15
0
THMs
µg/l
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'84
Quarter Sampled
'87
Quarterly average
Substituted quarterly average

Plant: Davie County			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0230015						
Population Served: 12843						
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
01/26/88		26				
"		26				
"		23				
"		15	22		22	
12/17/87		33				
"		54				
"		35				
"		36	39		39	
09/16/87		112				
"		93				
"	Ω	153				
"		105	116	103	103	Σ
06/19/87		78				
"		62				
"		66				
"		72	69		69	
02/25/87		17				
"		19				
"		25				
"		20	20		20	
11/13/86		90				
"		100				
"		97				
"		86	93		93	
09/19/86		79				
"		79				
"		48				
"		86	73		73	
06/18/86		44				
"		43				
"		45				
"		45	44		44	

Davie County THM Records

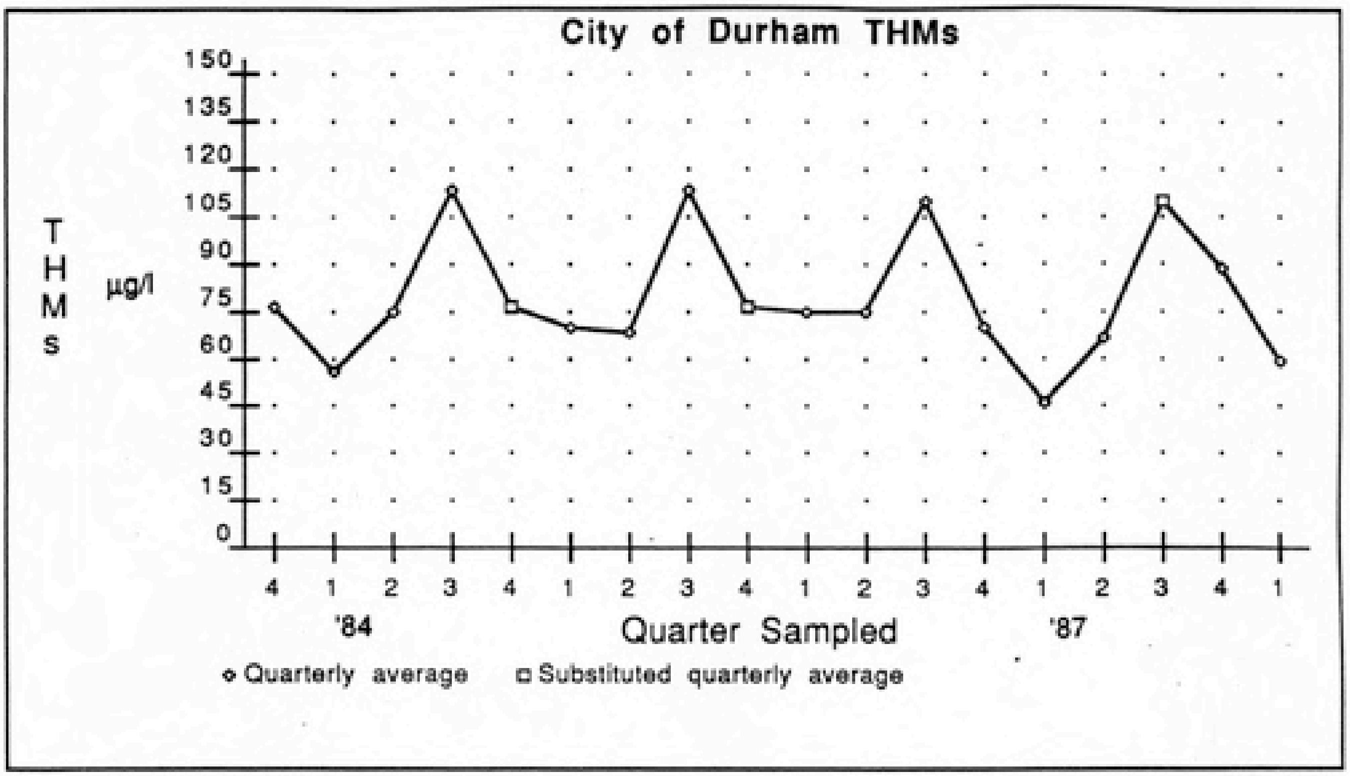
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
01/17/86		15				
"		13				
"		15				
"		16	15		15	
10/16/85		82				
"		89				
"		79				
"		86	84		84	
07/17/85		83				
"		89				
"		86				
"		97	89		89	
05/10/85		55	55			
04/17/85		60				
"		60				
"		52				
"		63	59		58	
12/19/84		48				
"		51				
"	Ω	48				
"	Ω	51	49	49	49	Σ
08/08/84		69				
"		116				
"		119	101		101	
05/09/84		68				
"		64				
"		85				
"		80	74		74	
12/29/83		26				
"		30				
"		84				
"		55	49		49	


Dunn THMs
THMs µg/l
150
135
120
105
90
75
60
45
30
15
0
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'83
'84
Quarter Sampled
'87
'88
Quarterly average
Substituted quarterly average

Plant: Dunn		Ω-measurement discarded for adjusted average calculation		
		∑-some measurements(Ω) discarded before calculating average		
PWID: 0343010				
Population Served:				
Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
05/27/88	65			
"	47			
"	62			
"	44	54		54
02/29/88	26			
"	53			
"	40			
"	42			
"	38	40		40
12/02/87	41			
"	71			
"	60			
"	51	56		56
08/31/87	92			
"	66			
"	91			
"	81	83		83
05/29/87	13			
"	59			
"	40			
"	77	47		47
02/19/87	8			
"	17			
"	29			
"	27	20		
01/22/87	58	58		28
11/19/86	15			
"	85			
"	166			
"	55	80		80

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
08/13/86	125			
"	130			
"	25			
"	148	107		107
05/08/86	16			
"	47			
"	95			
"	74	58		58
08/15/85	41			
"	142			
"	143			
"	162	122		122
02/18/85	10			
"	46			
"	45			
"	40	35		35
11/14/84	16			
"	82			
"	58			
"	96	63		63
08/09/84	52			
"	168			
"	201			
"	150	143		143
05/11/84	80			
"	89			
"	67			
"	28	66		66
02/14/84	110			
"	15			
"	72			
"	16	53		53
11/28/83	78			
"	92			
"	71			
"	26	67		67

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
08/29/83		132				
"		41				
"		134				
"		19	82		82	
03/01/83		43				
"		80				
"		109				
"		63	74		74	
11/22/82		93				
"		122				
"		125				
"		147	122		122	


City of Durham THMs
150
135
120
105
90
75
60
45
30
15
0
THMs
µg/l
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'84
Quarter Sampled
'87
Quarterly average
Substituted quarterly average

City of Durham THM Records

Plant: City of Durham

Ω-measurement discarded for adjusted average calculation

Σ-some measurements(Ω) discarded before calculating average

PWID: 0332010

Population Served: 147000

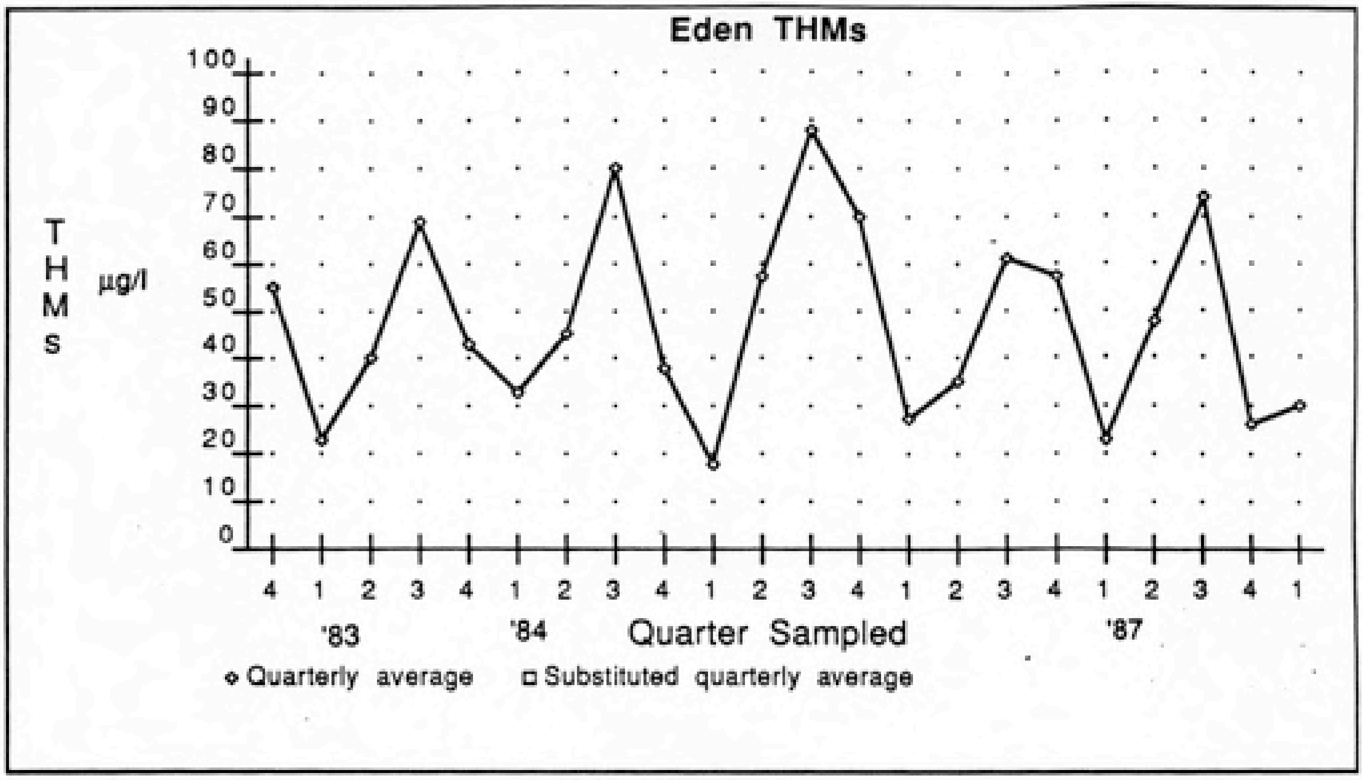
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
03/23/88		49				
"		52				
"		67				
"		57				
"		68				
"		72				
"		56				
"		50	59			
01/07/88	Ω	121	121		59	Σ
12/07/87		97				
"		56				
"		94				
"		48				
"	Ω	140				
"		121				
"		82				
"		112	94	87		
10/01/87		114				
"		69				
"		103				
"		79				
"		102				
"		89				
"		81				
"		80	90		88	Σ
04/14/87		56				
"		58				
"		82				
"		67				
"		76				
"		89				
"		61				
"		49	67		67	

City of Durham THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/11/87		44				
"		35				
"		61				
"		38				
"		73				
"		41				
"		41				
"		32	46		46	
12/23/86		66				
"		69				
"		71				
"		75				
"		68				
"		69				
"		66				
"		78	70		70	
09/19/86	Ω	50				
"		146				
"		139				
"		119				
"		86	108	122		
09/18/86		79				
"		78				
"		126	94		110	Σ
04/21/86		70				
"		74				
"		73				
"		60				
"		85				
"		67				
"		89				
"		82	75		75	
02/26/86		60				
"		59				
"		72				
"		60				
"		61				
"		65				
"		57				
"		61	62			

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
01/08/86		94				
"		92				
"	Ω	131				
"		93				
"		87				
"		91				
"		100	98	93	75	Σ
09/11/85		88				
"		91				
"		155				
"		95				
"		144				
"		97				
"		108				
"		127	113		113	
04/01/85		60				
"		61				
"		77				
"		68				
"		97				
"		59				
"		58				
"		61	68		68	
02/01/85		58				
"		62				
"		75				
"		64				
"		90				
"		65				
"		59				
"		68	68			
01/08/85		63				
"		89				
"		63				
"		71				
"		94				
"		69				
"		70				
"		62	73			

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
01/03/85		70				
"	Ω	152	111	70	70	Σ
09/25/84		107				
"		108				
"		126				
"		106				
"		124				
"		118				
"		107				
"		109	113		113	
06/07/84		63				
"		65				
"		96				
"		66				
"		91				
"		80				
"		72				
"		65	75		75	
03/27/84		55				
"		56				
"		85				
"		56				
"		40				
"		61				
"		42				
"		52	56		56	
12/29/83		79				
"		55				
"		79				
"		75	72			
12/15/83		60				
"		67				
"		96				
"		60				
"		121	81		77	


Eden THMs
THMS µg/l
100
90
80
70
60
50
40
30
20
10
0
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
Quarter Sampled
'87
◇ Quarterly average
□ Substituted quarterly average

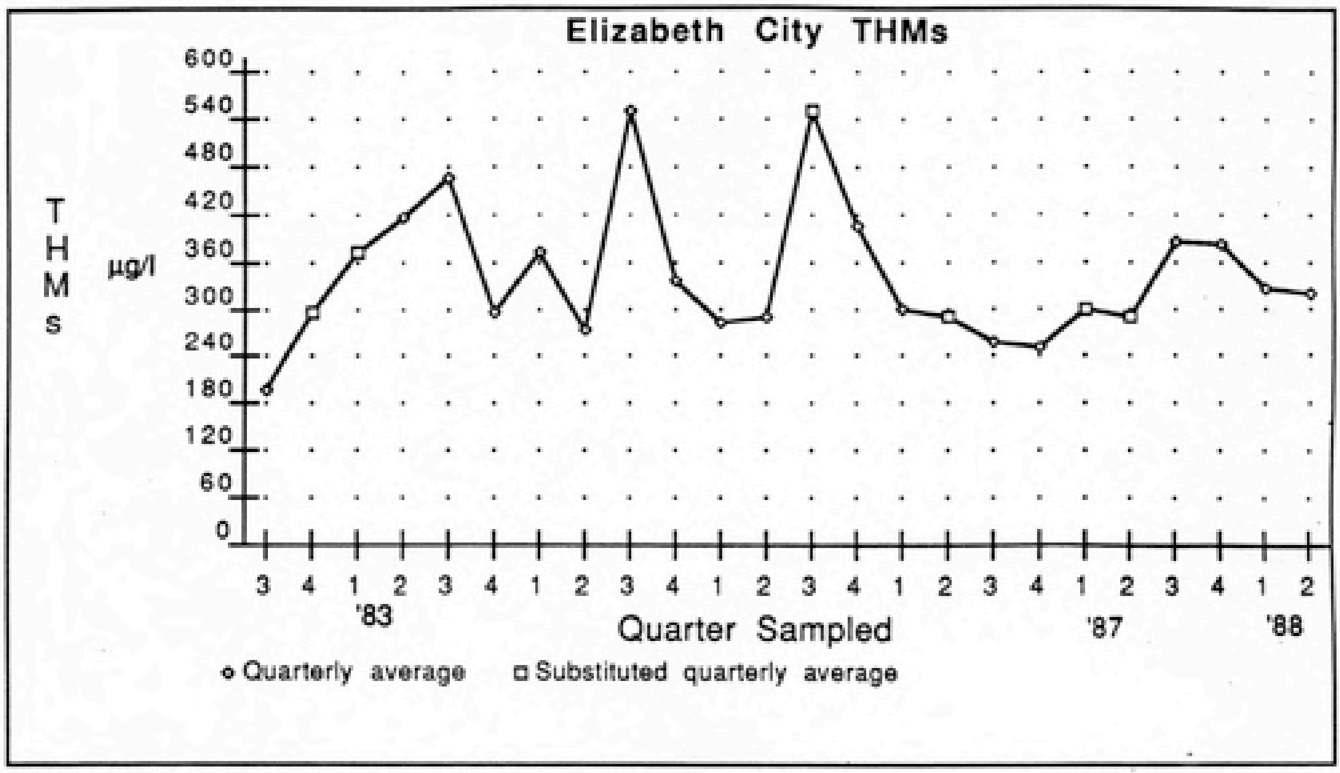
Plant: Eden			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0279010						
Population Served: 15708						
			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
03/04/88	Ω	28				
"	Ω	36	32			
02/18/88		28				
"		36	32			
02/09/88		25	25		30	Σ
11/24/87	Ω	26				
"	Ω	18	22			
11/17/87		26				
"	Ω	18	22	26	26	Σ
09/01/87	Ω	83				
"	Ω	66	74			
08/19/87		66				
"		83	74		74	
05/20/87	Ω	50				
"	Ω	46				
05/18/87		46				
"		50	48		48	
02/09/87		23	23		23	
12/08/86		57	57			
12/03/86		58	58		57	
08/26/86		62				
"		61	61		61	
05/12/86		43	43			
04/25/86		27	27		35	

Eden THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/12/86		27				
"		27	27		27	
12/10/85		67				
"		74	70		70	
08/16/85		95				
"		82	88		88	
05/13/85		64				
"		51	57		57	
02/07/85		22				
"		15	18		18	
11/14/84		34				
"		42	38		38	
08/16/84		75				
"		86	80		80	
05/10/84		49				
"		41	45		45	
02/09/84	Ω	41				
"		33	37	33	33	Σ
11/30/83		43				
"		43	43		43	
08/11/83		76				
"		61				
"		76				
"		69				
"		78				
"		67				
"		77				
"		50	69		69	

Eden THM Records

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
05/06/83	30			
"	50			
"	40			
"	30			
"	40			
"	50			
"	40			
"	40	40		40
02/16/83	23			
"	18			
"	21			
"	17			
"	23			
"	22			
"	27			
"	33			
"	23	23		23
11/18/82	55			
"	50			
"	51			
"	51			
"	56			
"	46			
"	62			
"	63			
"	54			
"	59	55		55


Elizabeth City THMs
600
540
480
420
360
300
240
180
120
60
0
T H M s
µg/l
3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'83
Quarter Sampled
'87
'88
Quarterly average
Substituted quarterly average

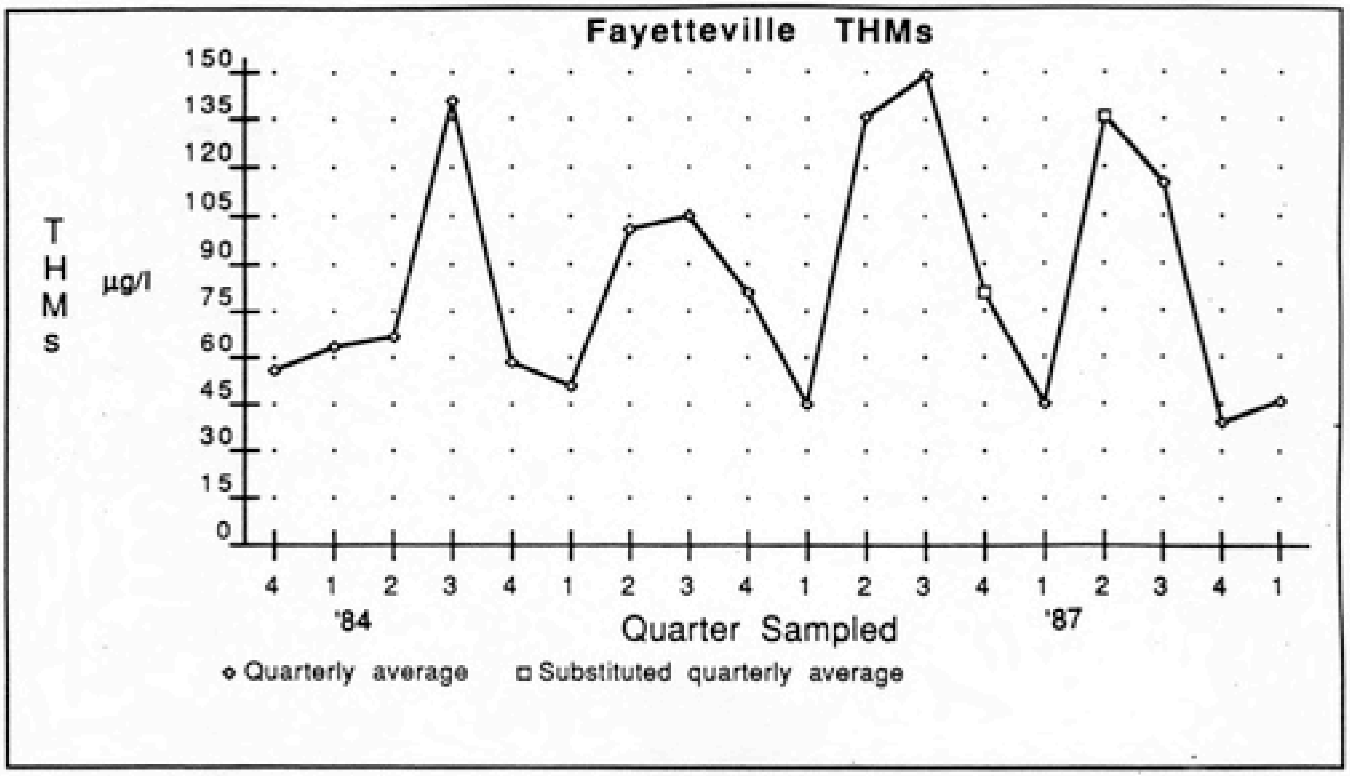
Plant: Elizabeth City			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0470010						
Population Served: 15500						
			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
04/20/88		367				
"	Ω	1				
"		520				
"		489				
"		515				
"		579	412	494		
04/04/88		84				
"		73				
"		85				
"		176	105		321	Σ
03/18/88		322				
"		308				
"		314				
"		322	317			
03/14/88	Ω	89				
"		93				
"	Ω	82				
"	Ω	41	76	93		
02/10/88	Ω	378				
"	Ω	400				
"	Ω	432				
"	Ω	377	397			
1/22/88	Ω	38				
"	Ω	400				
"	Ω	432				
"	Ω	377	312			
01/11/88		378				
"		400				
"		432				
"		377	397		327	Σ

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
12/07/87	Ω	407				
"	Ω	363				
"	Ω	97				
"	Ω	397	316			
11/30/87		397				
"	Ω	97				
"		363				
"		407	316	389		
10/12/87		373				
"		358				
"		423				
"		357	378		383	Σ
09/28/87		397	397			
08/31/87		468				
"		482				
"		467				
"		471	472			
08/03/87		262				
"		268				
"		265				
"	Ω	40	209	265	385	Σ
12/19/86		269				
"		226				
"		245				
"		262	250		250	
08/13/86		249				
"		273				
"		257				
"		252	258		258	
01/12/86		284				
"		305				
"		259				
"		267	279			

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
01/06/86		295				
"		315				
"		356				
"		327	323		301	
11/26/85		325	325			
10/29/85		406				
"		449				
"	Ω	528				
"		447	457	434	407	Σ
06/13/85		294				
"		274				
"		287				
"		306	290		290	
02/28/85	Ω	282	282			
02/22/85	Ω	280				
"		280				
"	Ω	300				
"		300				
"	Ω	269				
"		269				
"		282	283		283	Σ
11/26/84		346				
"		336				
"		333				
"		346				
"		325				
"		336				
"		333	336		336	
08/27/84		564				
"		541				
"		538				
"		554	549		549	
04/19/84		251				
"		301				
"		275				
"		266	273		273	

Elizabeth City THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
03/21/84		386			
"		369			
"		358			
"		382	374		374
12/27/83		267			
"		309			
"		284			
"		327	297		297
09/12/83		432			
"		471			
"		496			
"		475	468		468
06/29/83		484			
"		469			
"		208			
"		509	417		417
10/01/82	Ω	196			
"	Ω	192			
"	Ω	219			
"	Ω	182	197		
09/28/82		192			
"		196			
"		182			
"		219	197		197



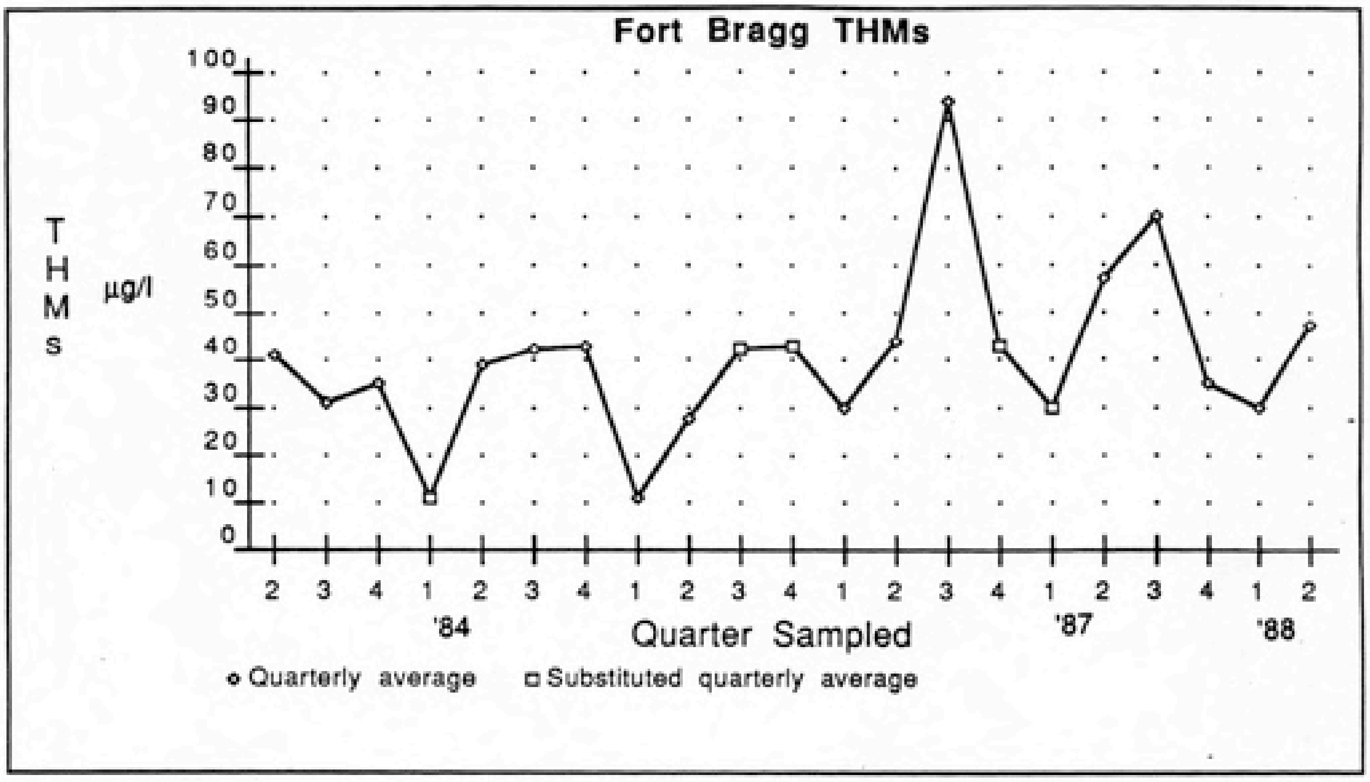
Fayetteville THMs
T H M s µg/l
150
135
120
105
90
75
60
45
30
15
0
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'84
'87
Quarter Sampled
◇ Quarterly average
□ Substituted quarterly average

Plant: Fayetteville			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0326010						
Population Served: 100000						
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/18/88		48				
"		48				
"		45				
"		50				
"		38				
"		46				
"		44				
"		50	46		46	
12/21/87		31				
"		28				
"		28				
"		43				
"		38				
"		39				
"		47				
"		59	39		39	
09/15/87		120				
"		92				
"		90				
"		74				
"		129				
"		105				
"		90				
"		108	101			
07/02/87		154				
"		130				
"		124				
"	Ω	198				
"		117				
"		135				
"		124				
"		140	140	132	115	Σ

			Unadjusted	Adjusted	Quarterly	
Date of Sampling		TTHM's µg/l	Average Reading µg/l	Average Reading µg/l	Average Reading µg/l	
02/27/87		46				
"		37				
"	Ω	79				
"		53				
"		44				
"		40				
"		49	50	45		
01/06/87		54				
"		46				
"		37				
"		57				
"		31				
"		43				
"		45				
"		52	46		45	Σ
09/25/86		172				
"		120				
"		145				
"		152				
"		115				
"		169				
"		171				
"	Ω	200	155	149	149	Σ
06/11/86		136				
"		134				
"		139				
"		149				
"		119				
"		133				
"		131				
"		144	136		136	
02/25/86		46				
"		36				
"		52				
"		52				
"		52				
"		41				
"		35				
"		45	45		45	

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
12/06/85		37				
"		91				
"		87				
"		100				
"		62				
"		91				
"		87				
"		97	81		81	
09/11/85		111				
"		66				
"		68				
"		124				
"		110				
"		107				
"		121				
"		133	105		105	
05/20/85		119				
"		106				
"		94				
"		111				
"		107				
"		93				
"		85				
"		91	101		101	
03/04/85		55				
"		47				
"		47				
"		44				
"		50				
"		63				
"		63				
"		42				
"		48	51		51	
12/07/84		63				
"		70				
"		52				
"		65				
"		58				
"		63				
"		44				
"		49	58		58	

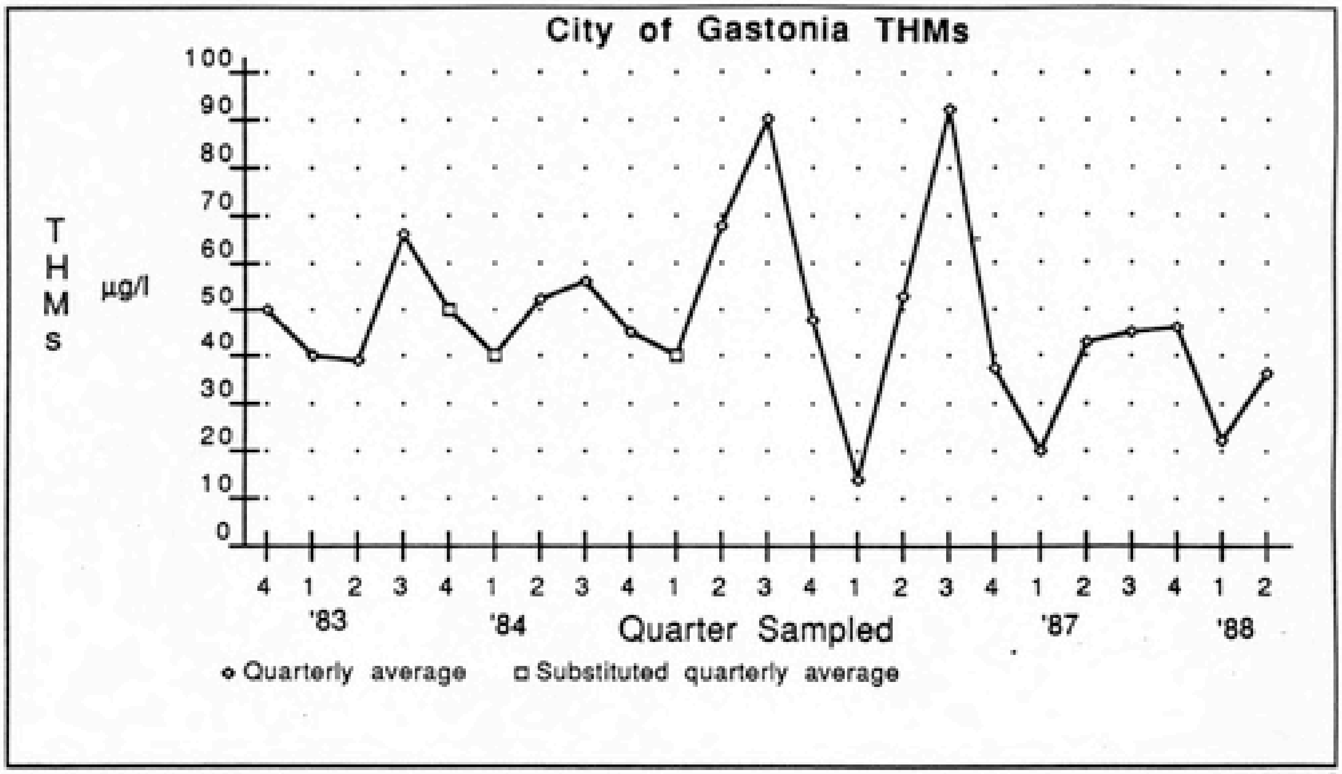
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
08/20/84		144				
"		133				
"		144				
"		159				
"		126				
"		133				
"		133				
"		155	141		141	
05/16/84		79				
"		65				
"		62				
"		80				
"		53				
"		61				
"		61				
"		79	67		67	
03/01/84		55				
"		59				
"		48				
"		70				
"		75				
"	Ω	86				
"		69				
"	Ω	93	69	63	63	Σ
12/30/83		70				
"		48				
"		49				
"		38				
"		53				
"		40				
"		36				
"		42	47			
10/03/83		84				
"		72				
"		86	81		56	


Fort Bragg THMs
T
H
M
s
µg/l
100
90
80
70
60
50
40
30
20
10
0
2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'84
Quarter Sampled
'87
'88
Quarterly average
Substituted quarterly average

Plant: Fort Bragg			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0326344						
Population Served: 58000						
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
04/29/88		49				
"		37				
"		50				
"		53	47		47	
01/27/88		31				
"		31				
"		30				
"		29	30		30	
12/17/87		32				
"		30				
"		29				
"		32	31			
10/09/87	Ω	1				
"		36				
"		41				
"		37				
"		40	31	38	35	Σ
09/08/87	Ω	1				
"		99				
"		110				
"		70				
"	Ω	2				
"		70				
"		66				
"		65				
"		80	63	80		
07/10/87		54				
"		58				
"		53				
"		50				
"	Ω	1	43	54	70	Σ

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
04/08/87	Ω	1				
"		42				
"		45				
"		48				
"		50				
"	Ω	1				
"		72				
"		61				
"		64				
"		70	45	57	57	Σ
09/08/86		94				
"	Ω	124	109	94	94	Σ
06/11/86		55				
"		52				
"		54				
"		60				
"		54	55			
04/10/86	Ω	1				
"		28				
"		36				
"		33				
"		28	25	31	44	Σ
01/09/86		30	30		30	
12/09/85	Ω	11				
"	Ω	11				
"	Ω	12				
"	Ω	10				
"	Ω	1	9			
05/21/85		24				
"		33	28		28	
02/05/85	Ω	1				
"		10				
"		12				
"		11				
"		11	9	11	11	Σ

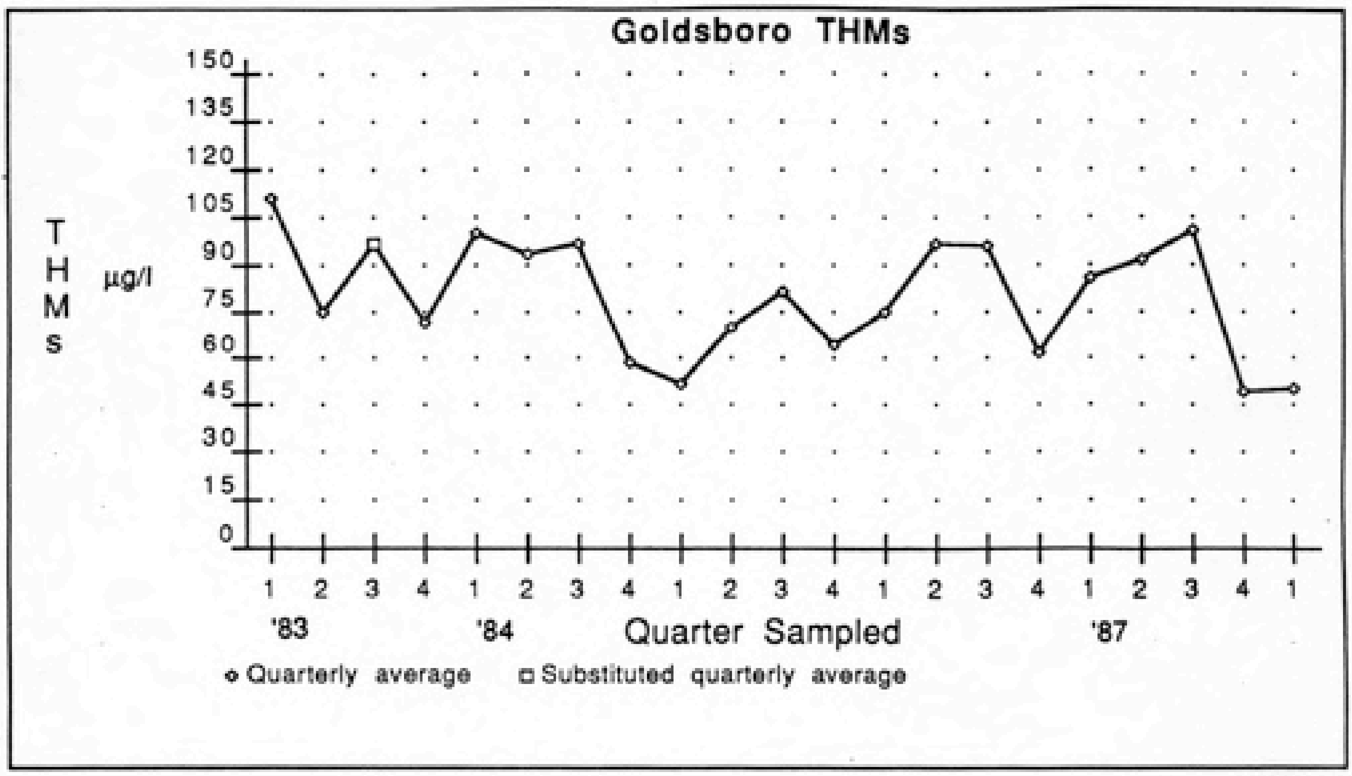
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
10/23/84	Ω	1				
"		10				
"		59				
"		43				
"		58	34	43	43	Σ
08/21/84	Ω	1				
"	Ω	44				
"	Ω	44				
"	Ω	34				
"	Ω	47				
"		44				
"		34				
"	Ω	1				
"		44				
"		47	34	42	42	Σ
06/13/84	Ω	1				
"		41				
"		36				
"		40	30	39	39	Σ
10/25/83	Ω	2				
"		29				
"		29				
"		33				
"		47	28	35	35	Σ
08/23/83	Ω	1				
"		21				
"		24				
"		26				
"		30	21	25		
08/11/83		52	52		31	Σ
06/13/80		41	41		41	


City of Gastonia THMs
100
90
80
70
60
50
40
30
20
10
0
THMs µg/l
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'83
'84
Quarter Sampled
'87
'88
◇ Quarterly average
□ Substituted quarterly average

Plant: City of Gastonia	Ω-measurement discarded for adjusted average calculation		
	Σ-some measurements(Ω) discarded before calculating average		
PWID: 0136010			
Population Served: 43684			

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
04/14/88	36	36		36
02/01/88	22	22		22
10/29/87	46	46		46
07/24/87	45	45		45
04/30/87	43	43		43
02/20/87	20	20		20
10/30/86	37	37		37
08/08/86	92	92		92
05/09/86	53	53		53
01/17/86	14	14		14
10/25/85	48	48		48
07/17/85	90	90		90
04/19/85	68	68		68
12/14/84	45	45		45
09/27/84	52	52		
07/02/84	60	60		56
04/17/84	52	52		52
08/19/83	59			
"	58			
"	62			
"	85	66		66

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
04/18/83		35				
"		42				
"		44				
"		37	39		39	
02/24/83		44				
"		33				
"		55				
"		29	40		40	
12/13/82		58				
"		42				
"		52				
"		50	50		50	

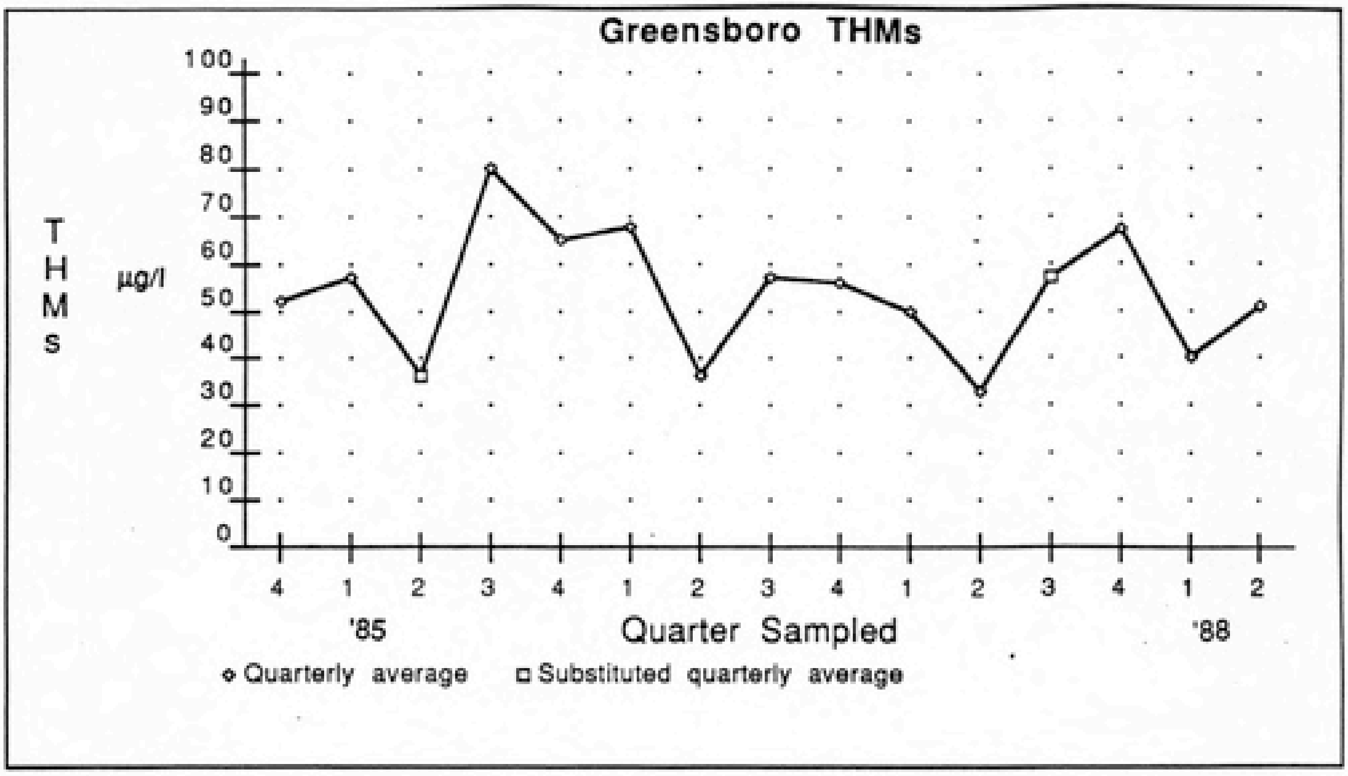

Goldsboro THMs
150
135
120
105
90
75
60
45
30
15
0
T
H
M
s
µg/l
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
Quarter Sampled
'87
Quarterly average
Substituted quarterly average

Plant: Goldsboro		Ω-measurement discarded for adjusted average calculation		
		Σ-some measurements(Ω) discarded before calculating average		
PWID: 0496010				
Population Served: 32900				
Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
03/16/88	53			
"	60			
"	46			
"	41	50		50
11/17/87	51			
"	61			
"	44			
"	42	49		49
09/01/87	99			
"	124			
"	97			
"	86	101		101
05/27/87	98			
"	108			
"	86			
"	78	92		92
03/11/87	91			
"	90			
"	84			
"	80	86		86
12/04/86	59			
"	79			
"	62			
"	48	62		62
09/25/86	100			
"	92			
"	108			
"	85	96		96
06/03/86	97			
"	109			
"	95			
"	88	97		97

Goldsboro THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
03/19/86		74				
"		87				
"		71				
"		68	75		75	
12/05/85	Ω	113				
"		65				
"		58				
"		68	76	64	64	Σ
09/20/85		83				
"		95				
"		85				
"		65	82		82	
04/16/85		59				
"		92				
"		68				
"		63	70		70	
02/07/85		50				
"		58				
"		53				
"		46	52		52	
12/18/84		58				
"		71				
"		50				
"		52	58		58	
09/18/84		96				
"		112				
"		94				
"		85	97		97	
05/03/84		96				
"		114				
"		73				
"		88	93		93	
03/06/84		100				
"		100				
"		100				
"		100	100		100	

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
11/22/83		73				
"		80				
"		75				
"		62				
"	Ω	73				
"	Ω	80				
"	Ω	75				
"	Ω	62	72	72	72	Σ
06/21/83		50				
"		93				
"		75				
"		84	75		75	
03/10/83		124				
"		111				
"		116				
"	Ω	162	128	117		
01/18/83		112				
"		142				
"		94				
"		81	107		111	Σ


Greensboro THMs
THMs µg/l
100
90
80
70
60
50
40
30
20
10
0
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'85
Quarter Sampled
'88
Quarterly average
Substituted quarterly average

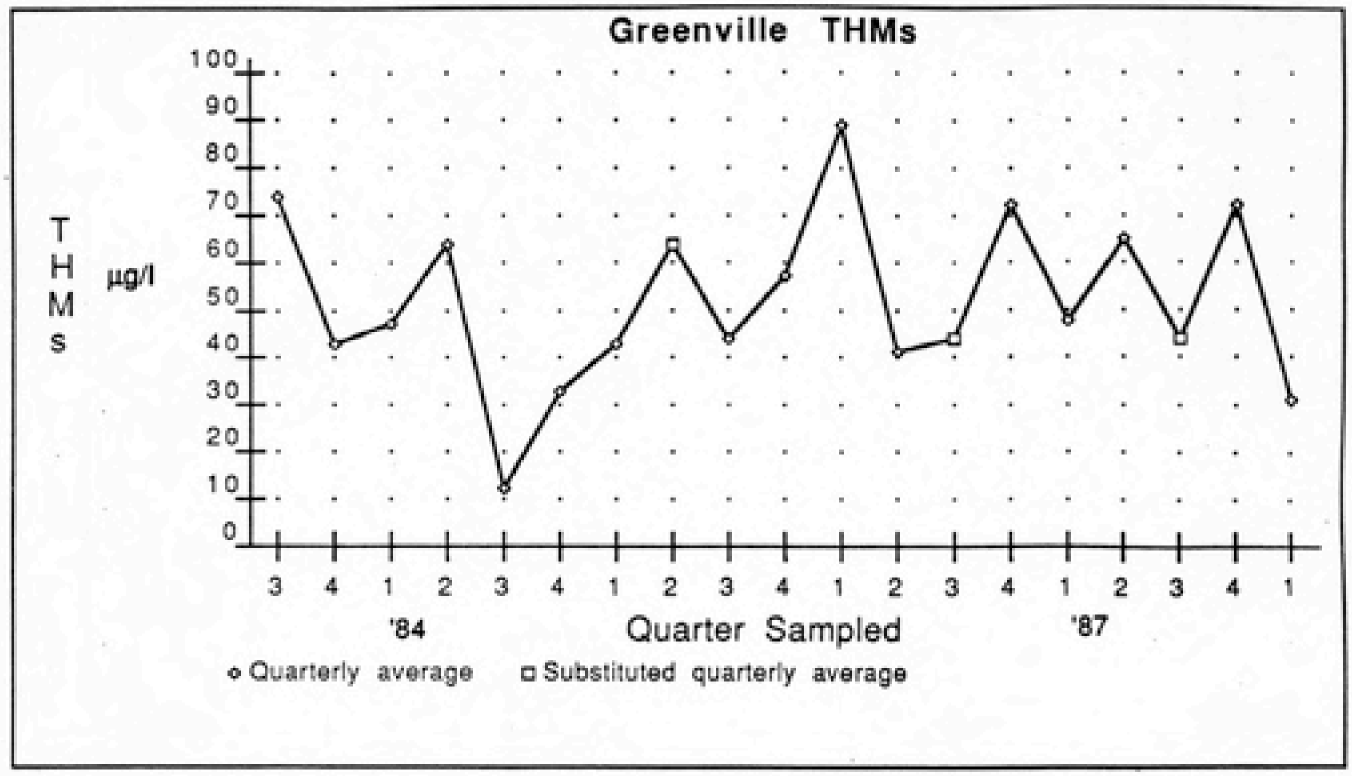
Plant: City of Greensboro			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0241010						
Population Served: 170000						
			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
04/25/88		47				
"		53				
"		46				
"		47				
"		60				
"		35				
"		58				
"		63	51		51	
02/02/88		5				
"		22				
"		6				
"		53				
"		58				
"		76				
"		70				
"		40				
"		41				
"		50				
"		28				
"		35	40		40	
12/02/87	Ω	3				
"		58				
"		53				
"	Ω	3				
"		74				
"		45				
"		97				
"		81				
"		64				
"		70				
"		64				
"		69	57	67	67	Σ

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
04/24/87		68				
"		39				
"		66				
"		59				
"		51				
"		20				
"		25				
"		30				
"		21				
"		2				
"		14				
"		2	33		33	
02/02/87		24				
"		31				
"		90				
"		34				
"		33				
"		61				
"		82				
"		75				
"		50				
"		74				
"		45				
"		5	50		50	
10/02/86		58				
"		69				
"		59				
"		64				
"	Ω	117				
"		72				
"		64				
"		56				
"		47				
"		36				
"		5				
"		84	61	56	56	Σ

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
07/03/86		62				
"		86				
"		77				
"		69				
"		81				
"		65				
"		71				
"		5				
"		31				
"		20				
"		49				
"		68	57		57	
04/15/86		31				
"		71				
"		31				
"		47				
"		36				
"		17				
"		24				
"		8				
"		6				
"	Ω	520				
"		70				
"		59	77	36	36	Σ
01/20/86		39				
"		53				
"		57				
"		86				
"		57				
"		42				
"		80				
"		98				
"		66				
"		88				
"		95				
"		56	68		68	

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
10/29/85		63				
"		52				
"		58				
"		90				
"		102				
"		65				
"		92				
"		55				
"		34				
"		59				
"		47	65		65	
07/10/85	Ω	1				
"		38				
"		44				
"		77				
"		74				
"		72				
"		118				
"		117				
"		93				
"		79				
"		90				
"		75	73	80	80	Σ
03/21/85		58				
"		66				
"		66				
"		52				
"	Ω	1				
"		35				
"		35				
"		79				
"		53				
"		51				
"		58				
"		75	52	57	57	Σ

			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
12/12/84	Ω	1				
"		31				
"		31				
"		81				
"		75				
"		44				
"		53	45	52	52	Σ



Greenville THMs
100
90
80
70
60
50
40
30
20
10
0
THMs µg/l
3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'84
Quarter Sampled
'87
◇ Quarterly average
□ Substituted quarterly average

Plant: Greenville		Ω-measurement discarded for adjusted average calculation		
		Σ-some measurements(Ω) discarded before calculating average		
PWID: 0474010				
Population Served: 43005				
		Unadjusted	Adjusted	Quarterly
Date of Sampling	TTHM's µg/l	Average Reading µg/l	Average Reading µg/l	Average Reading µg/l
02/11/88	46			
"	17			
"	11			
"	14			
"	37			
"	48			
"	37			
"	34	31		31
12/22/87	86			
"	28			
"	19			
"	17			
"	61			
"	77			
"	64			
"	59	51		
10/21/87	105			
"	110			
"	128			
"	111			
"	53			
"	62			
"	60			
"	106	92		72
06/17/87	100			
"	109			
"	37			
"	33			
"	22			
"	23			
"	98			
"	97	65		65

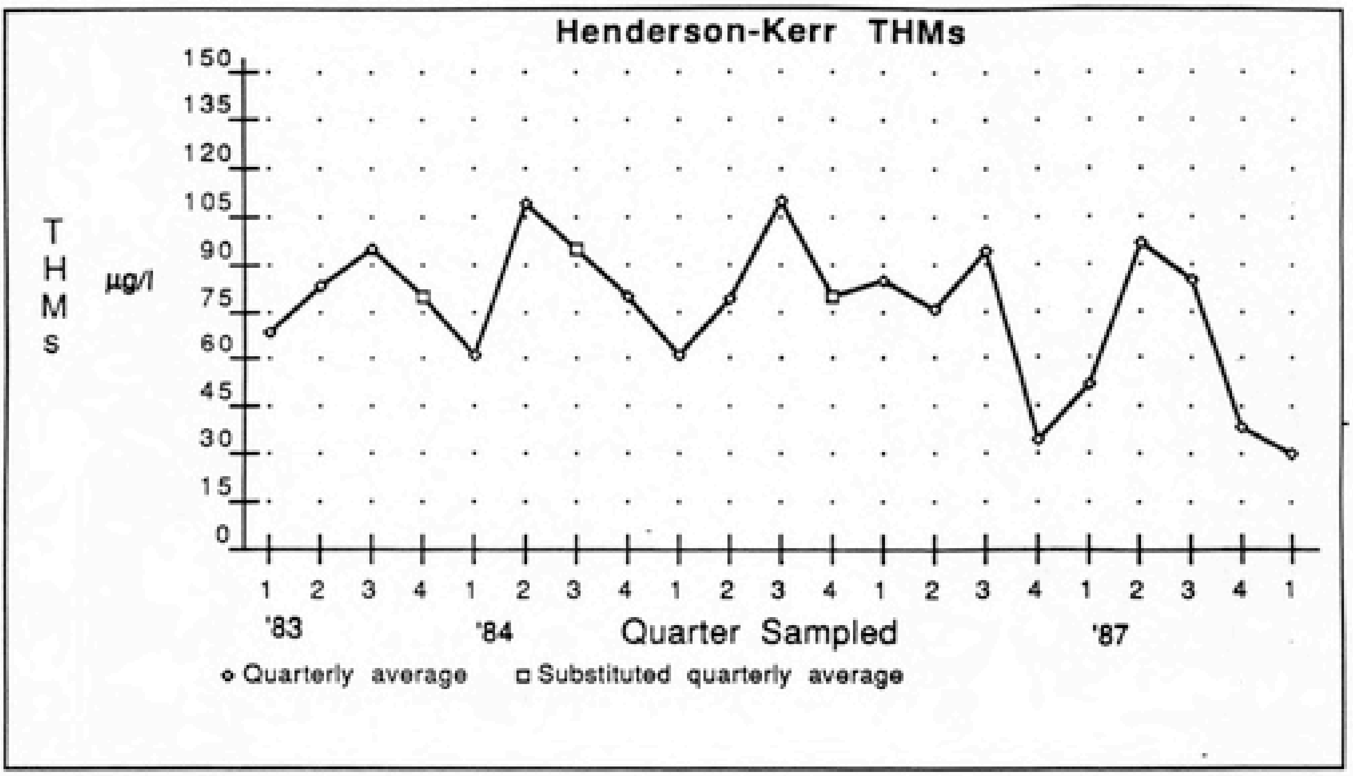
Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
03/30/87	64			
"	66			
"	73			
"	65			
"	3			
"	19			
"	7			
"	14	39		
01/06/87	68			
"	84			
"	93			
"	72			
"	53			
"	17			
"	10			
"	53	56		48
10/28/86	115	115		
10/23/86	136			
"	116			
"	114			
"	11			
"	11			
"	11			
"	60	66		72
06/23/86	67			
"	58			
"	72			
"	59			
"	10			
"	21			
"	6			
"	38	41		
04/21/86	78			
"	81			
"	81			
"	10			
"	10			
"	10			
"	10	40		41

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/28/86		80	80			
02/19/86		90				
"		75				
"		95				
"		96				
"		90				
"		91				
"		89				
"		91	90		89	
10/14/85	Ω	931				
"		120				
"	Ω	163				
"		82				
"		50				
"		29				
"		21				
"		40	179	57	57	Σ
09/26/85		23	23			
07/18/85		79				
"		104				
"		86				
"		11				
"		9				
"		12				
"		26	47		44	
03/13/85		21				
"		31				
"		86				
"		44				
"		43				
"		41				
"		46				
"		28	43		43	

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
12/13/84		29				
"		39				
"		49				
"		40				
"		48				
"		27				
"		20				
"		13	33		33	
09/26/84		9				
"		16				
"	Ω	144				
"		12				
"		7				
"		18	34	12	12	Σ
06/19/84		140				
"	Ω	171				
"	Ω	213				
"		142				
"		10				
"		13				
"		31				
"		46	96	64	64	Σ
03/23/84		51				
"		53				
"		105				
"		59				
"		17				
"		13				
"		47				
"		35	47		47	
12/16/83		49				
"		54				
"		67				
"		57				
"		16				
"		6				
"		15				
"		32	37			
11/18/83		93	93		43	

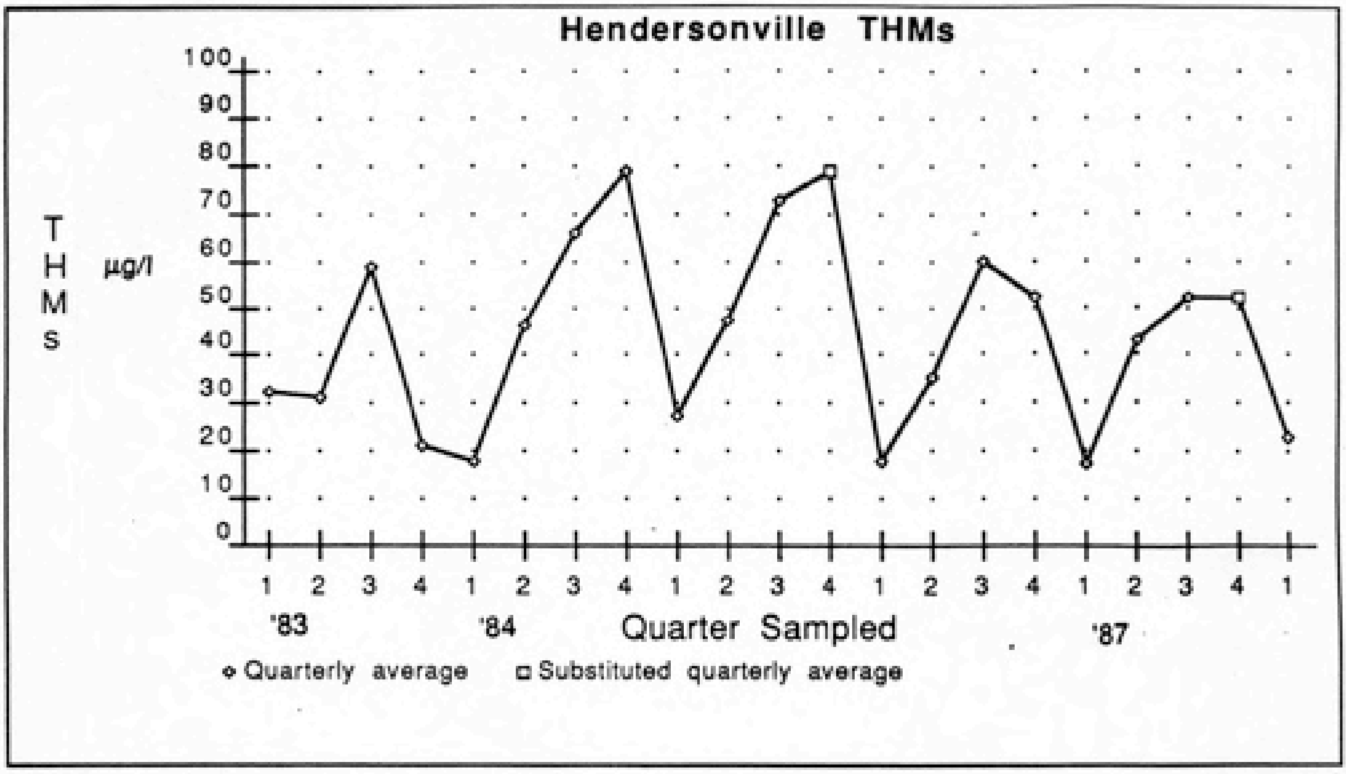
Greenville THM Records

Date of Sampling	TTHM's μg/l	Unadjusted Average Reading μg/l	Adjusted Average Reading μg/l	Quarterly Average Reading μg/l
09/29/83	62			
"	71			
"	98			
"	66	74		74


Henderson-Kerr THMs
THMs
µg/l
150
135
120
105
90
75
60
45
30
15
0
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
Quarter Sampled
'87
Quarterly average
Substituted quarterly average

Plant: Henderson-Kerr		Ω-measurement discarded for adjusted average calculation		
		Σ-some measurements(Ω) discarded before calculating average		
PWID: 0291010				
Population Served: 20700				
Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
01/26/88	30	30		30
12/16/87	38	38		38
09/23/87	85	85		85
06/24/87	97	97		97
03/25/87	52	52		52
12/10/86	34	34		34
09/11/86	94	94		94
06/18/86	76	76		76
03/13/86	79	79		
01/03/86	92	92		85
09/11/85	99	99		
07/09/85	122	122		110
04/15/85	79	79		79
01/09/85	61	61		61
10/04/84	80	80		80
06/27/84	109	109		109
03/29/84	61	61		61
09/08/83	111			
"	99			
"	102			
"	68	95		95

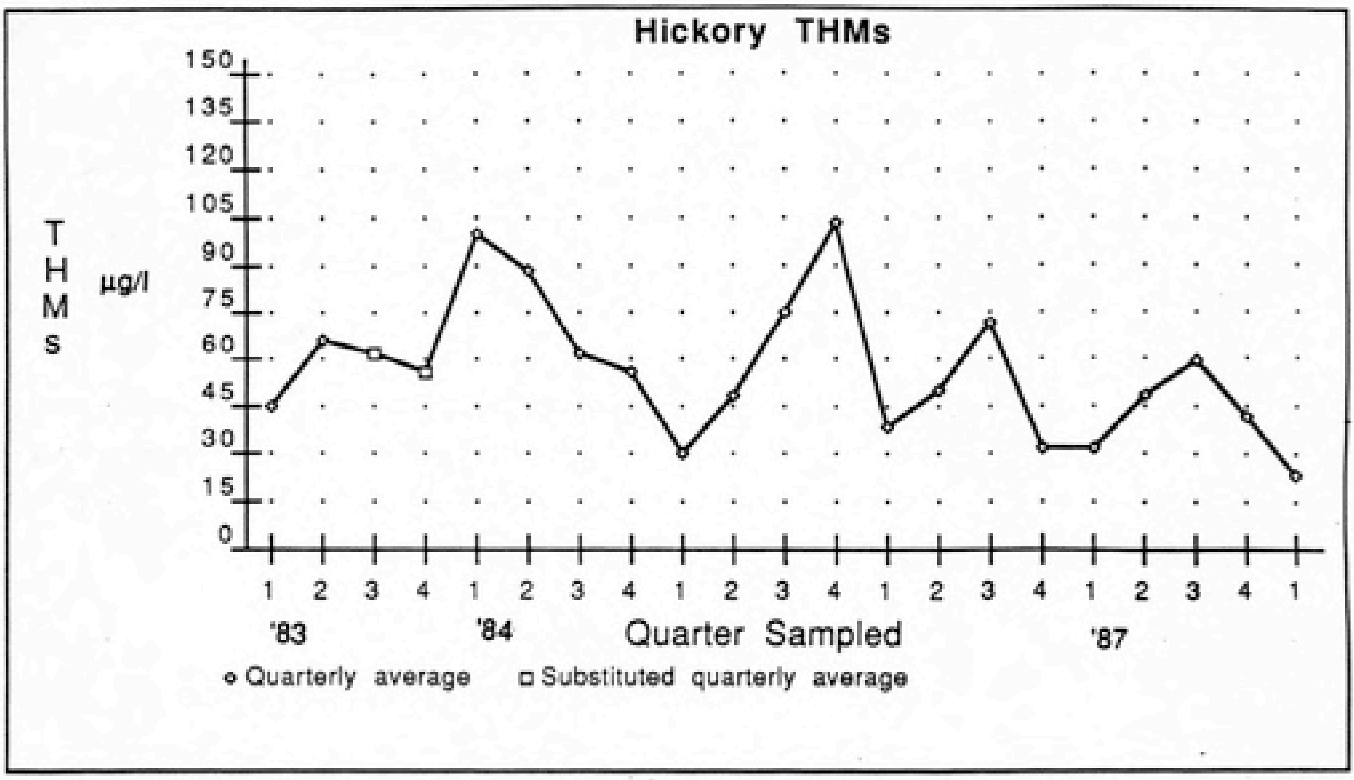
Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
05/18/83	51			
"	90			
"	68			
"	125	83		83
03/08/83	34			
"	66			
"	54			
"	92	61		
01/07/83	50			
"	87			
"	88			
"	74	75		68


Hendersonville THMs
T H M s µg/l
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
Quarter Sampled
'87
Quarterly average
Substituted quarterly average

Plant: Hendersonville			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0145010						
Population Served: 30000						
			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
02/05/88		22				
"	Ω	2				
"		22				
"		25	18	23	23	Σ
08/06/87		58				
"		55				
"		52				
"		43	52		52	
05/18/87		50				
"		42				
"		39				
"		40	43		43	
02/05/87		15				
"		25				
"		11				
"		16	17		17	
11/05/86		37				
"		58				
"		53				
"		60	52		52	
08/15/86		44				
"		58				
"		82	61			
07/28/86		58	58		60	
05/07/86		25				
"		30				
"		45				
"		41	35		35	

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
02/06/86	17			
"	19			
"	18			
"	19	18		18
07/17/85	83			
"	71			
"	65			
"	71	73		73
04/04/85	44			
"	47			
"	48			
"	47	47		47
01/09/85	27			
"	27			
"	27			
"	27	27		27
10/17/84	69			
"	83			
"	82			
"	83	79		79
07/17/84	47			
"	82			
"	83			
"	51	66		66
04/09/84	48			
"	47			
"	51			
"	37	46		46
01/09/84	14			
"	23			
"	17			
"	18	18		18
12/29/83	17			
"	31			
"	28			
"	17	23		

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
10/14/83		21				
"		20				
"		17				
"		21	20		21	
07/13/83		75				
"		51				
"		70				
"		42	59		59	
04/13/83		39				
"		22				
"		31				
"		31	31		31	
01/19/83		31				
"	Ω	48				
"		33				
"		33	36	32	32	Σ


Hickory THMs
150
135
120
105
90
75
60
45
30
15
0
THMs µg/l
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
Quarter Sampled
'87
◦ Quarterly average
□ Substituted quarterly average

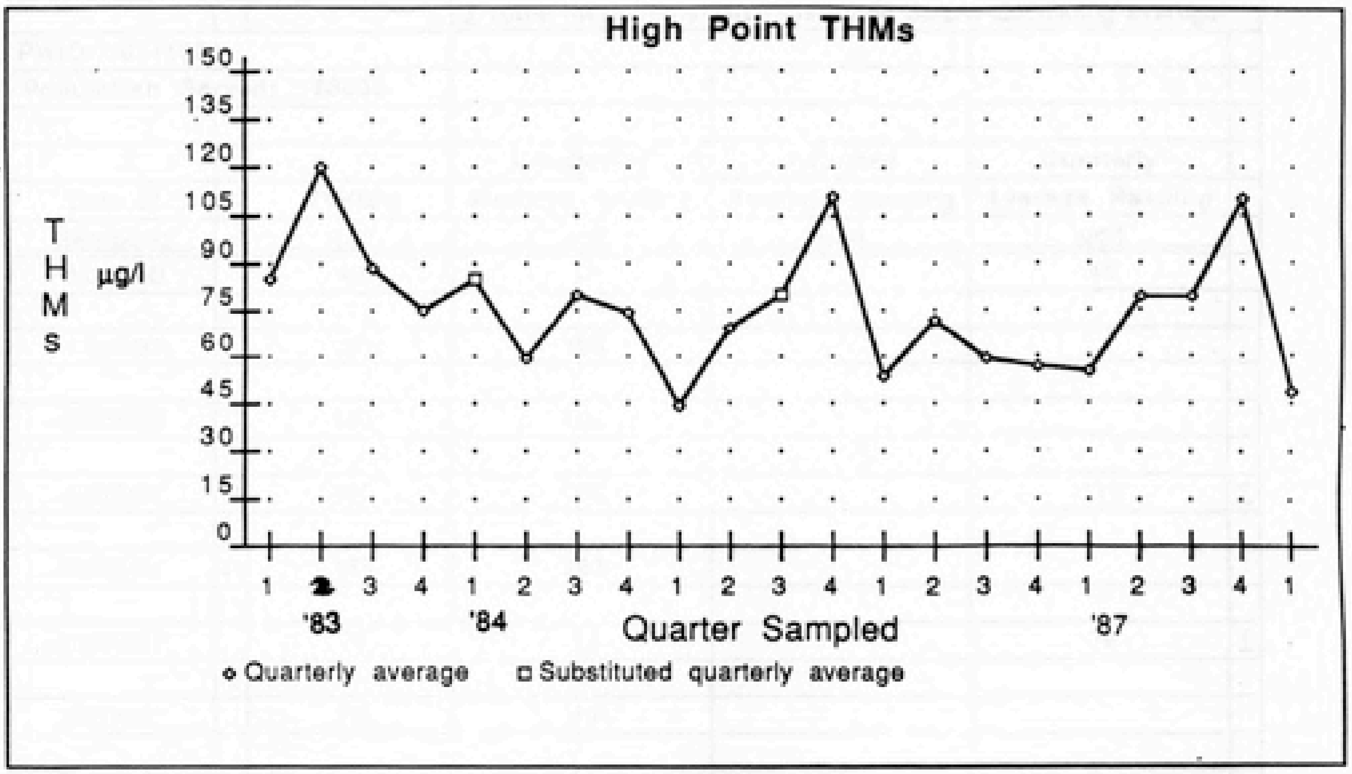
Plant: Hickory		Ω-measurement discarded for adjusted average calculation		
		Σ-some measurements(Ω) discarded before calculating average		
PWID: 0118010				
Population Served: 40000				
		Unadjusted	Adjusted	Quarterly
Date of Sampling	TTHM's µg/l	Average Reading µg/l	Average Reading µg/l	Average Reading µg/l
03/08/88	13			
"	55			
"	12			
"	12	23		23
11/17/87	32			
"	70			
"	32			
"	35	42		42
08/21/87	50			
"	98			
"	43			
"	47	59		59
05/28/87	34			
"	87			
"	35			
"	38	48		48
03/17/87	27			
"	22			
"	59			
"	22	32		32
11/24/86	23			
"	30			
"	45			
"	31	32		32
08/26/86	57			
"	97			
"	68			
"	66	72		72
05/28/86	46			
"	52			
"	53			
"	48	50		50

Hickory THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
03/25/86		21				
"		78				
"		30				
"		23	38		38	
11/13/85		92				
"	Ω	161				
"		105				
"		112	117	103	103	Σ
08/23/85		67				
"		77				
"		70				
"		86	75		75	
05/16/85		35				
"		61				
"		48				
"		50	48		48	
03/13/85		23				
"		38				
"		36				
"		25	30		30	
11/26/84		57				
"		60				
"		50				
"		59	56		56	
09/06/84		61				
"	Ω	132				
"		61				
"		63	79	62	62	Σ
06/07/84		70				
"		83				
"		91				
"		107	88		88	
03/13/84		100				
"		100				
"		100				
"		100	100		100	

Hickory THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
07/27/83	Ω	114				
"	Ω	66				
"	Ω	64				
"	Ω	67				
04/14/83	Ω	114				
"		66				
"		64				
"		67	78	66	66	Σ
02/08/83		41				
"		102				
"		51				
"		53	62			
1/06/83	Ω	130				
"		45				
"		40				
"		49	66	45	45	Σ


High Point THMs
150
135
120
105
90
75
60
45
30
15
0
T H M s µg/l
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
Quarter Sampled
'87
Quarterly average
Substituted quarterly average

High Point THM Records

Plant: High Point

Ω-measurement discarded for adjusted average calculation

Σ-some measurements(Ω) discarded before calculating average

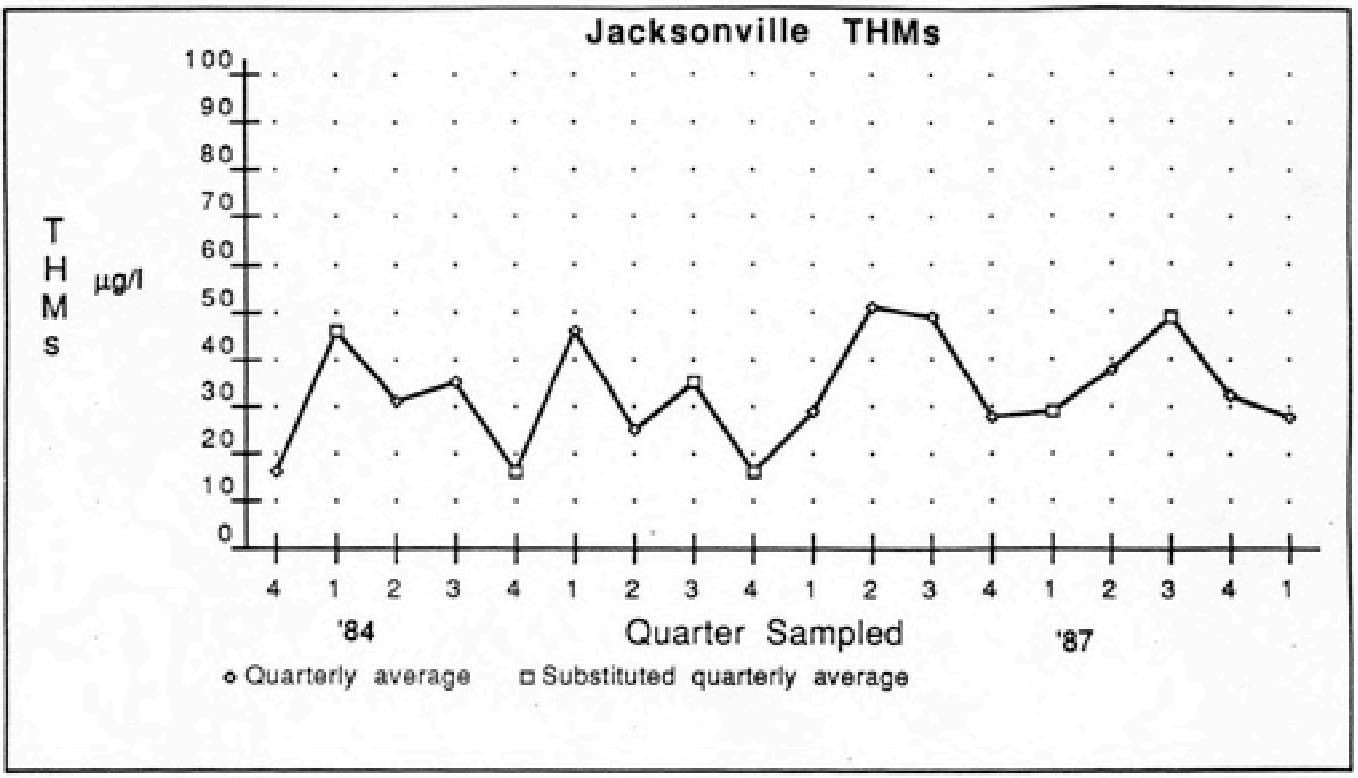
PWID: 0241020

Population Served: 68000

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/18/88		48	48		48	
12/09/87		120	120			
10/26/87		100	100			
10/12/87	Ω	155	155		110	Σ
09/23/87	Ω	163	163			
07/06/87		79	79		79	Σ
06/24/87		79	79			
06/15/87		79	79		79	
03/18/87		44	44			
01/07/87		66	66		55	
12/30/86		57	57		57	
09/23/86		59	59		59	
04/17/86		72				
"		72	72		72	
02/10/86		53	53			
01/02/86		53	53		53	
11/18/85		108	108			
10/31/85		115	115		111	
04/17/85		54				
"		76				
"		63				
"		84	69		69	

High Point THM Records

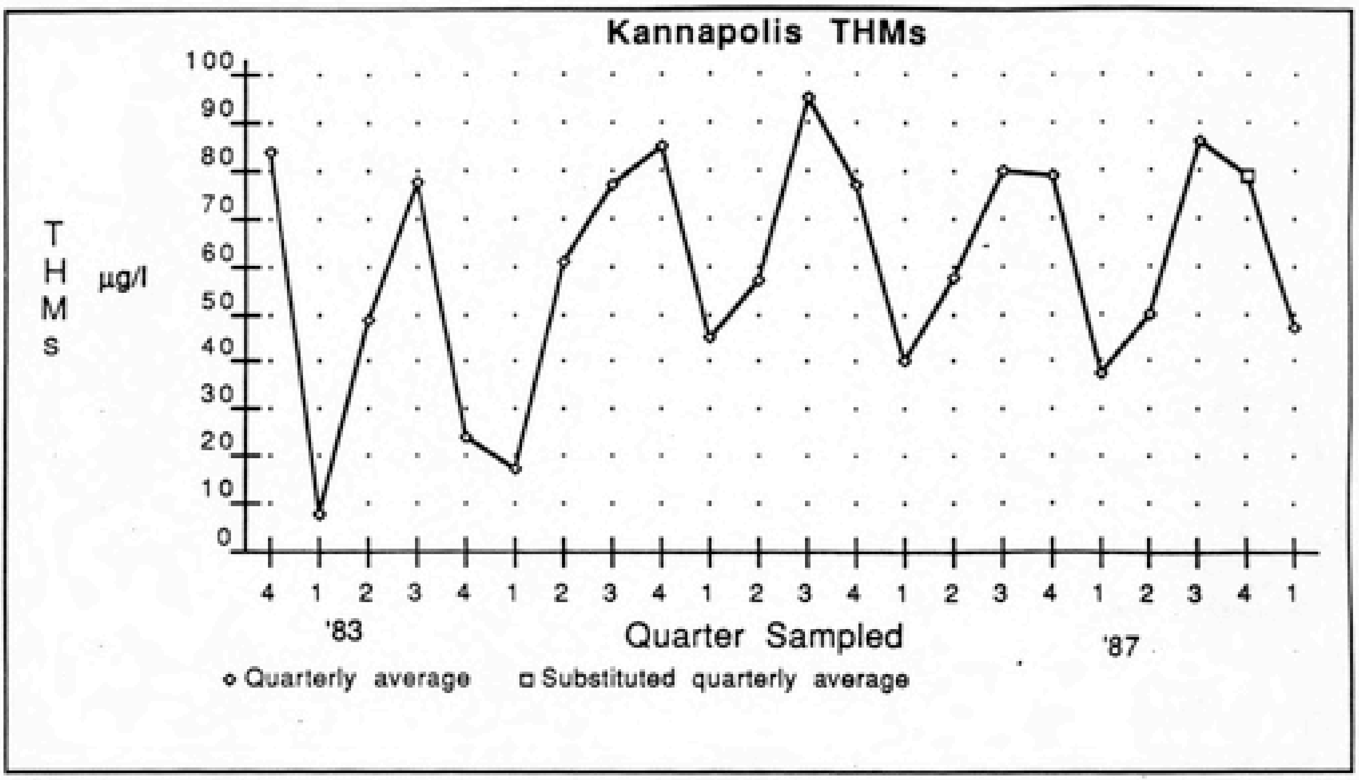
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/14/85		42				
"		44				
"		38				
"		42				
		54	44		44	
12/05/84		47				
"		78				
"		76				
"		97	74		74	
09/26/84		81				
"		85				
"		72				
"		82	80		80	
04/18/84		51				
"		61				
"		45				
"		79	59		59	
11/02/83		92				
"		79				
"		50				
"		81	75		75	
08/24/83		84				
"		87				
"		109				
"		72	88		88	
05/17/83		101				
"		131				
"		126				
"		122	120		120	
03/08/83		66				
"		87				
"		74				
"		77	76			
01/04/83	Ω	142				
"		109				
"		87				
"		94	108	97	85	


Jacksonville THMs
THMs µg/l
100
90
80
70
60
50
40
30
20
10
0
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'84
Quarter Sampled
'87
Quarterly average
Substituted quarterly average

Plant: Jacksonville			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0467010						
Population Served: 32358						
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
03/03/88		23				
"		33	28		28	
12/17/87		30				
"		43	37			
10/02/87		21				
"	Ω	49	35	21	32	
07/09/87	Ω	51				
"	Ω	37	44			
06/23/87		37				
"		51	44			
04/17/87		19				
"		45	32		38	
12/31/86		28				
"	Ω	50	39	28	28	Σ
09/25/86		49	49		49	
06/25/86		62				
"		41	51		51	
02/05/86		20				
"		25				
"		26				
"		18				
"	Ω	1				
"		32				
"		43				
"		41	26	29	29	Σ

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
06/27/85		38				
"		38				
"		40				
"		3				
"		3				
"		36				
"		37				
"		15				
"		1	23			
05/22/85		36				
"	Ω	36				
"		50				
"	Ω	50				
"		43				
"	Ω	43				
"		1				
"	Ω	1				
"		36				
"	Ω	36				
"		27				
"		2				
"		23				
"	Ω	23				
"		17				
"	Ω	17	28	26	25	Σ
02/05/85		26				
"		34				
"		52				
"		56				
"	Ω	1				
"		49				
"		54				
"		49	40	46	46	Σ
09/20/84		38				
"		38				
"		40				
"	Ω	3				
"		36				
"		37				
"		15				
"		18	28	32		

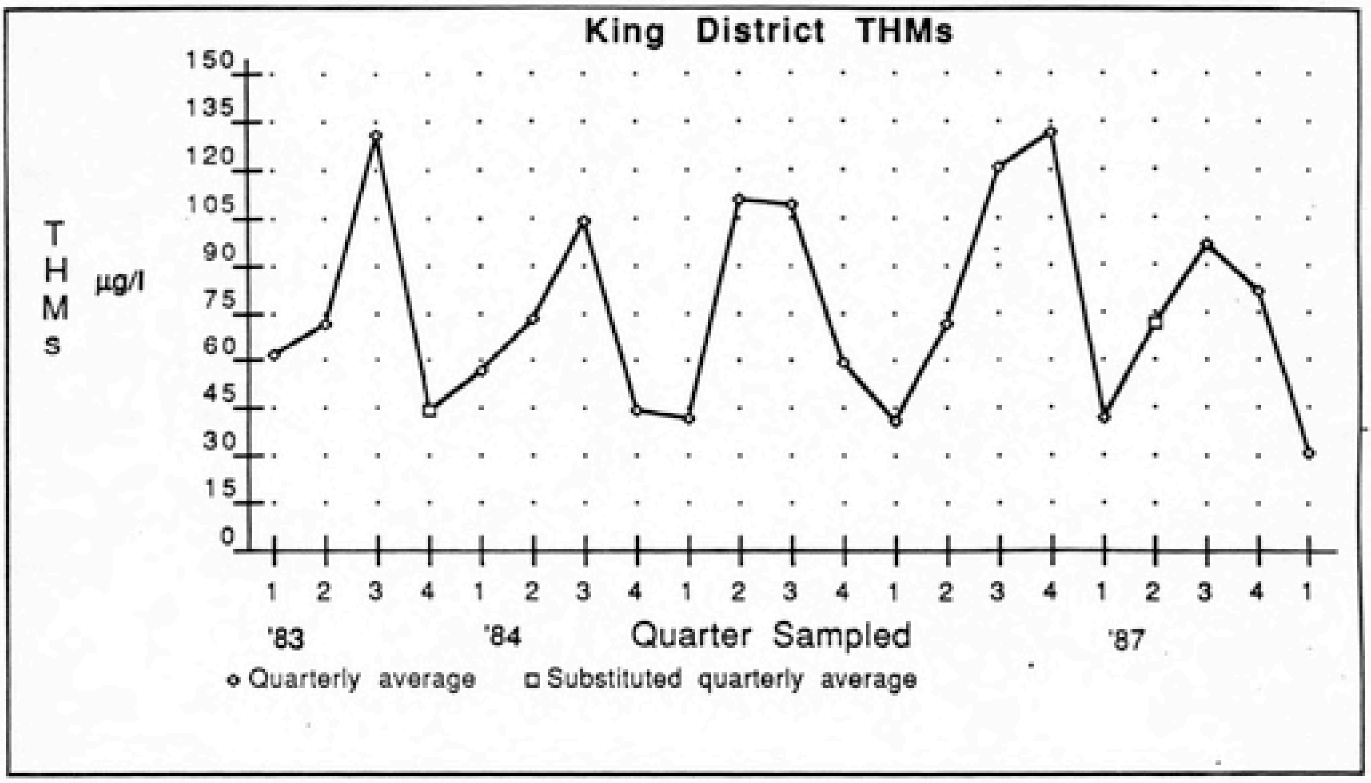
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
07/23/84	Ω	2				
"		35				
"		54				
"		40				
"		22				
"		22				
"		42				
"		51	33	38	35	Σ
05/09/84		29				
"		23				
"		47				
"		33				
"	Ω	1				
"		21				
"		31				
"		36	28	31	31	Σ
10/11/83		9				
"		10				
"		15				
"		22				
"		5				
"		15				
"		25				
"		24				
"		22				
"		15				
"		10				
"		9				
"		5				
"		15				
"		25				
"		24	16		16	
11/23/82		5				
"		23				
"		23				
"		28				
"		6				
"		31				
"		20				
		27	20		20	


Kannapolis THMs
100
90
80
70
60
50
40
30
20
10
0
THMs µg/l
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
Quarter Sampled
'87
◇ Quarterly average
□ Substituted quarterly average

Plant: Kannapolis			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0180065						
Population Served: 27860						
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/05/88		31				
"		29				
"		31				
"		40	33			
01/16/87		59				
"		54				
"		57				
"		72	60		47	Σ
08/06/87		96				
"		83				
"		76				
"		88	86		86	
05/04/87		58				
"		48				
"		45				
"		50	50		50	
02/05/87		38				
"		28				
"		36				
"		47	37		37	
10/20/86		75				
"		65				
"		72				
"		103	79		79	
08/08/86		82				
"		69				
"		70				
"		99	80		80	
05/07/86	Ω	77				
"		60				
"		52				
"		62	63	58	58	Σ

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/06/86		53				
"		54				
"		51				
"		72	57		57	
11/04/85	Ω	318				
"		58				
"		50				
"		84				
"		96				
"		120	121	81		
10/11/85		37	37			
10/10/85		96	96		77	Σ
07/25/85		94				
"		89				
"		101				
"	Ω	115	100	95	95	Σ
04/17/85		55				
"		52				
"		56				
"		65	57		57	
01/09/85		45				
"		41				
"		38				
"		54	45		45	
10/15/84		87				
"		71				
"		72				
"		110	85		85	
07/19/84		93				
"		67				
"		66				
"		80	77		77	
04/11/84		68				
"		57				
"		58				
"		60	61		61	

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
01/20/84		21				
"		15				
"		18				
"		15	17		17	
10/17/83		33				
"		13				
"		5				
"		43	24		24	
07/22/83		79				
"		67				
"		76				
"		89	78		78	
04/21/83		50				
"		38				
"		49				
"		60	49		49	
01/18/83		9				
"		7				
"		11				
"		7	8		8	
10/20/82		81				
"		77				
"		79	79			
10/19/82		98	98		84	


King District THMs
150
135
120
105
90
75
60
45
30
15
0
THMs µg/l
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
Quarter Sampled
'87
Quarterly average
Substituted quarterly average

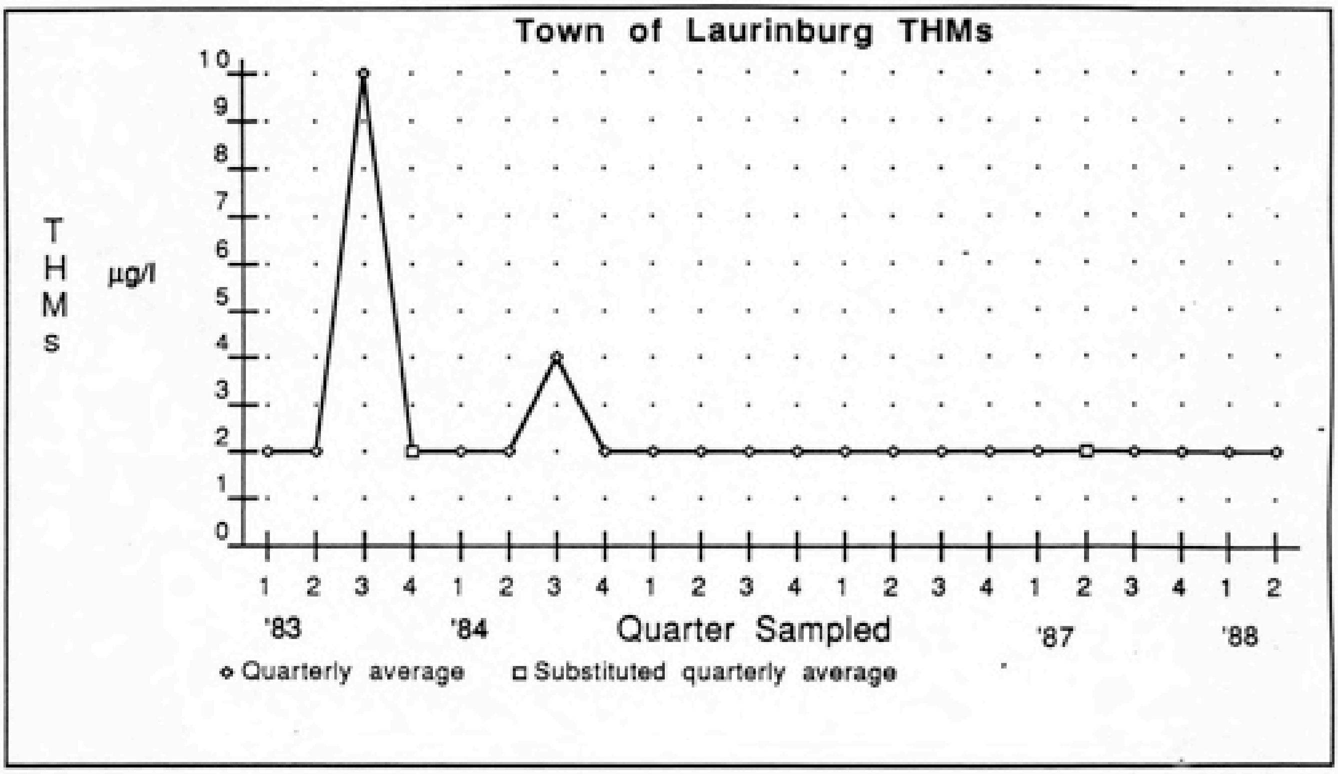
Plant: King District		Ω-measurement discarded for adjusted average calculation		
		Σ-some measurements(Ω) discarded before calculating average		
PWID: 0285010				
Population Served: 13700				
		Unadjusted	Adjusted	Quarterly
Date of	TTHM's	Average Reading	Average Reading	Average Reading
Sampling	µg/l	µg/l	µg/l	µg/l
03/09/88	37			
"	32			
"	27			
"	27	31		31
11/17/87	102			
"	63			
"	95			
"	70	82		82
08/19/87	95			
"	83			
"	124			
"	88	97		97
03/10/87	37			
"	45			
"	37			
"	48	42		42
10/16/86	152			
"	117			
"	120			
"	140	132		132
07/31/86	93			
"	127			
"	127			
"	138	121		121
05/21/86	77			
"	74			
"	71			
"	67	72		72
03/18/86	40			
"	44			
"	32			
"	49	41		41

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
12/11/85		48				
"		80				
"		60				
"		49	59		59	
09/17/85		98				
"		98				
"		105				
"		135	109		109	
06/26/85		128				
"		119				
"		100				
"		96	111		111	
03/27/85		35				
"		42				
"		36				
"		55	42		42	
12/18/84		42				
"		46				
"		48				
"		42	44		44	
09/18/84		88				
"		116				
"		124				
"		89	104		104	
06/22/84		58				
"	Ω	9				
"		88				
"		73	57	73	73	Σ
03/22/84		56				
"		55				
"		60				
"		58	57		57	
09/01/83		136				
"		132				
"		129				
"		126	131		131	

King District THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
05/16/83		50				
"		68				
"		77				
"		93	72		72	
03/10/83		58				
"		54				
"		55				
"		60	57			
01/06/83		75				
"	Ω	84				
"		67				
"		67	73	70	62	Σ

Plant: City of Kinston		Ω-measurement discarded for adjusted average calculation			
		Σ-quarterly average calculation included an adjusted value			
PWID: 0454010					
Population Served: 28518					
			Unadjusted	Adjusted	Quarterly
Date of		TTHM's	Average Reading	Average Reading	Average Reading
Sampling		µg/l	µg/l	µg/l	µg/l
01/27/88		2			
"		2			
"		1			
"		6	3		3



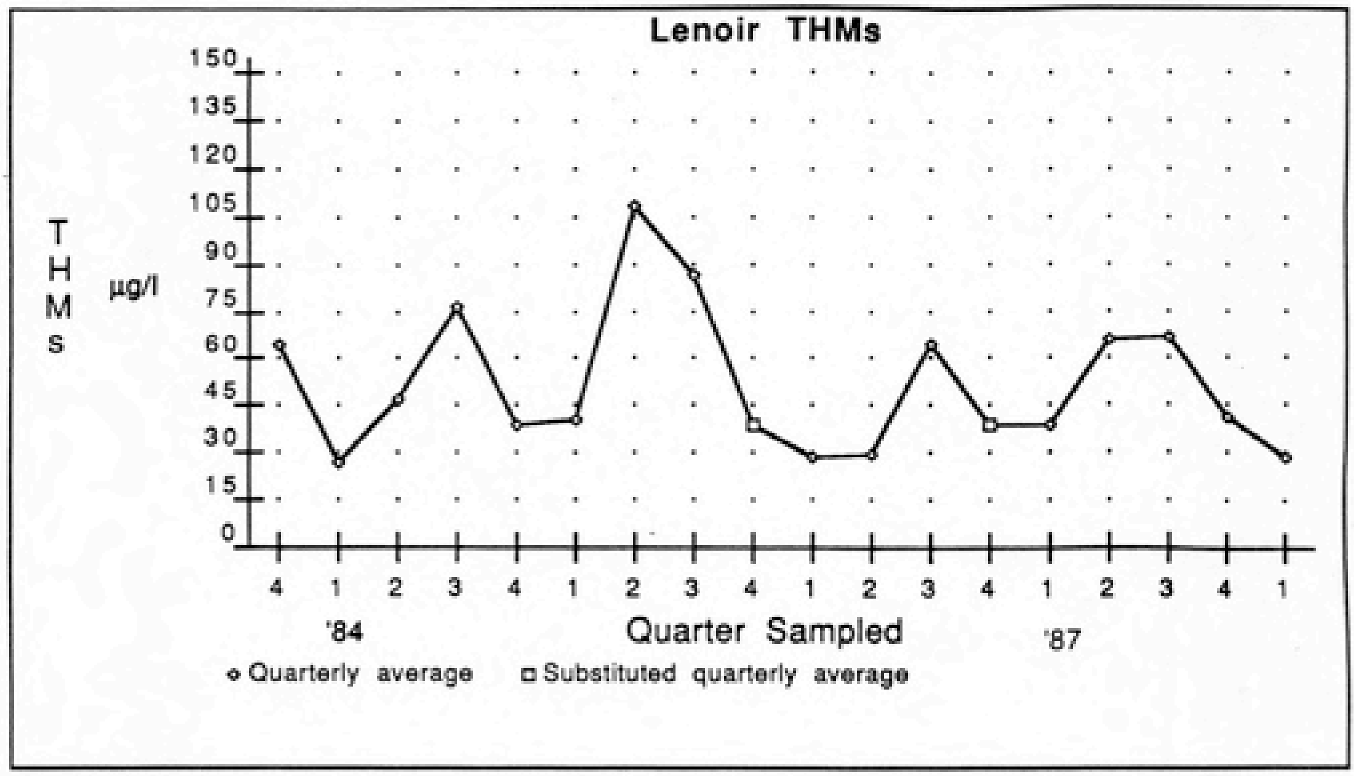
Town of Laurinburg THMs
T H M s µg/l
10
9
8
7
6
5
4
3
2
1
0
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'83
'84
Quarter Sampled
'87
'88
Quarterly average
Substituted quarterly average

Town of Laurinburg THM Records

Plant: Laurinburg		Ω-measurement discarded for adjusted average calculation			
		Σ-some measurements(Ω) discarded before calculating average			
PWID: 0383010					
Population Served: 15579					
			Unadjusted	Adjusted	Quarterly
Date of		TTHM's	Average Reading	Average Reading	Average Reading
Sampling		µg/l	µg/l	µg/l	µg/l
05/10/88		2	2		2
02/12/88		2	2		2
10/22/87		2	2		2
07/21/87		2	2		2
02/19/87		2	2		2
10/21/86		2	2		2
07/23/86		2	2		2
05/06/86		2	2		2
02/25/86		2	2		2
11/05/85		2	2		2
07/30/85		2	2		2
05/01/85		2	2		2
02/14/85		2	2		2
11/26/84		2	2		2
08/28/84		4	4		4
06/12/84		2	2		2
02/22/84		2	2		2
08/31/83		2			
"		12			
"		23			
"		2	10		10

Town of Laurinburg THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
05/17/83		2				
"		2				
"		2				
"		2	2		2	
03/02/83		2				
"		2				
"		2				
"		2	2			
01/11/83		2				
"		2				
"		2				
"		2	2		2	

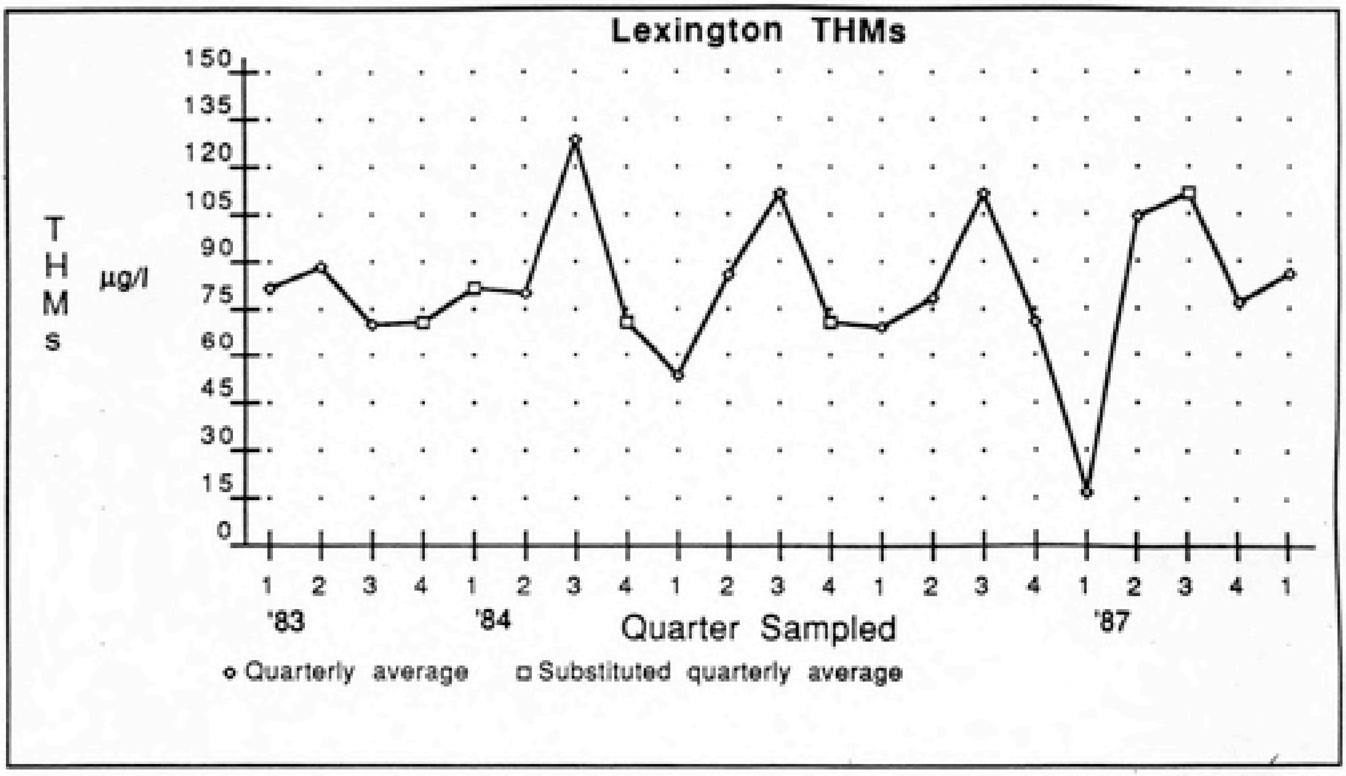


Lenoir THMs
150
135
120
105
90
75
60
45
30
15
0
T H M s
µg/l
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'84
Quarter Sampled
'87
◇ Quarterly average
□ Substituted quarterly average

Plant: Lenoir			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0114010						
Population Served: 15200						
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/24/88		24				
"		31				
"		32				
"		30	29			
01/14/88		23	23		28	
12/22/87		39				
"		43				
"		42	41		41	
09/17/87		46				
"		73				
"		78				
"		72	67		67	
05/29/87	Ω	73				
"	Ω	73	73			
05/27/87		73				
"	Ω	68				
"	Ω	52				
"		73	66	73		
05/20/87		52				
"		68	60		66	Σ
03/05/87		26				
"		30				
"		27				
"		22	26			
02/05/87	Ω	52				
"		50				
"	Ω	55				
"	Ω	45	51	50		
01/29/87		55				
"		45				
"		52	51		38	Σ

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
09/19/86	Ω	58				
"	Ω	59				
"	Ω	105				
"	Ω	97	80			
09/18/86		97				
"		105				
"		59				
"		58	80			
07/08/86	Ω	38				
"	Ω	51				
"	Ω	30				
"	Ω	75	49			
07/07/86		30				
"		51				
"		38				
"		75	49		64	Σ
04/01/86		22				
"		30				
"		30				
"		34	29		29	
01/02/86		21				
"		38				
"		25				
"		30	28		28	
09/12/85	Ω	57				
"	Ω	99				
"	Ω	94				
"	Ω	93				
"		57				
"		94				
"		99				
"		93	86	86		
07/09/85	Ω	72				
"	Ω	70				
"	Ω	106	83			

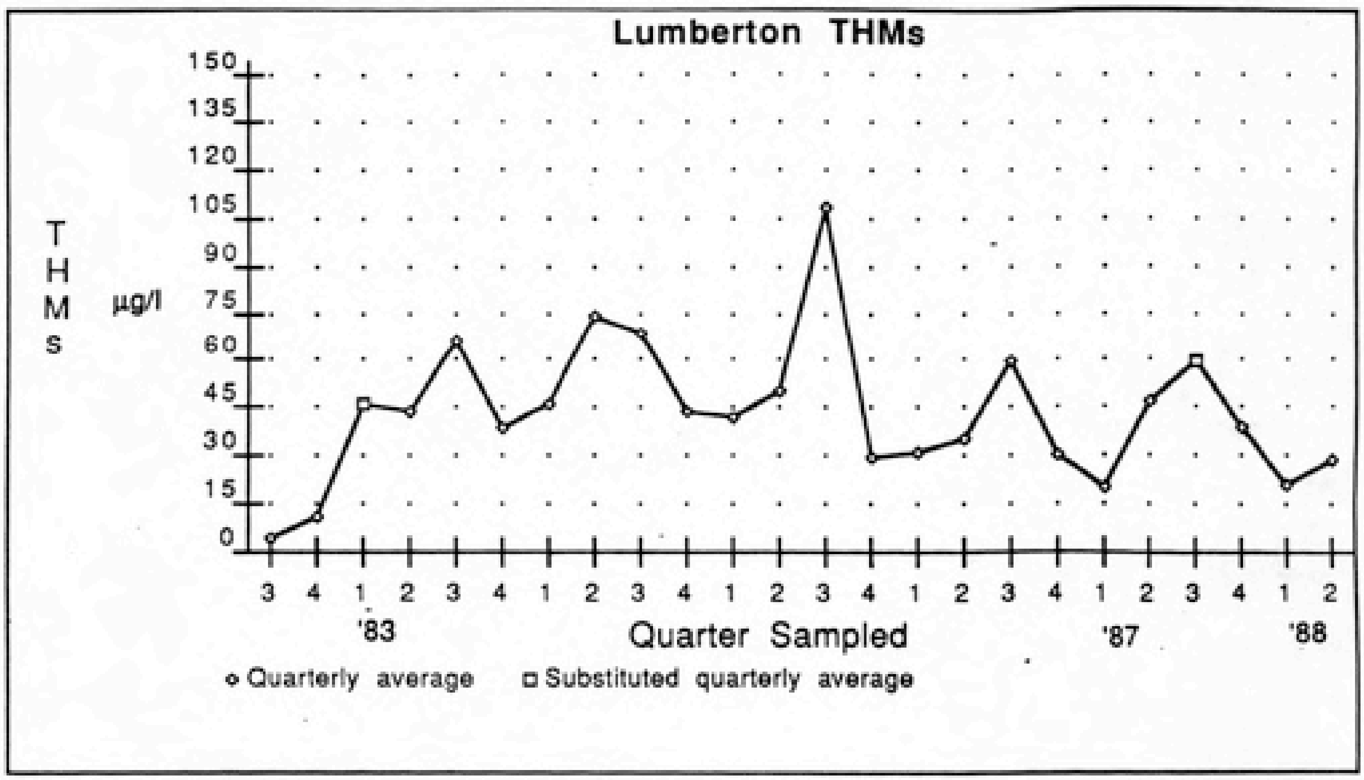
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
07/02/85		106				
"		70				
"		72				
"		108	89		87	Σ
06/09/85		108	108		108	
03/13/85	Ω	36				
"	Ω	51				
"	Ω	36				
"	Ω	35				
		35				
"		36				
"		36				
"		51	40	40	40	Σ
12/19/84		37				
"	Ω	37				
"		40				
"	Ω	40	39	38	38	Σ
09/26/84		79				
"		65				
"		65				
"		43	63			
07/13/84		120				
"		89				
"		84				
"		74	92		77	
04/19/84		57				
"		46				
"		47				
"		40	47		47	
02/18/83		30				
"		28				
"		30				
"		22	27		27	
12/16/82		61				
"		76				
"		59				
"		61	64		64	


Lexington THMs
150
135
120
105
90
75
60
45
30
15
0
T H M s
µg/l
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
'87
Quarter Sampled
Quarterly average
Substituted quarterly average

Plant: Lexington			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0229010						
Population Served: 21000						
			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
02/18/88		63				
"		41				
"		52				
"		48	51		51	
12/22/87		58				
"		46				
"		61				
"		56	55			
10/14/87		94				
"		94				
"		105				
"		99	98		77	
06/23/87		99				
"		100				
"		110				
"		107	104		104	
03/06/87		17				
"		12				
"		21				
"		19	17		17	
12/23/86		62				
"		90				
"		58				
"		76	71		71	
08/07/86		120				
"		115				
"		100	112		112	
04/25/86		70				
"		62				
"		73				
"	Ω	48				
"		108	72	78	78	Σ

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
03/06/86	56			
"	43			
"	70			
"	49	54		
01/06/86	83			
"	76			
"	82			
"	92	83		69
08/12/85	104			
"	95			
"	117			
"	113	107		
07/11/85	118			
"	122			
"	109			
"	115	116		112
04/16/85	82			
"	82			
"	90			
"	92	86		86
01/23/85	55			
"	52			
"	48			
"	58	53		53
08/31/84	123			
"	123			
"	136			
"	130	128		128
05/16/84	79			
"	65			
"	88			
"	89	80		80
09/23/83	68			
"	72			
"	69	70		70

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
06/20/83	83			
"	88			
"	93			
"	88	88		88
03/09/83	93			
"	72			
"	86			
"	77	82		82



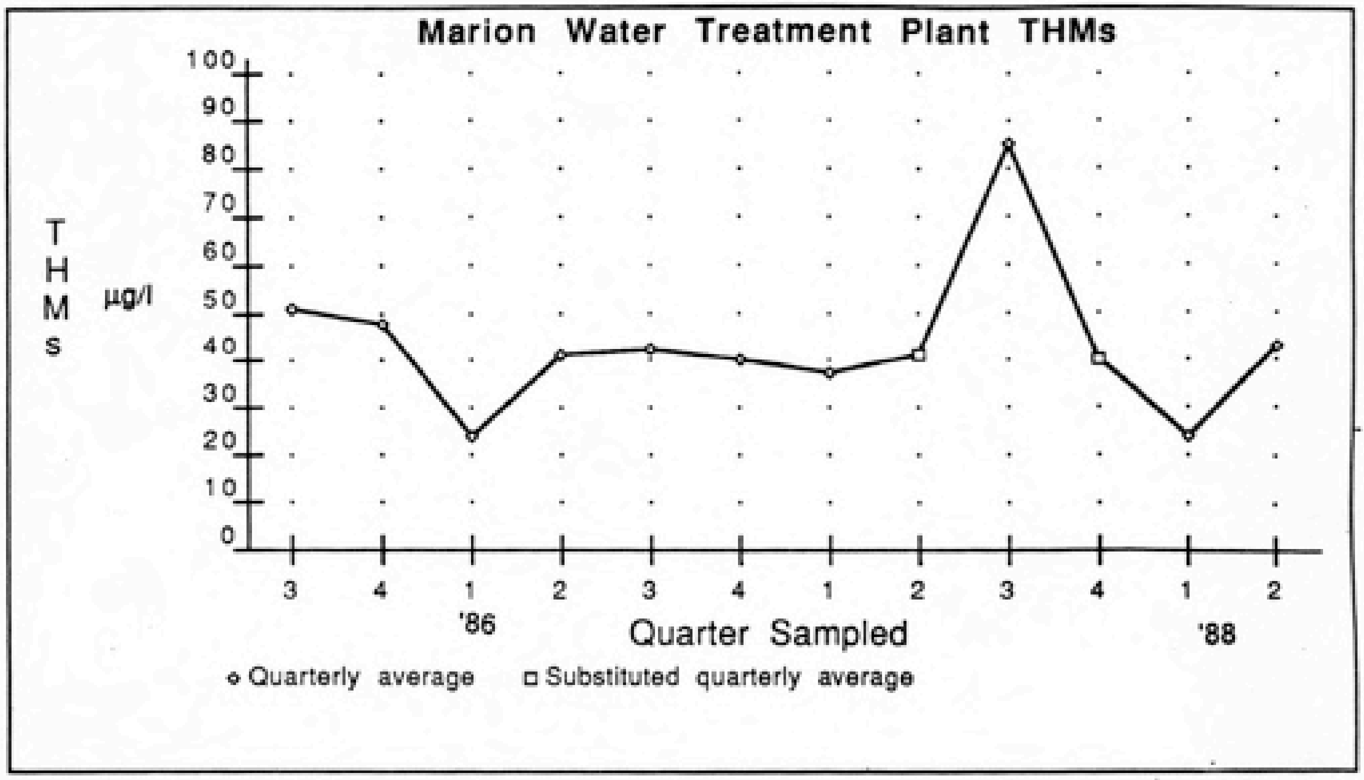
Lumberton THMs
T H M s µg/l
150
135
120
105
90
75
60
45
30
15
0
3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'83
Quarter Sampled
'87
'88
○ Quarterly average
□ Substituted quarterly average

Plant: Lumberton		Ω-measurement discarded for adjusted average calculation		
		Σ-some measurements(Ω) discarded before calculating average		
PWID: 0378010				
Population Served: 20000				
Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
04/12/88	23			
"	26			
"	35			
"	27	28		28
02/10/88	21			
"	22			
"	23			
"	20	21		21
12/07/87	36			
"	43			
"	47			
"	51	44		
10/05/87	19			
"	49			
"	35			
"	26	32		38
06/16/87	41			
"	66			
"	40			
"	43	47		47
02/26/87	13			
"	18			
"	18			
"	30	20		20
12/18/86	27			
"	31			
"	36			
"	28	30		30
07/29/86	43			
"	46			
"	66			
"	83	59		59

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
05/14/86		42				
"		24				
"		48				
"		25	35		35	
02/26/86		15				
"		19				
"		29				
"		63	31		31	
12/17/85		17				
"		22				
"		49				
"	Ω	85	43	29	29	Σ
08/20/85		90				
"		97				
"		126				
"		118	108		108	
05/09/85		36				
"		37				
"		49				
"		80	50		50	
03/11/85		31				
"		33				
"		33				
"		46				
"		68	42		42	
11/07/84		22				
"		32				
"		48				
"		70	43		43	
08/30/84		42				
"		55				
"		86				
"		91	68		68	
06/05/84		56				
"		73				
"		94				
"	Ω	112	84	74	74	Σ

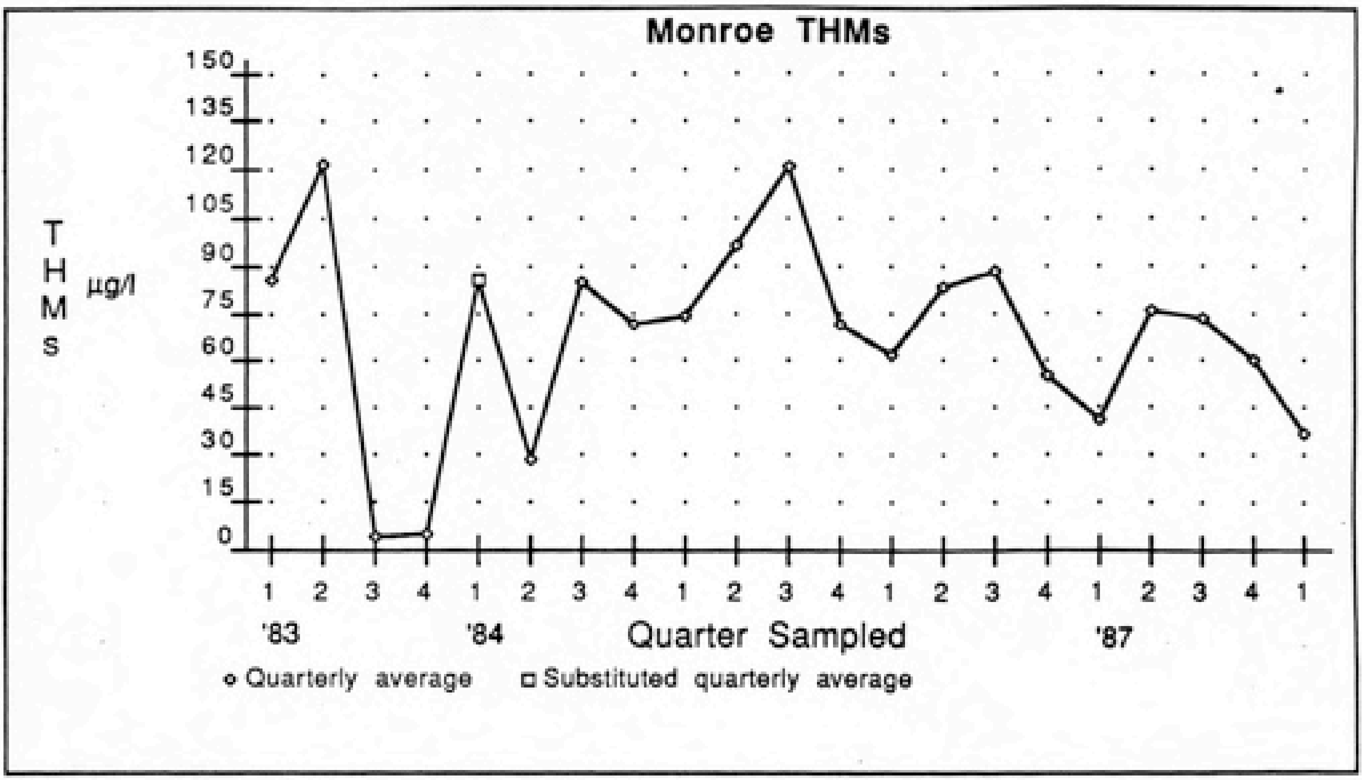
Lumberton THM Records

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
03/07/84	64			
"	50			
"	40			
"	31	46		46
12/26/83	39			
"	14			
"	47			
"	52	38		38
08/22/83	56			
"	59			
"	67			
"	91			
"	56	66		66
05/18/83	19			
"	44			
"	56			
"	55	43		43
12/22/82	10			
"	13	11		11
08/26/82	3			
"	5	4		4


Marion Water Treatment Plant THMs
THMs
µg/l
100
90
80
70
60
50
40
30
20
10
0
3
4
1
2
3
4
1
2
3
4
1
2
'86
Quarter Sampled
'88
Quarterly average
Substituted quarterly average

Marion Water Treatment Plant THM Records

Plant: Marion			Ω-measurement discarded for adjusted average calculation		
			Σ-some measurements(Ω) discarded before calculating average		
PWID: 0156010					
Population Served: 10000					
			Unadjusted	Adjusted	Quarterly
Date of		TTHM's	Average Reading	Average Reading	Average Reading
Sampling		µg/l	µg/l	µg/l	µg/l
04/14/88		43	43		43
01/11/88		24	24		24
07/06/87	Ω	85	85		
07/01/87		85	85		85
04/27/87	Ω	37	37		
03/27/87		37	37		37
12/29/86	Ω	40	40		
12/22/86		40	40		40
09/30/86		42	42		42
05/29/86		38			
"		37			
"		39			
"		49	41		41
03/03/86		25			
"		22			
"		25	24		24
11/04/85		47			
"		46			
"		43			
"		57	48		48
08/09/85		43			
"		41			
"		80			
"		41	51		51


Monroe THMs
150
135
120
105
90
75
60
45
30
15
0
THMs µg/l
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
'87
Quarter Sampled
Quarterly average
Substituted quarterly average

Plant: Monroe

Ω-measurement discarded for adjusted average calculation

Σ-some measurements(Ω) discarded before calculating average

PWID: 0190010

Population Served: 15500

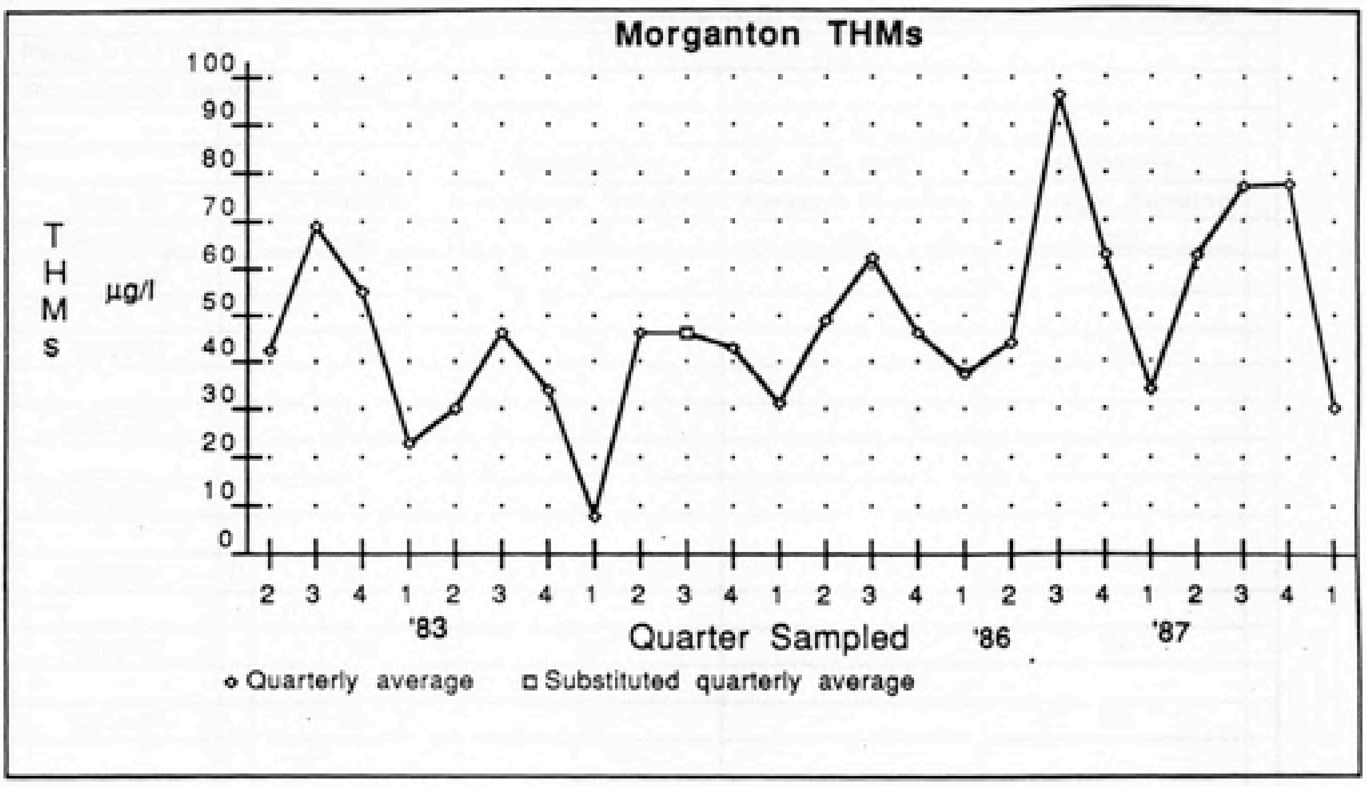
Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
03/18/88	14			
"	41			
"	43			
"	49	37		37
12/10/87	22			
"	95			
"	57			
"	66	60		60
09/18/87	11			
"	89			
"	92			
"	100	73		73
06/11/87	27			
"	82			
"	89			
"	107	76		76
03/25/87	11			
"	48			
"	51			
"	56	41		41
12/05/86	18			
"	60			
"	65			
"	78	55		55
09/11/86	18			
"	106			
"	106			
"	123	88		88
06/05/86	27			
"	93			
"	101			
"	113	83		83

Monroe THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
03/19/86		14				
"		79				
"		77				
"		77	62		62	
10/30/85		20				
"		82				
"		84				
"		102	72		72	
09/06/85		22				
"		157				
"		151				
"		156	121		121	
05/01/85		122				
"		125				
"		117				
"		25	97		97	
02/20/85		109				
"		89				
"		85				
"		15	74		74	
12/05/84		71				
"		88				
"		88				
"		43	72		72	
09/14/84		104				
"		59				
"		86				
"		90	85		85	
05/01/84		5				
"		30				
"		41				
"		36	28		28	
12/20/83		5				
"		5				
"		6				
"		5	5		5	

Monroe THM Records

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
08/11/83	3			
"	3			
"	4			
"	5	4		4
04/26/83	109			
"	117			
"	125			
"	136	122		122
02/24/83	88			
"	82			
"	86			
"	90	86		86
12/16/82	122			
"	161			
"	146			
"	149	144		144

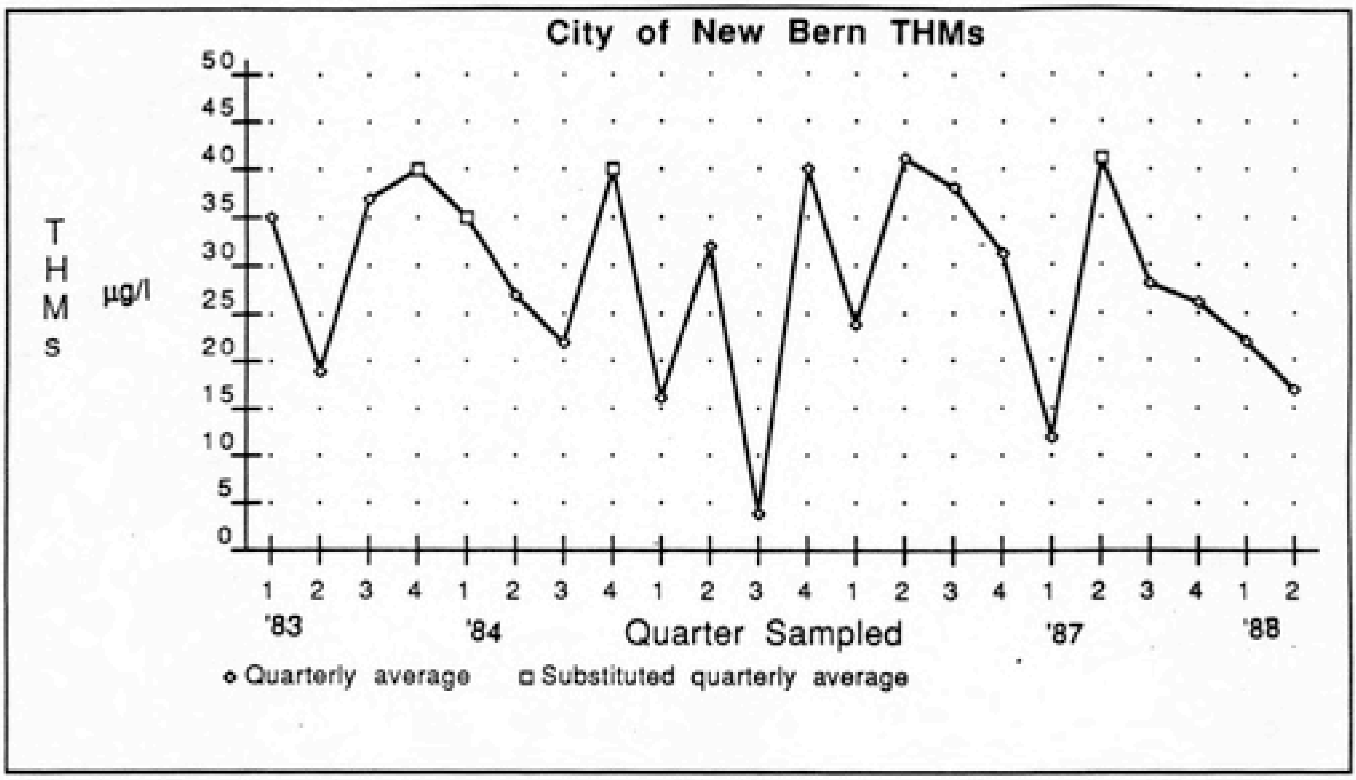

Morganton THMs
100
90
80
70
60
50
40
30
20
10
0
THMs
µg/l
2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
Quarter Sampled
'86
'87
Quarterly average
Substituted quarterly average

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/24/84		8	8		8	
11/22/83		60				
"		39				
"		45				
"		37				
"		35				
"		33				
"		42				
"		28				
"		13				
"		16				
"		25				
"		38	34		34	
08/12/83		47				
"		33				
"		20				
"		15				
"		37				
"		47				
"		42				
"		44				
"		68				
"		71				
"		64				
"		65	46		46	
04/19/83		40				
"		30				
"		32				
"		32				
"		26				
"		27				
"		31				
"		24				
"	Ω	4				
"	Ω	6				
"		33				
"		30	26	30	30	Σ

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/11/83		21				
"		26				
"		16				
"		22				
"		20				
"		6				
"		13				
"		18				
"		35				
"		34				
"		29				
"		30	23		23	
11/29/82		55				
"		66				
"	Ω	517				
"		54				
"		91				
"		66				
"		63				
"		69				
"		18				
"		8				
"		33	95	52		
11/22/82		87	87		55	Σ
08/29/82		98	98			
08/26/82		86				
"		81				
"		76				
"		49				
"		69				
"		51				
"		51				
"		97				
"		26				
"		66				
"		83	67		69	

Morganton THM Records

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
05/21/82	52			
"	53			
"	50			
"	51			
"	42			
"	14			
"	29			
"	48			
"	42			
"	45			
"	42			
"	41	42		42

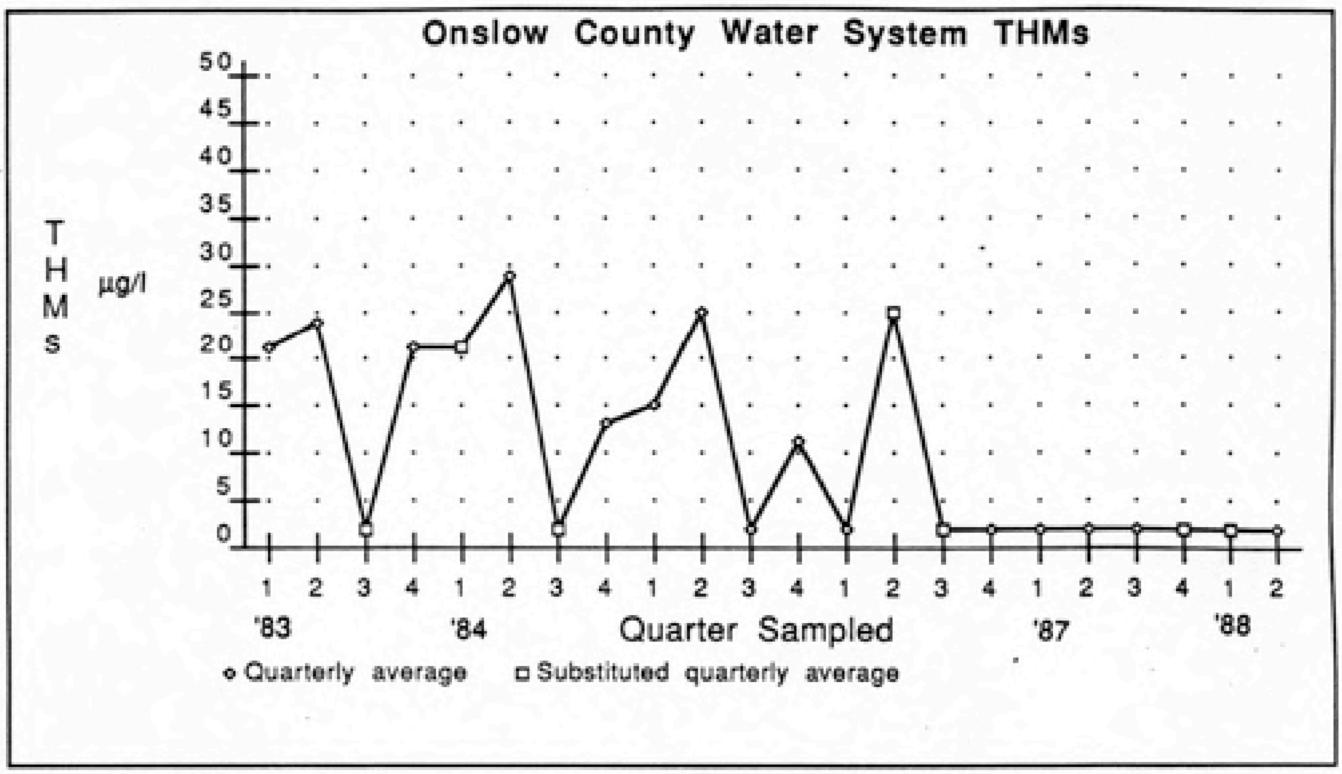

City of New Bern THMs
50
45
40
35
30
25
20
15
10
5
0
THMs µg/l
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'83
'84
Quarter Sampled
'87
'88
Quarterly average
Substituted quarterly average

Plant: City of New Bern	Ω-measurement discarded for adjusted average calculation		
	Σ-some measurements(Ω) discarded before calculating average		
PWID: 0425010			
Population Served: 22263			

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
05/10/88	17	17		17
01/27/88	22	22		22
10/21/87	26	26		26
07/29/87	28	28		28
01/15/87	12	12		12
11/04/86	31	31		31
07/30/86	38	38		38
05/14/86	41	41		41
01/23/86	24	24		24
10/15/85	40	40		40
07/16/85	4	4		4
06/13/85	32	32		32
01/18/85	14	14		
01/04/85	18	18		16
09/26/84	22	22		22
05/09/84	27	27		27
09/28/83	34			
"	42			
"	36			
"	35	37		37

City of New Bern THM Records

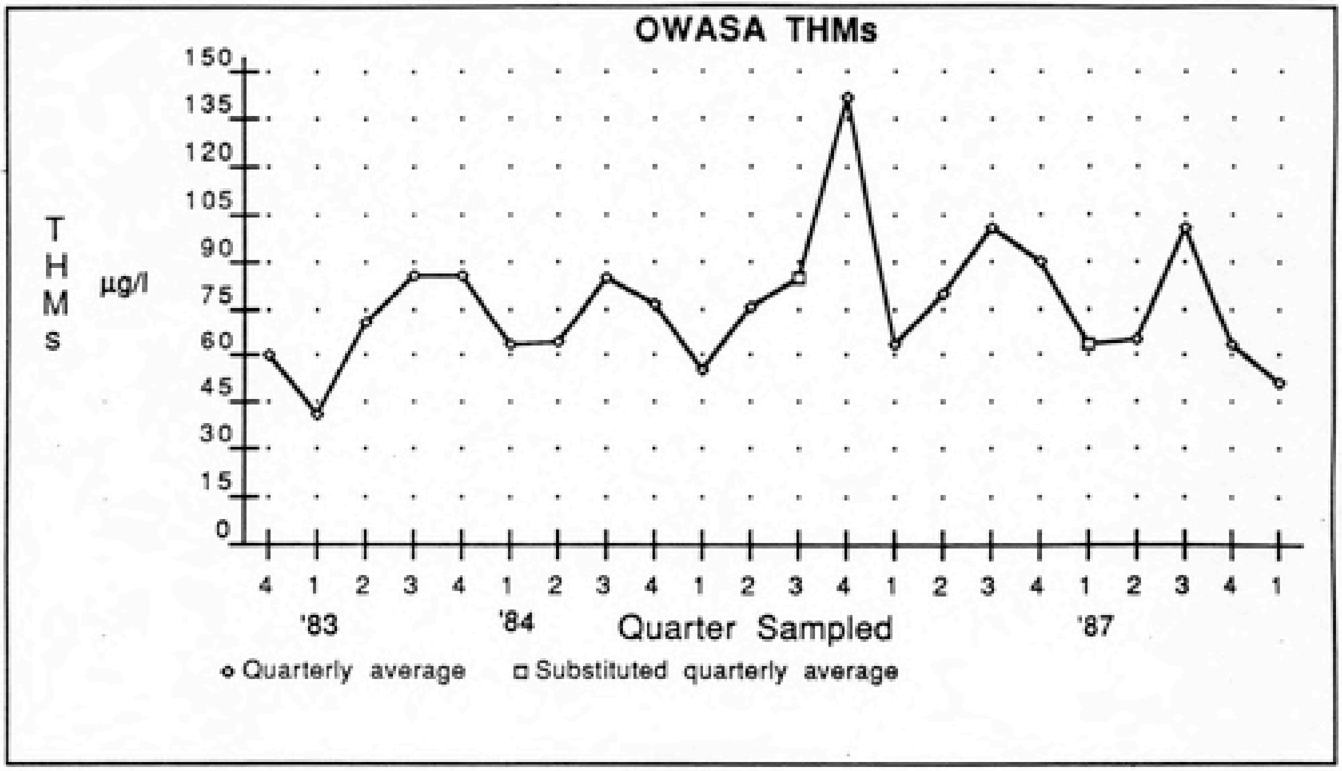
Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
06/15/83	11			
"	22			
"	26			
"	16	19		19
03/08/83	37			
"	35			
"	41			
"	42	39		
01/17/83	30			
"	32			
"	26			
"	34	30		35


Onslow County Water System THMs
THMs µg/l
50
45
40
35
30
25
20
15
10
5
0
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'83
'84
Quarter Sampled
'87
'88
Quarterly average
Substituted quarterly average

Plant: Onslow County		Ω-measurement discarded for adjusted average calculation		
		Σ-some measurements(Ω) discarded before calculating average		
PWID: 0467035				
Population Served: 46250				
		Unadjusted	Adjusted	Quarterly
Date of Sampling	TTHM's µg/l	Average Reading µg/l	Average Reading µg/l	Average Reading µg/l
05/17/88	2			
"	2			
"	2			
"	2	2		2
08/10/87	2			
"	2			
"	2			
"	2	2		2
05/27/87	2			
"	2			
"	2			
"	2	2		2
02/13/87	4			
"	2			
"	2			
"	2	2		2
11/18/86	2			
"	2			
"	2			
"	2	2		2
02/12/86	3			
"	3			
"	0			
"	3	2		2
10/17/85	11			
"	11			
"	11			
"	11	11		11
07/17/85	2			
"	2			
"	2			
"	2	2		2

Onslow County Water System THM Records

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
04/18/85	24			
"	24			
"	24			
"	27	25		25
01/18/85	15	15		15
12/27/84	11			
"	3			
"	11			
"	11	9		
10/15/84	15			
"	15			
"	18			
"	19	17		13
05/30/84	20			
"	36			
"	36			
"	24	29		29
10/07/83	21	21		21
06/16/83	24	24		24
03/11/83	26	26		
01/14/83	17	17		21


OWASA THMs
150
135
120
105
90
75
60
45
30
15
0
T H M s
µg/l
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
Quarter Sampled
'87
Quarterly average
Substituted quarterly average

Plant: OWASA			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0368010						
Population Served: 60000						
			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
02/26/88		38				
"		51				
"		44				
"		62				
"		58	51		51	
11/19/87		42				
"		79				
"		58				
"		62	60			
11/13/87		71				
"	Ω	1				
"	Ω	1	24	71		
11/11/87		64	64		63	Σ
09/23/87		98	98			
08/20/87	Ω	102				
"	Ω	102				
"	Ω	124				
"	Ω	95				
"	Ω	88	102			
08/17/87		102				
"		102				
"		124				
"		95				
"		88	102			
07/09/87		98				
"	Ω	1				
"	Ω	1	33	98	101	Σ
06/03/87		69				
"		103				
"		87				
"		99				
"	Ω	127	97	89		

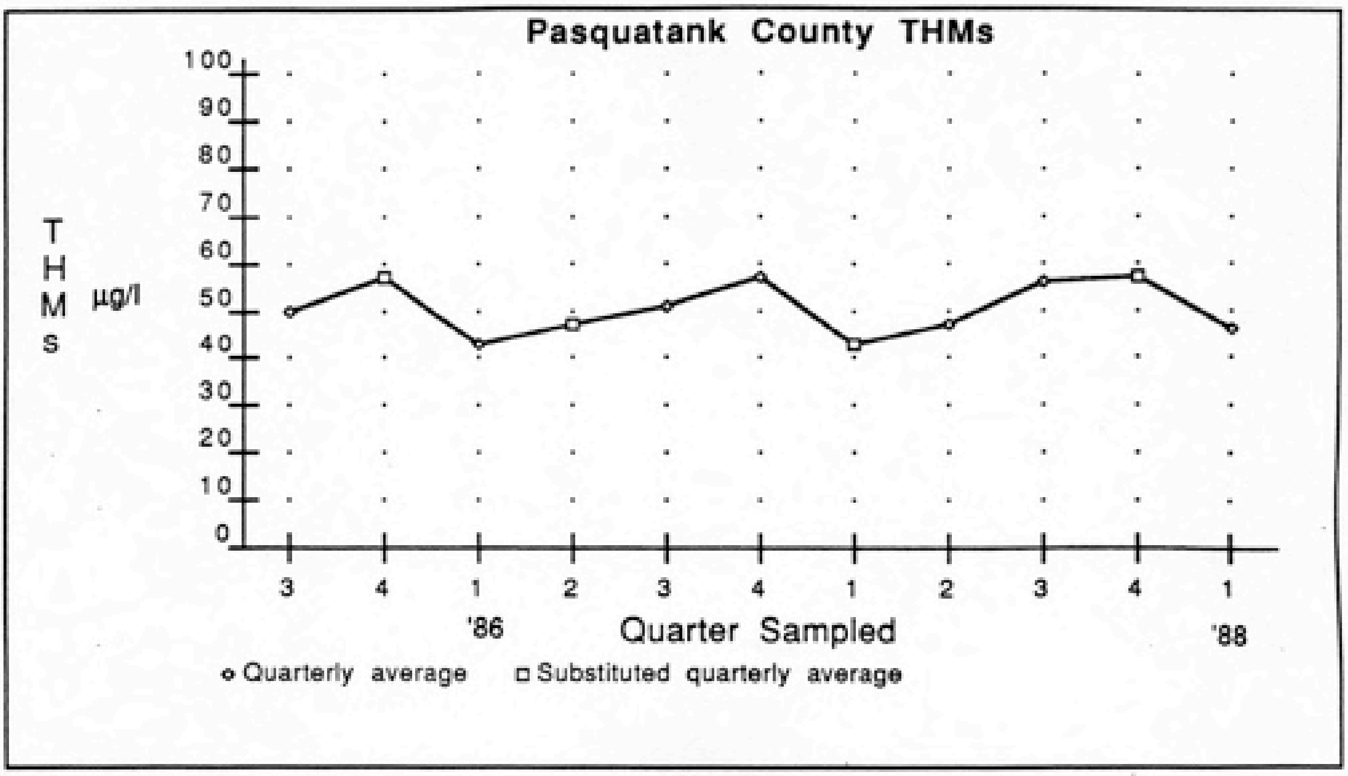
OWASA THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
04/15/87		36				
"		40				
"		56				
"		41				
"		55	46		65	Σ
12/10/86		53				
"		99				
"		119				
"		67				
"		101	88			
11/13/86		100	100		90	
08/20/86		123				
"		110				
"		109				
"		126	117			
08/07/86		68				
"		68	68		101	
06/11/86		90				
"		71				
"	Ω	90				
"	Ω	71	80	80	80	Σ
02/26/86		68				
"		65				
"		56				
"		62	63			
01/08/86		69	69			
01/06/86		59				
"		69				
"		56	61		63	
10/16/85		142				
"		159				
"		127				
"		139	142		142	

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
05/19/85	Ω	69				
"	Ω	99				
"	Ω	70				
"	Ω	68	76			
05/16/85		69				
"		70				
"		99				
"		68	76		76	
02/21/85		52				
"		52				
"		65				
"		52	55		55	
11/09/84		94				
"		54				
"		78				
"		83	77		77	
08/15/84		87				
"		78				
"		92				
"		82	85		85	
04/26/84		55				
"		75				
"		54				
"		72	64		64	
03/02/84		65				
"		54				
"		78				
"		55	63		63	
11/28/83		94				
"	Ω	94				
"		79				
"	Ω	79	86	86	86	Σ
08/04/83		82				
"		79				
"		98				
"		87	86		86	

OWASA THM Records

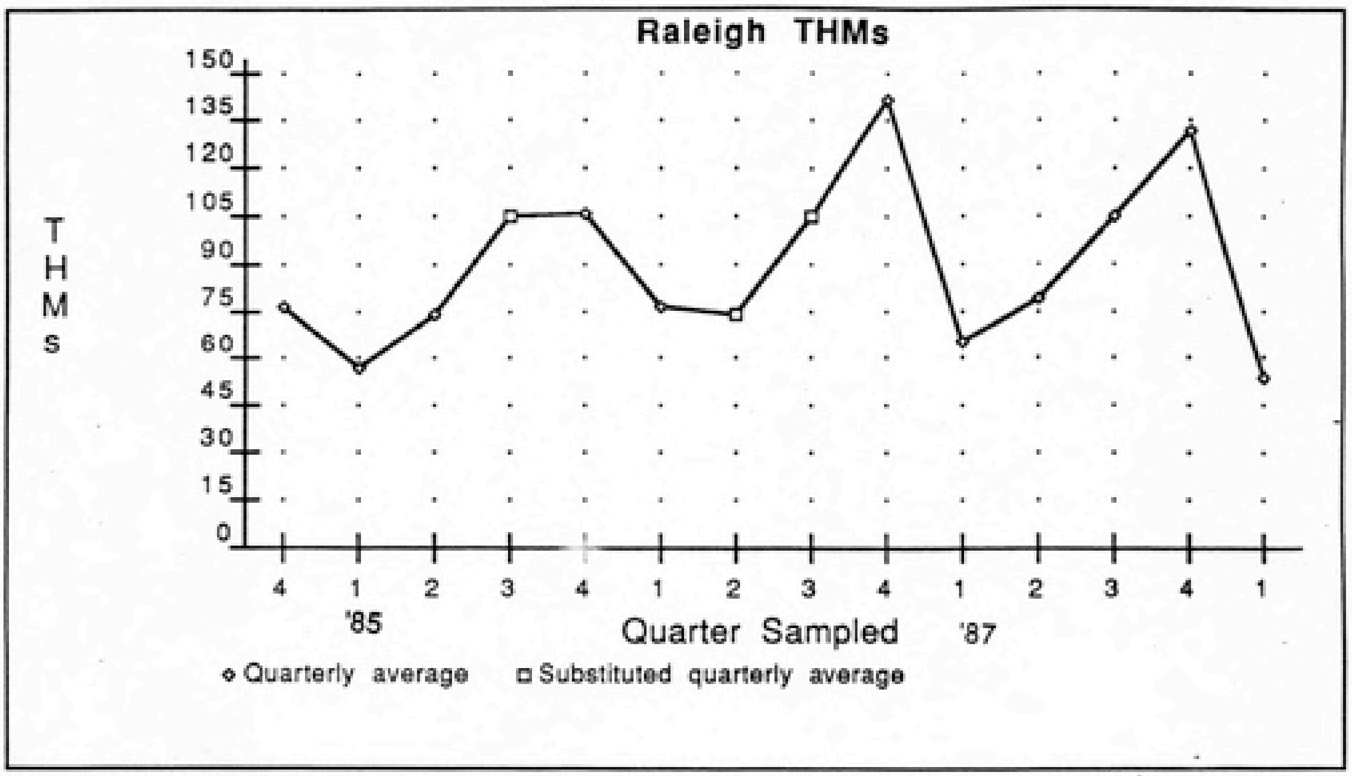
Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
05/19/83	76			
"	59			
"	59			
"	89	71		71
02/02/83	37			
"	43			
"	42			
"	42	41		41
12/29/82	47			
"	56			
"	60			
"	77	60		60


Pasquatank County THMs
100
90
80
70
60
50
40
30
20
10
0
THMs µg/l
3
4
1
2
3
4
1
2
3
4
1
'86
Quarter Sampled
'88
Quarterly average
Substituted quarterly average

Plant: Pasquatank County			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0470015						
Population Served: 13000						
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
01/11/88		20				
"		37				
"		60				
"		67	46		46	
09/25/87	Ω	144				
"		70				
"		33				
"		30	69	45		
09/01/87	Ω	106				
"	Ω	76				
"	Ω	49				
"	Ω	30	65			
08/31/87		30				
"		49				
"		106				
"		76	65		56	Σ
06/22/87	Ω	73				
"	Ω	53				
"	Ω	42				
"	Ω	21	47			
06/18/87		21				
"		73				
"		42				
"		53	47		47	
10/20/86		29				
"		42				
"		20				
"		137	57		57	
08/29/86		23				
"		8				
"		70				
"		88	47			

Pasquatank County THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
07/07/86		30			
"		51			
"		61			
"		75	55		51
05/07/86	Ω	66			
"	Ω	51			
"	Ω	51			
"	Ω	11	45		
02/13/86		11			
"		51			
"		44			
"		66	43		43
07/26/85	Ω	14			
"	Ω	48			
"	Ω	50			
"	Ω	87	50		
07/15/85		48			
"		14			
"		50			
"		87	50		50


Raleigh THMs
150
135
120
105
90
75
60
45
30
15
0
T H M s
4 1 2 3 4 1 2 3 4 1 2 3 4 1
'85
Quarter Sampled
'87
◇ Quarterly average
□ Substituted quarterly average

Plant: City of Raleigh			Ω-measurement discarded for adjusted average calculation		
			Σ-some measurements(Ω) discarded before calculating average		
PWID: 0392010					
Population Served: 170000					
			Unadjusted	Adjusted	Quarterly
Date of Sampling		TTHM's µg/l	Average Reading µg/l	Average Reading µg/l	Average Reading µg/l
03/16/88	Ω	55			
"	Ω	54			
"	Ω	53			
"	Ω	51			
"	Ω	49			
"	Ω	45			
"	Ω	38			
"	Ω	63			
"	Ω	43			
"	Ω	46	50		
02/29/88		55			
"		54			
"		53			
"		51			
"		49			
"		45			
"		38			
"		63			
"		43			
"		46			
"		44	49		
01/11/88		44			
"	Ω	46			
"	Ω	49			
"	Ω	54			
"	Ω	60			
"	Ω	74			
"	Ω	62			
"	Ω	88			
"	Ω	47			
"	Ω	46	57	44	

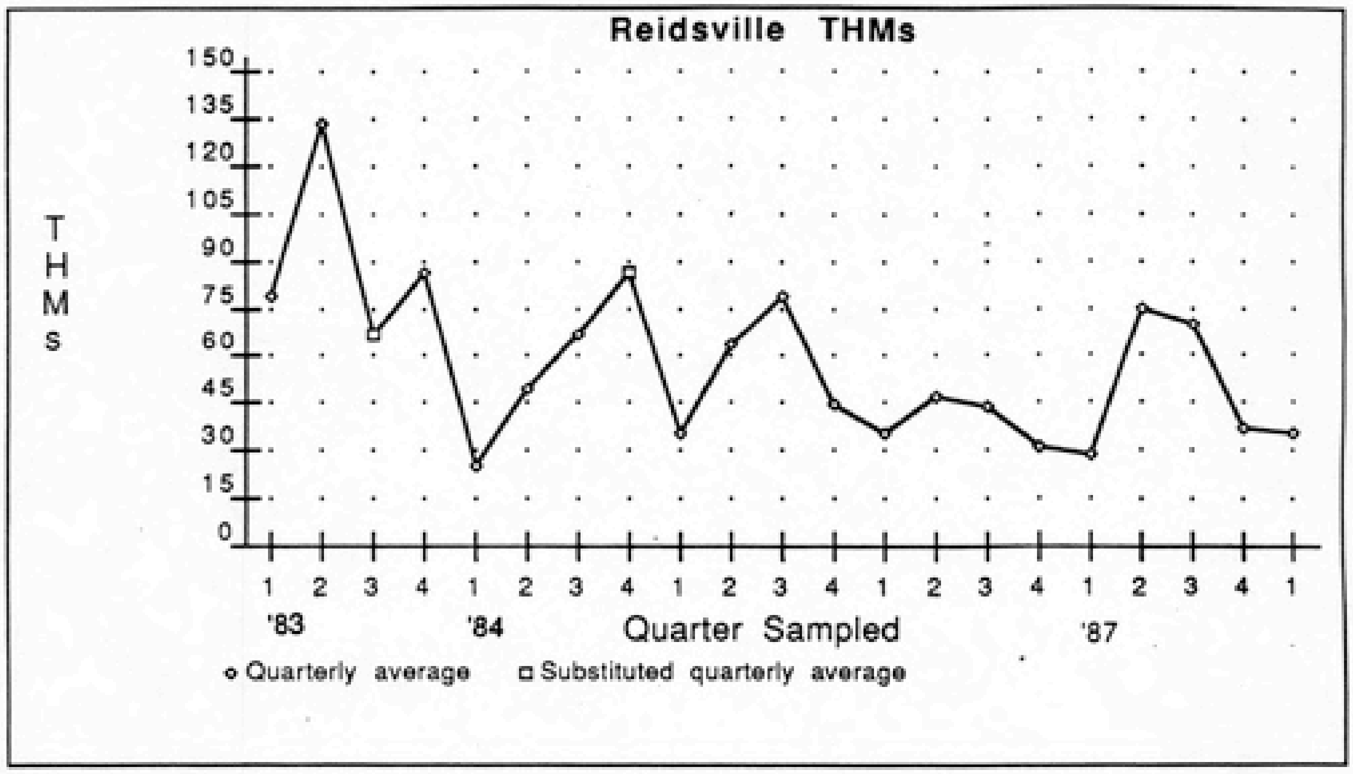
City of Raleigh THM Records

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
03/24/87	62			
"	60			
"	68			
"	70			
"	71			
"	66			
"	66			
"	60			
"	66			
"	72	66		
01/08/87	65			
"	69			
"	69			
"	69			
"	64			
"	60			
"	50			
"	70			
"	64			
"	70	65		
01/06/87	44	44		65
10/20/86	127			
"	141			
"	143			
"	110			
"	136			
"	148			
"	154			
"	149			
"	155			
"	156	142		142

City of Raleigh THM Records

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
03/10/86	71			
"	90			
"	89			
"	87			
"	76			
"	73			
"	71			
"	64			
"	79			
"	69			
"	74	77		77
10/17/85	124			
"	113			
"	115			
"	111			
"	103			
"	99			
"	89			
"	104			
"	103			
"	100	106		106
06/26/85	85			
"	83			
"	81			
"	73			
"	71			
"	58			
"	68			
"	65			
"	68	72		
06/25/85	86	86		74

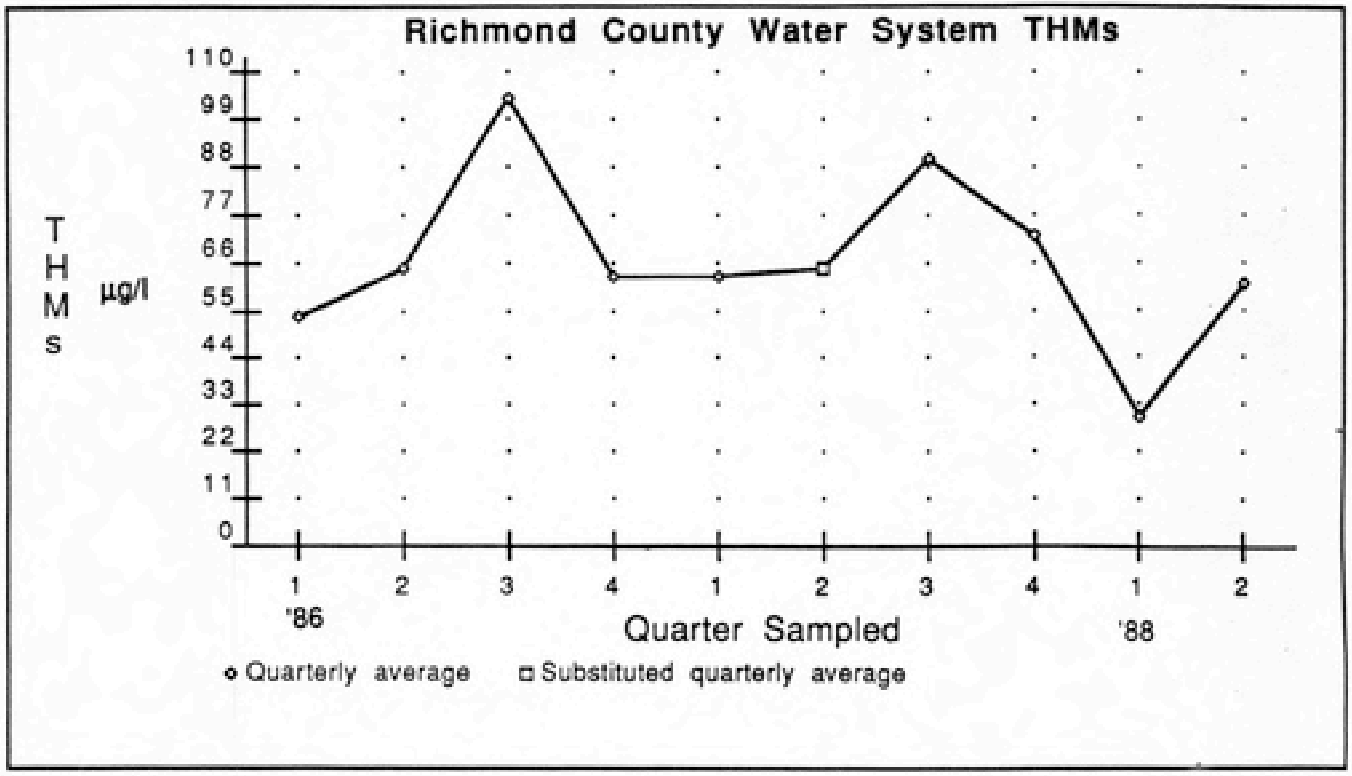
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/28/85	Ω	51				
		51	51	51		
02/26/85	Ω	57				
"		57				
"	Ω	51				
"		51				
"	Ω	53				
"		53				
"	Ω	51				
"		51				
"	Ω	52				
"		52				
"	Ω	52				
"		52				
"	Ω	78				
"		78				
"	Ω	57				
"		57				
"	Ω	71				
"		71	58	58	57	Σ
12/17/84		77				
"		77				
"		78	77		77	


Reidsville THMs
THMs
150
135
120
105
90
75
60
45
30
15
0
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
'87
Quarter Sampled
Quarterly average
Substituted quarterly average

Plant: Reidsville			Ω-measurement discarded for adjusted average calculation		
			Σ-some measurements(Ω) discarded before calculating average		
PWID: 0279020					
Population Served: 13000					
			Unadjusted	Adjusted	Quarterly
Date of Sampling		TTHM's µg/l	Average Reading µg/l	Average Reading µg/l	Average Reading µg/l
03/16/88		30			
"		35			
"		34			
"		41	35		35
12/08/87		34			
"		34			
"		44			
"		38	37		37
09/28/87	Ω	62			
"	Ω	65			
"	Ω	75			
"	Ω	78	70		
09/03/87		62			
"		65			
"		75			
"		78	70		
07/31/87	Ω	76			
"	Ω	76			
"	Ω	77			
"	Ω	73	75		70
06/04/87		73			
"		76			
"		77			
"		76	75		75
03/19/87		36			
"		28			
"		26			
"		23	28		28
11/25/86		33			
"		28			
"		33			
"		32	31		31

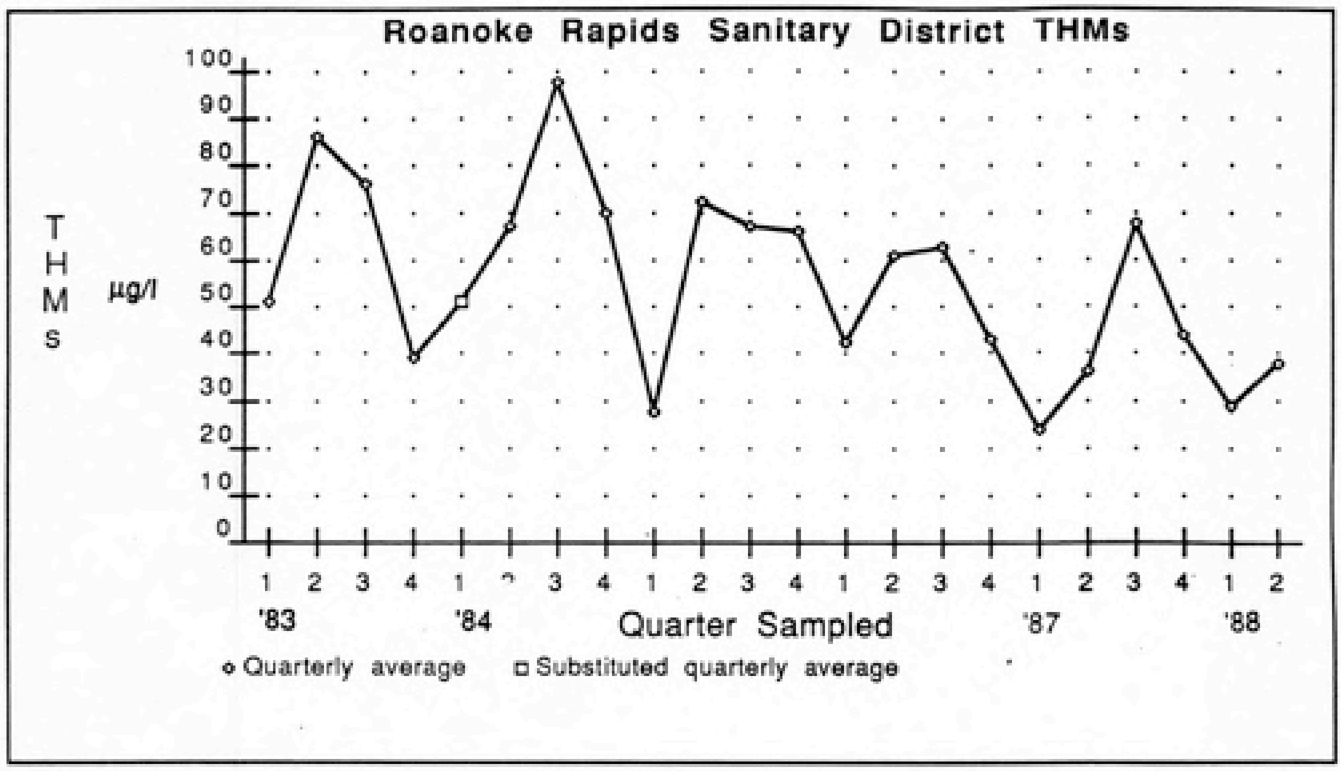
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
08/27/86		43				
"		39				
"		42				
"		49	43		43	
05/29/86		46				
"		39				
"		52				
"		54	48			
04/03/86		43				
"		52				
"		50				
"		42	47		47	
12/03/85		45				
"		55				
"		25				
"		51	44		44	
09/03/85		77				
"		80				
"		89				
"		72	79		79	
05/21/85		63				
"		71				
"		70				
"		50	63		63	
03/19/85		32				
"		29				
"		42				
"		36	35		35	
08/02/84		65				
"		77				
"		57				
"		69	67		67	
05/15/84		52				
"		48				
"		46				
"		49	49		49	

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
01/10/84		21				
"		32				
"		25				
"		23	25		25	
10/14/83		73				
"		101				
"		88				
"		87	87		87	
06/15/83		123				
"		140				
"		132				
"		139	133		133	
02/09/83		88				
"		79				
"	Ω	104				
"		69	85	79	79	Σ


Richmond County Water System THMs
THMs µg/l
110
99
88
77
66
55
44
33
22
11
0
1
2
3
4
1
2
3
4
1
2
'86
Quarter Sampled
'88
Quarterly average
Substituted quarterly average

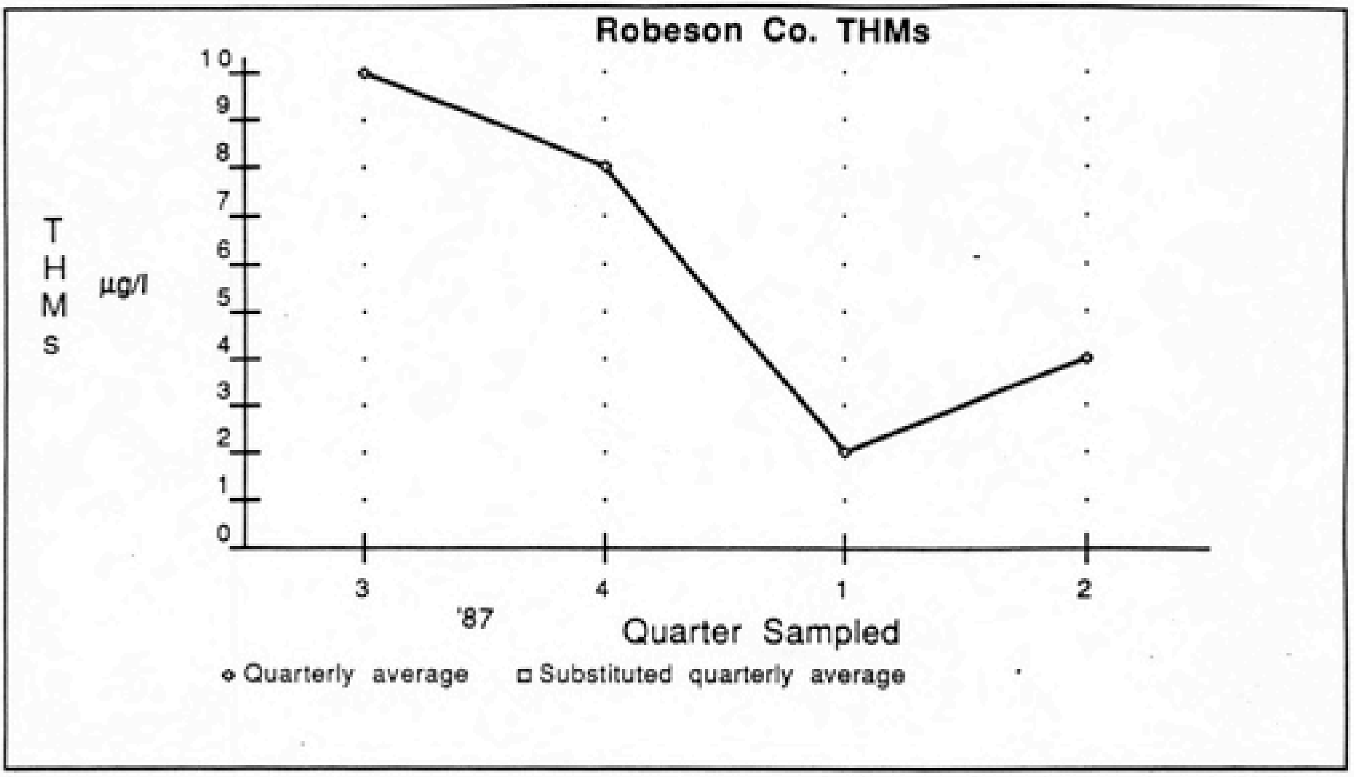
Plant: Richmond County			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0377109						
Population Served: 13000						
			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
05/12/88		92				
"		44				
"		51				
"		56	61		61	
02/18/88		35				
"		24				
"		25				
"		35	30		30	
12/08/87		59				
"		71				
"		60				
"		72	65			
10/20/87		45				
"		73				
"	Ω	147				
"		122	97	80	72	Σ
07/01/87		79				
"		88				
"		103				
"		90	90		90	
03/31/87		97				
"		36				
"		56				
"	Ω	114	76	63	63	Σ
12/10/86		52				
"		47				
"		84				
"		69	63		63	
09/16/86		80				
"		101				
"	Ω	207				
"		132	130	104	104	Σ

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
06/23/86		59				
"		71				
"	Ω	123				
"		65	79	65	65	Σ
03/21/86		49				
"		39				
"		50				
"		77	54		54	
12/19/85		67				
"		49				
"		70				
"		94	70		70	

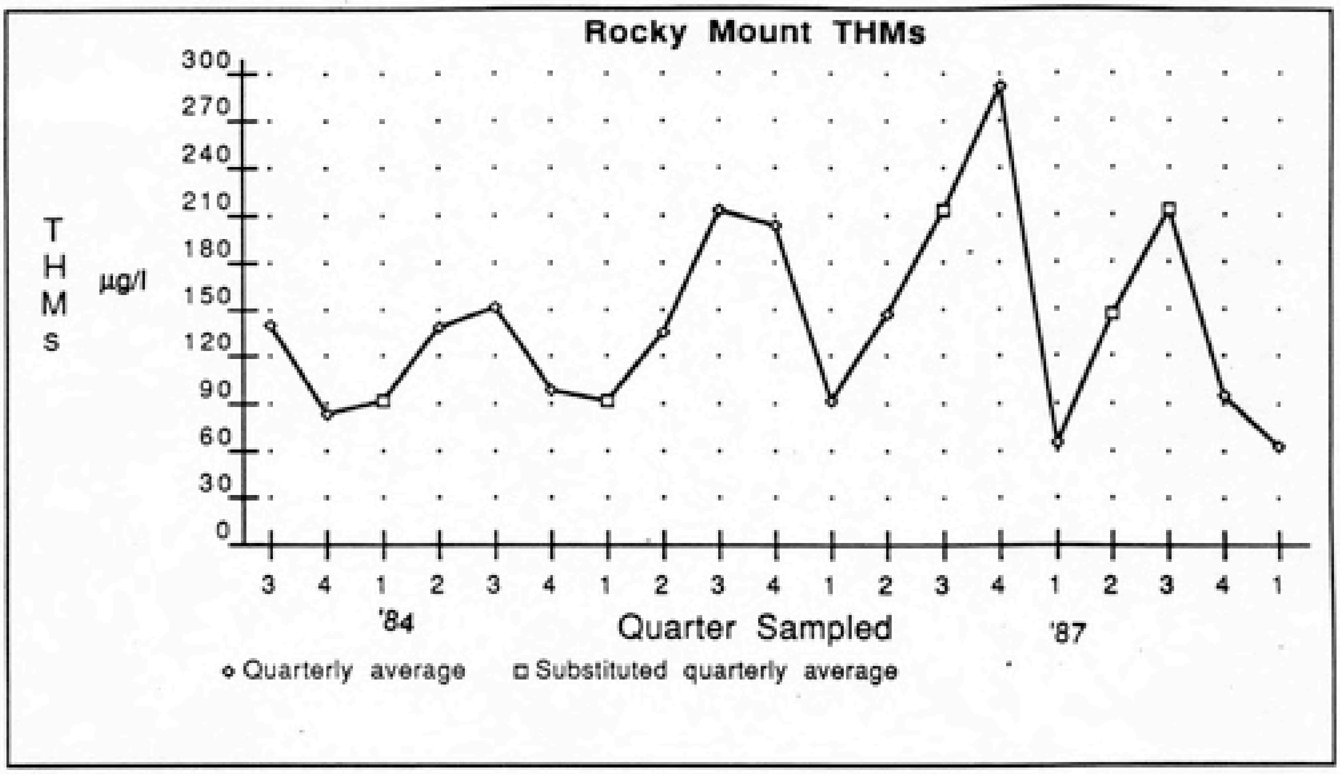

Roanoke Rapids Sanitary District THMs
THMs µg/l
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'83
'84
Quarter Sampled
'87
'88
Quarterly average
Substituted quarterly average

Plant: Roanoke Rapids		Ω-measurement discarded for adjusted average calculation		
		Σ-some measurements(Ω) discarded before calculating average		
PWID: 0442010				
Population Served: 20595				
Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
05/05/88	38	38		38
02/09/88	29	29		29
11/30/87	44	44		44
07/24/87	68	68		68
04/24/87	36	36		36
02/13/87	24	24		24
10/15/86	43	43		43
07/17/86	63	63		63
05/06/86	61	61		61
02/25/86	42	42		42
11/07/85	66	66		66
07/31/85	67	67		67
04/30/85	72	72		72
02/20/85	28	28		28
10/31/84	70	70		70
08/31/84	93	93		
07/17/84	104	104		98
04/25/84	67	67		67
12/15/83	39	39		39

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
09/21/83	59			
"	71			
"	87			
"	89	76		76
06/13/83	66			
"	88			
"	103			
"	89	86		86
03/10/83	64			
"	53			
"	69			
"	49	59		
01/14/83	31			
"	36			
"	50			
"	54	43		51


Robeson Co. THMs
10
9
8
7
6
5
4
3
2
1
0
T
H
M
S
µg/l
3
4
1
2
'87
Quarter Sampled
Quarterly average
Substituted quarterly average

Plant: Robeson County			Ω-measurement discarded for adjusted average calculation		
			Σ-some measurements(Ω) discarded before calculating average		
PWID: 0378055					
Population Served: 20800					
			Unadjusted	Adjusted	Quarterly
Date of Sampling		TTHM's µg/l	Average Reading µg/l	Average Reading µg/l	Average Reading µg/l
04/12/88		8			
"		2			
"		2	4		4
01/26/88		2			
"		3			
"		2	2		2
12/01/87		2			
"		13			
"		8	8		8
08/17/87		4			
"		20			
"		2			
"		13	10		10


Rocky Mount THMs
300
270
240
210
180
150
120
90
60
30
0
THMs
µg/l
3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'84
Quarter Sampled
'87
Quarterly average
Substituted quarterly average

Plant: Rocky Mount			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0464010						
Population Served: 50139						
			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
02/29/88		31				
"		36				
"		36				
"		42				
"		84				
"		86				
"		85				
"		57	57			
01/11/88	Ω	1				
"		35				
"		38				
"		36				
"		43				
"		110				
"		106				
"		113				
"		88	63	71	64	Σ
11/09/87	Ω	90				
"	Ω	88				
"	Ω	77				
"	Ω	99				
"	Ω	93				
"	Ω	88				
"	Ω	96				
"	Ω	139	96			
11/04/87	Ω	90				
"	Ω	88				
"	Ω	77				
"	Ω	99				
"	Ω	93				
"	Ω	88				
"	Ω	90				
"	Ω	139	95			

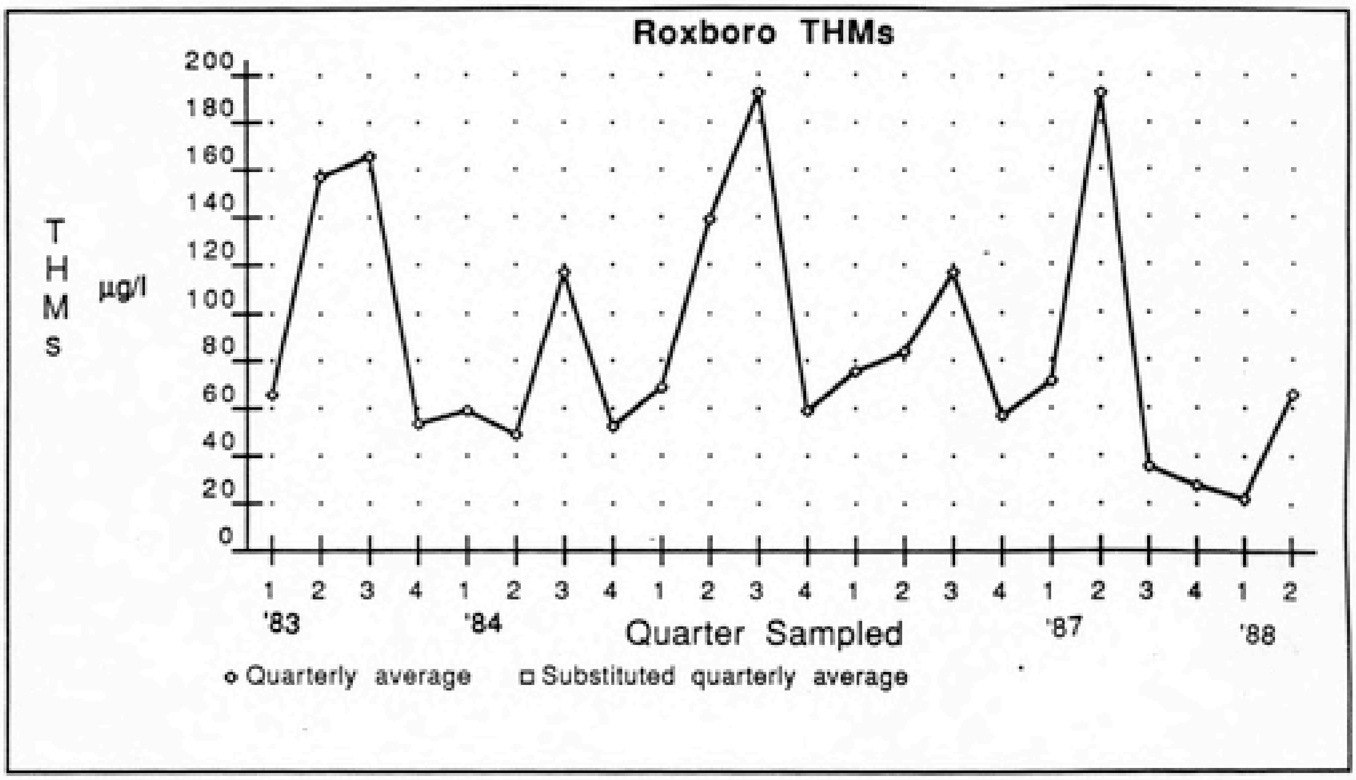
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
10/15/87		90				
"		88				
"		77				
"		99				
"		93				
"		88				
"		90				
"		139	95		95	Σ
03/09/87		38				
"		40				
"		38				
"		41				
"		87				
"		90				
"		41				
"		57	54			
01/02/87		67				
"		84				
"		52				
"		61				
"		54				
"		70				
"		107				
"		116	76		65	
10/09/86		233				
"		264				
"		231				
"		302				
"		311				
"		333				
"		335				
"		323	291		291	
05/12/86		150				
"		176				
"		160				
"		161				
"		122				
"		147				
"		120				
"		131	146		146	

Rocky Mount THM Records

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
02/26/86	108			
"	84			
"	78			
"	82			
"	86			
"	95			
"	107			
"	99	92		92
11/08/85	170			
"	224			
"	198			
"	178			
"	202			
"	245			
"	207			
"	207			
"	200	203		203
08/22/85	180			
"	210			
"	180			
"	220			
"	220			
"	250			
"	230	213		213
05/24/85	136			
"	148			
"	167			
"	133			
"	144			
"	148			
"	173			
"	144	149		
04/25/85	111			
"	149			
"	135			
"	114			
"	107			
"	136			
"	107			
"	111	121		135

Rocky Mount THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
12/17/84	Ω	12				
"		127				
"		102				
"		115				
"		84				
"		84				
"		91				
"		91	88	99	99	Σ
09/20/84		139				
"		208				
"		157				
"		154				
"		120				
"		170				
"		130				
"		136	152		152	
05/09/84		126				
"		157				
"		165				
"		133				
"		115				
"		141				
"		120				
"		144				
"		138	138		138	
12/27/83		83	83		83	
09/30/83		122				
"		118				
"		123				
"		126				
"		148				
"		176				
"		178				
"		133	140		140	

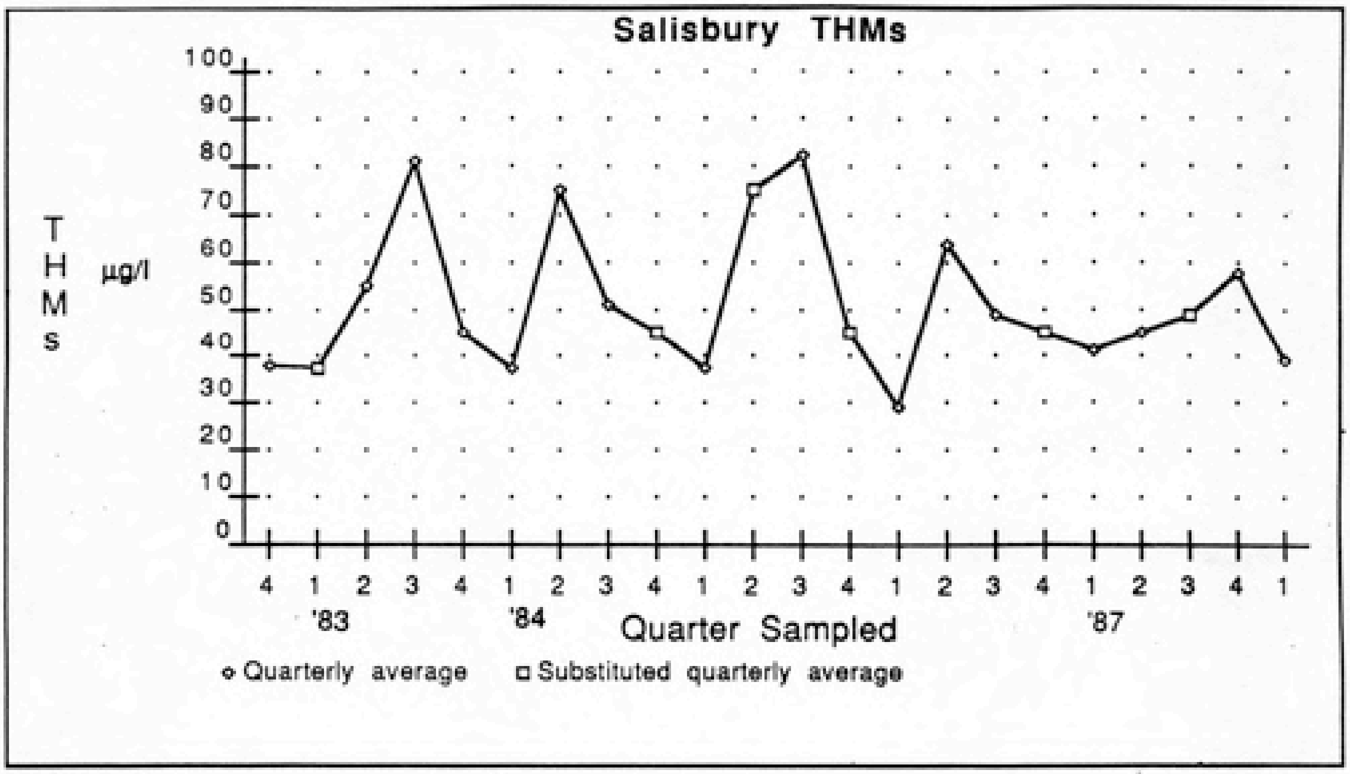

Roxboro THMs
200
180
160
140
120
100
80
60
40
20
0
T
H
M
s
µg/l
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'83
'84
'87
'88
Quarter Sampled
Quarterly average
Substituted quarterly average

Plant: Roxboro		Ω-measurement discarded for adjusted average calculation		
		Σ-some measurements(Ω) discarded before calculating average		
PWID: 0273010				
Population Served: 10970				
		Unadjusted	Adjusted	Quarterly
Date of Sampling	TTHM's µg/l	Average Reading µg/l	Average Reading µg/l	Average Reading µg/l
05/18/88	36			
"	99			
"	85			
"	46	66		66
02/10/88	9			
"	47			
"	19			
"	14	22		22
12/03/87	12			
"	54			
"	28			
"	17	28		28
09/30/87	30			
"	45			
"	48			
"	22	36		36
06/24/87	193			
"	160			
"	196			
"	218	192		192
03/25/87	95			
"	53			
"	54			
"	84	71		71
12/12/86	62			
"	51			
"	78			
"	37	57		57
09/24/86	116			
"	104			
"	147			
"	100	117		117

Roxboro THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
05/21/86		49				
"		75				
"		61				
"		146	83		83	
03/05/86		45				
"		51				
"		127				
"		76	75		75	
12/18/85		60				
"	Ω	135				
"		58				
"		58	78	59	59	Σ
09/25/85		151				
"		208				
"		231				
"		177	192		192	
06/26/85		122				
"		138				
"		133				
"		164	139		139	
03/06/85		50				
"		98				
"		74				
"		54	69		69	
11/16/84		54				
"		49				
"		66				
"		39	52		52	
09/19/84		120				
"		118				
"		96				
"		136	117		117	
04/06/84		38				
"		46				
"		64	49		49	

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
02/09/84		115				
"		36				
"		50				
"		35	59		59	
12/15/83		63				
"		65				
"		44				
"		41	53		53	
08/17/83		199				
"		159				
"		164				
"		142	166		166	
06/01/83		154				
"		160				
"		135				
"		180	157		157	
01/19/83		59				
"		68				
"		70				
"	Ω	165	90	66	66	Σ

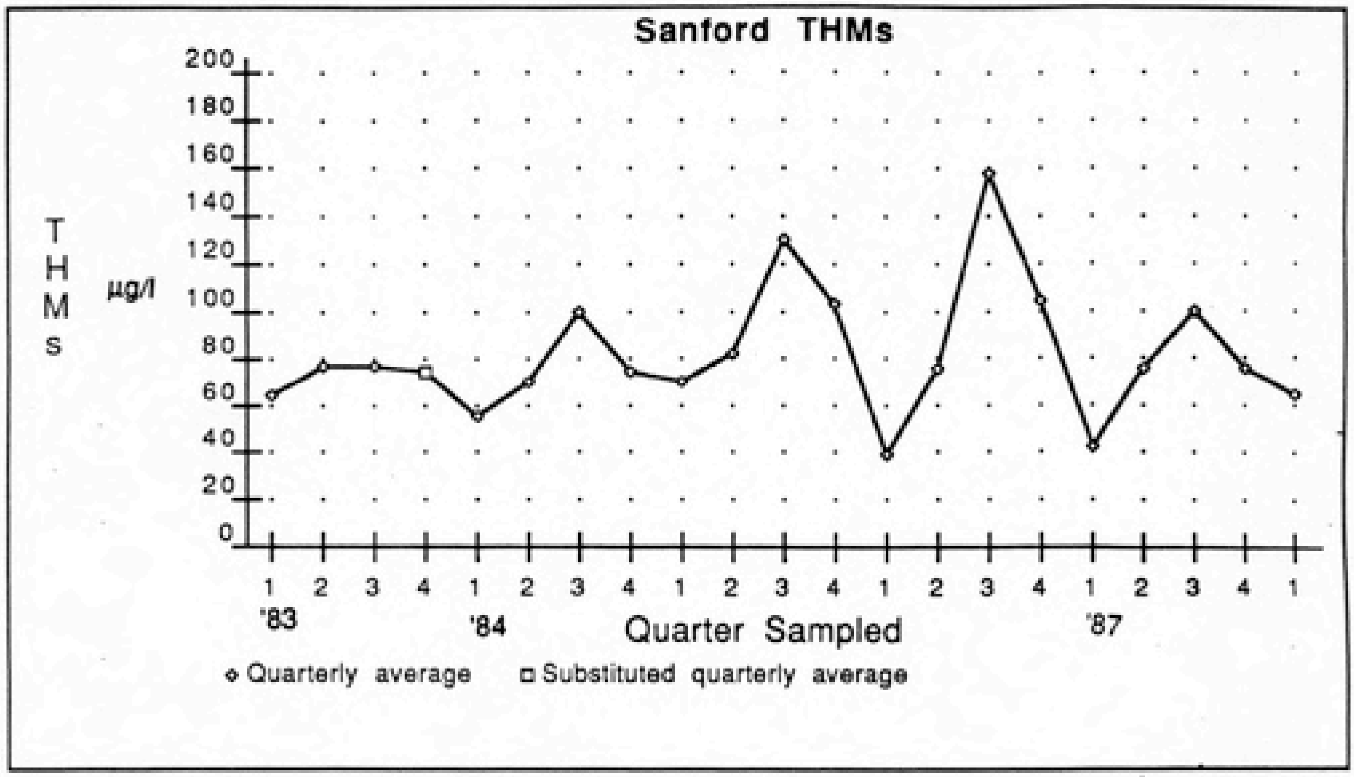

Salisbury THMs
100
90
80
70
60
50
40
30
20
10
0
THMs µg/l
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
'87
Quarter Sampled
Quarterly average
Substituted quarterly average

Plant: Salisbury			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0180010						
Population Served: 30000						
			Unadjusted	Adjusted	Quarterly	
Date of Sampling		TTHM's µg/l	Average Reading µg/l	Average Reading µg/l	Average Reading µg/l	
02/11/88		27				
"		26				
"		37				
"		29	30			
01/13/88	Ω	48				
"	Ω	51				
"	Ω	50				
"	Ω	42	48			
01/11/88		48				
"		51				
"		50				
"		42	48		39	Σ
10/22/87	Ω	57				
"	Ω	85				
"	Ω	61				
"	Ω	56	65			
10/21/87	Ω	57				
"	Ω	85				
"	Ω	61				
"	Ω	56	65			
10/08/87		56				
"		61				
"	Ω	85				
"		57	65	58	58	Σ
05/20/87	Ω	52				
"	Ω	54				
"	Ω	43				
"	Ω	42	48			
05/18/87		42				
"		43				
"		54				
"		52	48			

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
04/24/87		36	36		45	Σ
03/27/87	Ω	38				
"	Ω	41				
"		36				
"	Ω	34	37	36		
03/24/87		38				
"		41				
"		34	38			
01/19/87	Ω	44				
"	Ω	48				
"	Ω	43				
"	Ω	41	44			
01/07/87		44				
"		48				
"		43				
"		41	44		41	Σ
10/02/86	Ω	46				
"	Ω	60				
"	Ω	44				
"	Ω	45	49			
09/30/86		46				
"		60				
"		44				
"		45	49			
07/03/86	Ω	69				
"	Ω	70				
"	Ω	85				
"	Ω	73	74		49	Σ
05/28/86		85				
"		70				
"		69	75			
05/08/86		73	73			

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
04/01/86		48				
"		50				
"		68				
"		47	53		64	
01/10/86	Ω	30				
"	Ω	28				
"	Ω	29				
"	Ω	31	29			
01/02/86		30				
"		28				
"		29				
"		31	29		29	Σ
10/16/86	Ω	88				
"	Ω	81				
"	Ω	84				
"	Ω	87	85			
09/12/86		88				
"		81				
"		84				
"		87	85			
07/25/85	Ω	8				
"		77				
"		74				
"		82				
"	Ω	1	48	78	82	Σ
03/14/85		40				
"		34				
"		34				
"		38				
"	Ω	1	29	36		
01/14/85		40				
"		33				
"		35				
"		41				
"	Ω	1	30	37	37	Σ

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
09/26/84		54				
"		50				
"		49				
"		51				
"	Ω	1	41	51	51	Σ
06/19/84		77				
"		68				
"		73				
"		84				
"	Ω	1	61	75	75	Σ
03/22/84		41				
"		34				
"		38				
"		36				
"	Ω	1				
"	Ω	41				
"	Ω	38				
"	Ω	36				
"	Ω	1				
"	Ω	34	30	37	37	Σ
12/21/83	Ω	1				
"		45				
"		40				
"		47				
"		50	37	45	45	Σ
09/16/83		91				
"		81				
"		72				
"		81				
"	Ω	1	65	81	81	Σ
06/22/83		60				
"	Ω	60				
"		50				
"	Ω	50	55	55	55	Σ
11/15/82		46				
"		44				
"		30				
"		34	38		38	

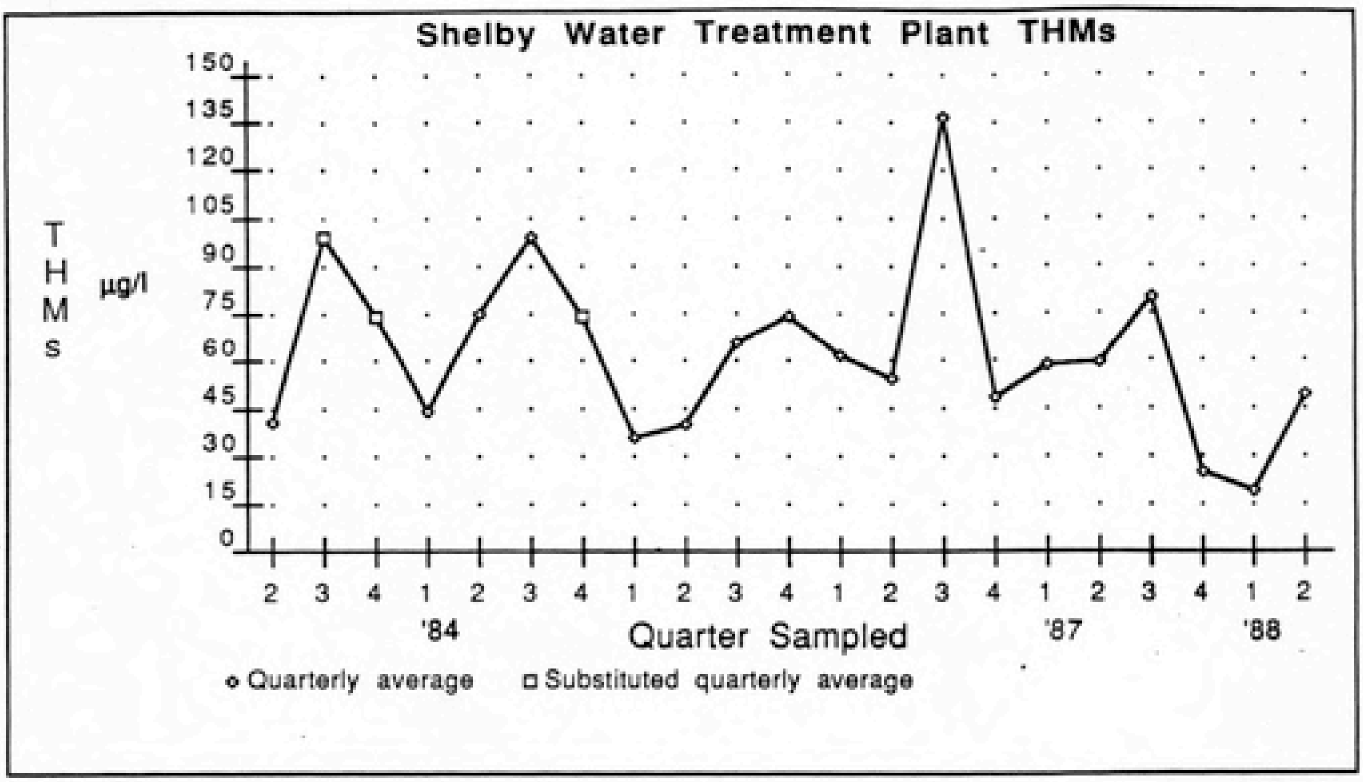

Sanford THMs
200
180
160
140
120
100
80
60
40
20
0
T H M s
µg/l
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
'87
Quarter Sampled
Quarterly average
Substituted quarterly average

Plant: Sanford		Ω-measurement discarded for adjusted average calculation		
		Σ-quarterly average calculation included an adjusted value		
PWID: 0353010				
Population Served: 18000				
		Unadjusted	Adjusted	Quarterly
Date of	TTHM's	Average Reading	Average Reading	Average Reading
Sampling	µg/l	µg/l	µg/l	µg/l
02/02/88	62			
"	80			
"	44			
"	74	65		65
12/08/87	55			
"	62			
"	64			
"	123	76		76
09/09/87	85			
"	97			
"	97			
"	123	100		100
06/01/87	59			
"	67			
"	66			
"	107	75		75
02/03/87	34			
"	60			
"	48			
"	27	42		42
11/04/86	89			
"	98			
"	103			
"	130	105		105
08/15/86	194	194		
08/12/86	136			
"	154			
"	148	146		158
05/29/86	76			
"	67			
"	71			
"	86	75		75

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
02/27/86	29			
"	33			
"	34			
"	60	39		39
11/05/85	130			
"	103			
"	103			
"	75	103		103
09/03/85	99			
"	110			
"	119			
"	194	130		130
06/17/85	57			
"	77			
"	73			
"	123	82		82
02/14/85	61			
"	67			
"	71			
"	80	70		70
11/09/84	59			
"	62			
"	68	63		
11/06/84	108	108		74
09/12/84	75			
"	95			
"	86			
"	144	100		100
05/09/84	50			
"	64			
"	54			
"	111	70		70
02/09/84	40			
"	61			
"	40			
"	81	55		55

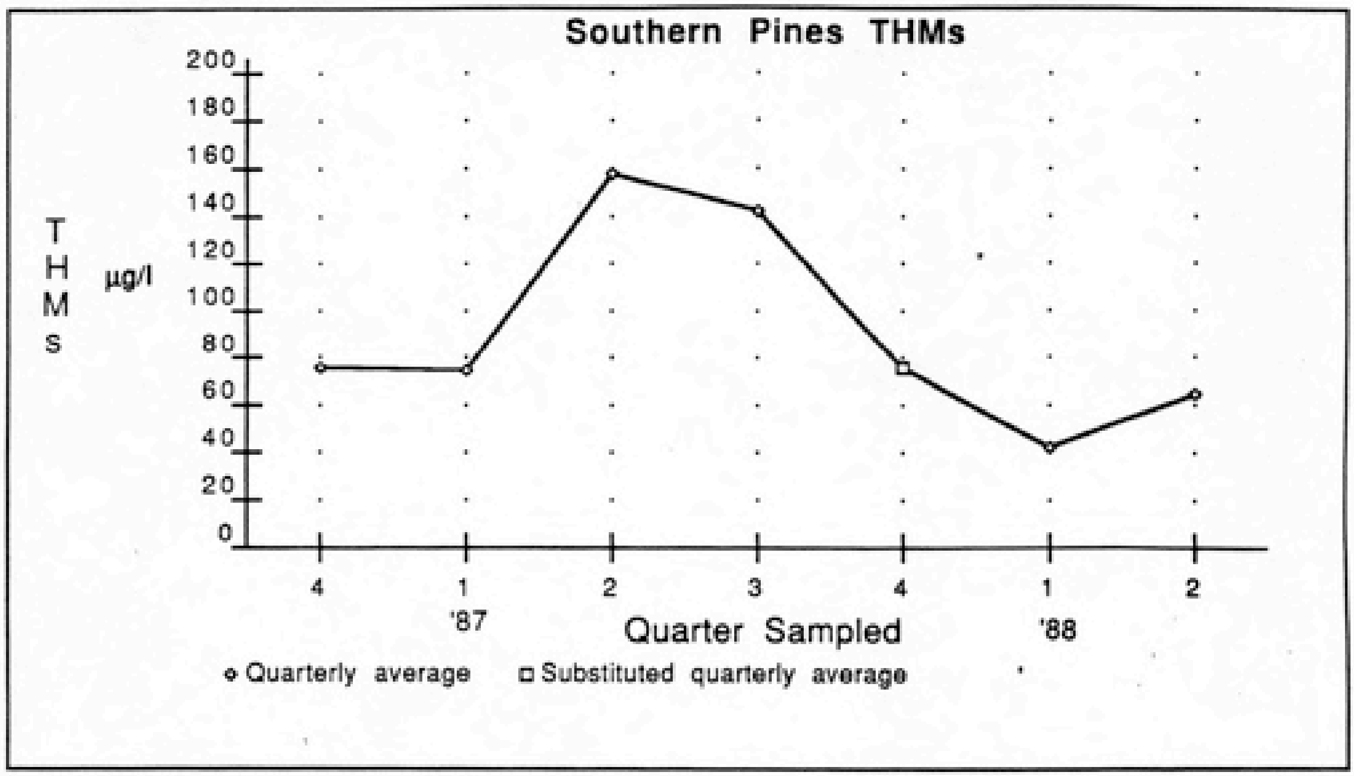
Sanford THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
08/10/83		80				
"		111				
"		101				
"		17	77		77	
05/10/83	Ω	6				
"		51				
"		60				
"		81				
"		69				
"		123	65	77	77	Σ
02/15/83		50				
"		54				
"		61				
"		96	65			
01/18/83		47				
"		46				
"		53				
"		114	65		65	


Shelby Water Treatment Plant THMs
THMs µg/l
150
135
120
105
90
75
60
45
30
15
0
2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'84
Quarter Sampled
'87
'88
Quarterly average
Substituted quarterly average

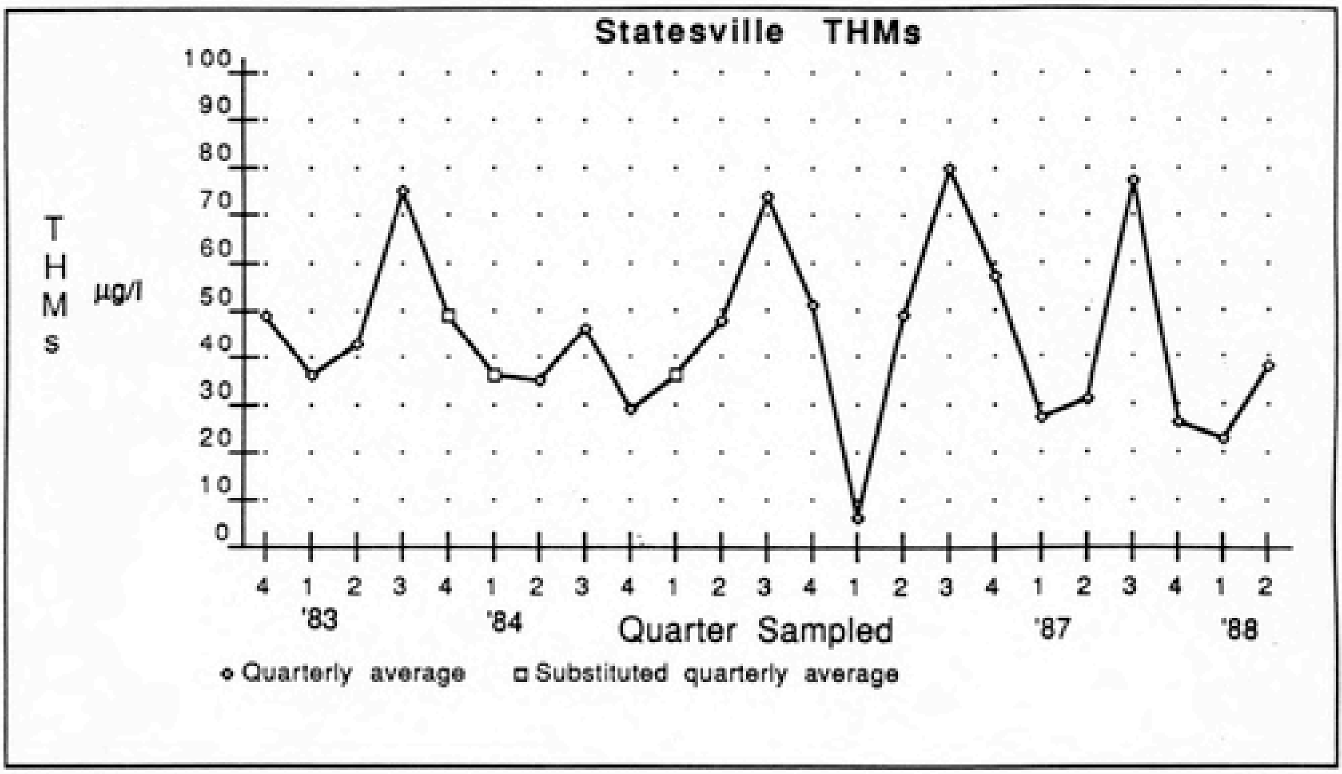
Plant: Shelby		Ω-measurement discarded for adjusted average calculation		
		Σ-some measurements(Ω) discarded before calculating average		
PWID: 0123010				
Population Served: 15310				
		Unadjusted	Adjusted	Quarterly
Date of Sampling	TTHM's µg/l	Average Reading µg/l	Average Reading µg/l	Average Reading µg/l
04/22/88	49	49		49
01/19/88	19	19		19
12/01/87	25	25		25
08/12/87	80	80		80
05/26/87	59	59		59
03/11/87	58	58		58
10/29/86	48	48		48
08/12/86	137	137		137
05/21/86	54	54		54
03/24/86	62	62		62
10/10/85	74	74		74
07/11/85	66	66		66
04/11/85	40	40		40
01/17/85	36	36		36
08/22/84	108			
"	96			
"	104			
"	87	99		99
06/07/84	64			
"	84			
"	93			
"	61	75		75

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
01/20/84		47				
"		47				
"		43				
"		41	44		44	
06/09/83		39				
"		46				
"		36				
"		43	41		41	


Southern Pines THMs
T H M s
µg/l
200
180
160
140
120
100
80
60
40
20
0
4
1
2
3
4
1
2
'87
Quarter Sampled
'88
Quarterly average
Substituted quarterly average

Town of Southern Pines THM Records

Plant: Southern Pines			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0363010						
Population Served: 12500						
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
04/15/88		62				
"		67				
"		64				
"		67	65		65	
01/26/88		40				
"		44				
"		43				
"		43	42		42	
09/15/87		145				
"		127				
"		154				
"	Ω	65	123	142	142	Σ
06/26/87		146				
"		165				
"		157				
"		163	158		158	
03/23/87		91				
"	Ω	178				
"		68				
"		63	100	74	74	Σ
12/30/86		78				
"	Ω	160				
"		66				
"		80	96	75	75	Σ

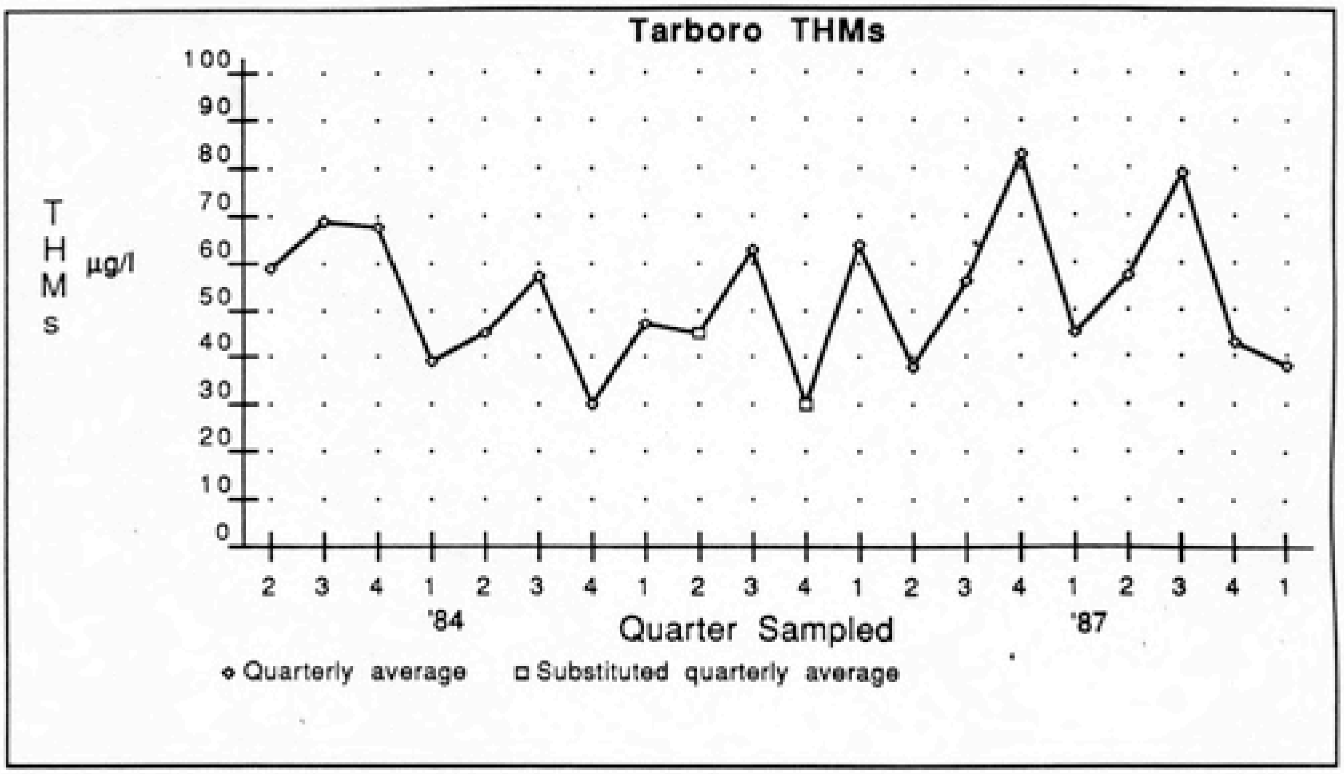

Statesville THMs
100
90
80
70
60
50
40
30
20
10
0
THMs µg/l
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'83
'84
Quarter Sampled
'87
'88
Quarterly average
Substituted quarterly average

Statesville THM Records

Plant: Statesville			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0149010						
Population Served: 19800						
			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
04/12/88		38	38		38	
02/12/88		23	23		23	
12/15/87		26	26		26	
07/22/87		77	77		77	
04/07/87		31	31		31	
01/14/87		27	27		27	
10/30/86		57	57		57	
07/25/86		80	80		80	
05/02/86		49	49		49	
01/30/86		6	6		6	
12/02/85		51	51		51	
09/10/85		74	74		74	
04/24/85		48	48		48	
12/27/84		29	29		29	
09/27/84		46	46		46	
06/29/84	Ω	83	83			
04/19/84		35	35		35	Σ
08/11/83		60				
"		68				
"		93				
"		80	75		75	

Statesville THM Records

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
04/21/83	28			
"	37			
"	51			
"	58	43		43
02/15/83	30			
"	43			
"	33			
"	37	36		36
12/21/82	51			
"	51			
	51			
	42	49		49



Tarboro THMs
100
90
80
70
60
50
40
30
20
10
0
THMs µg/l
2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'84
Quarter Sampled
'87
Quarterly average
Substituted quarterly average

Plant: Tarboro			Ω-measurement discarded for adjusted average calculation		
			∑-some measurements(Ω) discarded before calculating average		
PWID: 0433010					
Population Served: 14400					
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
03/14/88		49			
"		27			
"		38			
"		38	38		38
12/01/87		51			
"		34			
"		42			
"		44	43		
10/09/87	Ω	83			
"	Ω	81			
"	Ω	88			
"	Ω	64	79		43
09/24/87		88			
"		64			
"		81			
"		83	79		
07/10/87	Ω	66			
"	Ω	45			
"	Ω	41			
"	Ω	74	56		79
06/23/87		74			
"		41			
"		45			
"		66	56		
04/10/87		60			
"		57			
"		56			
"		57	57		57
01/09/87		47			
"		44			
"		46			
"		45	45		45

Tarboro THM Records

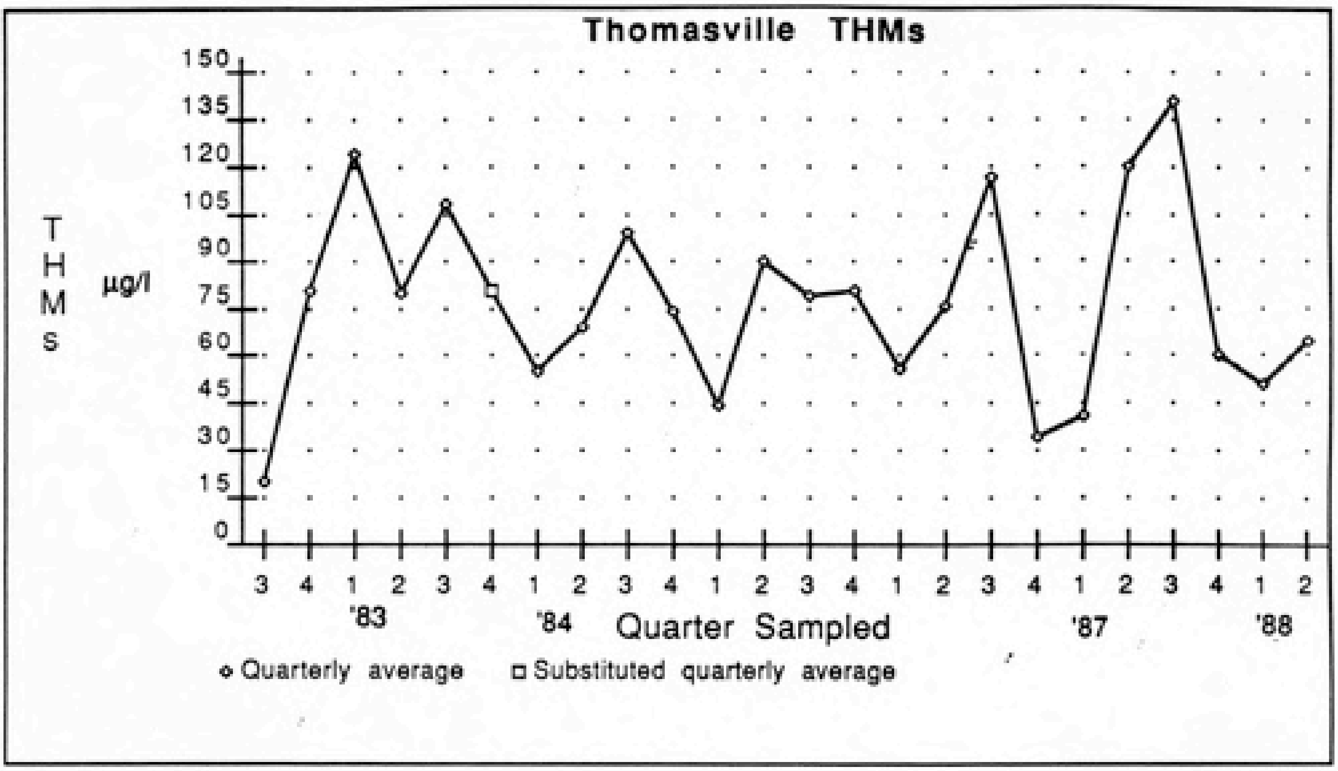
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
10/10/86		89				
"		69				
"		85				
"		89	83		83	
07/09/86		60				
"		40				
"		70				
"		53	56		56	
04/10/86		50				
"		32				
"		36				
"		35	38		38	
01/10/86	Ω	112				
"		46				
"		73				
"		72	76	64	64	Σ
09/23/85		92				
"		40				
"		66				
"		60	64			
07/10/85		79				
"		41				
"		79				
"		49	62		63	
02/28/85		57				
"		27				
"		57				
"		48	47		47	
11/30/84		36				
"		18				
"		38				
"		28	30		30	
08/30/84		67				
"		34				
"		69				
"		57	57		57	

Tarboro THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
05/24/84		52				
"		34				
"		52				
"		44	45		45	
02/16/84		41				
"		35				
"		41				
"		38	39		39	
12/20/83		84				
"		52				
"		65				
"		70	68		68	
09/22/83		98				
"		49				
"		61				
"		59	67			
09/16/83		105				
"	Ω	6				
"		66				
"		68	61	80		
09/08/83		106				
"		59				
"		74				
"		70	77			
08/18/83		88				
"		40				
"		48				
"		50	56			
07/27/83		94				
"		52				
"		57				
"		65	67		69	Σ
06/15/83	Ω	100				
"		53				
"		66				
"		59	69	59	59	Σ

Tarboro THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
03/31/83		260				
"		262				
"		294				
"	Ω	473	322	272	272	Σ



Thomasville THMs
150
135
120
105
90
75
60
45
30
15
0
THMs
µg/l
3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'83
'84
Quarter Sampled
'87
'88
Quarterly average
Substituted quarterly average

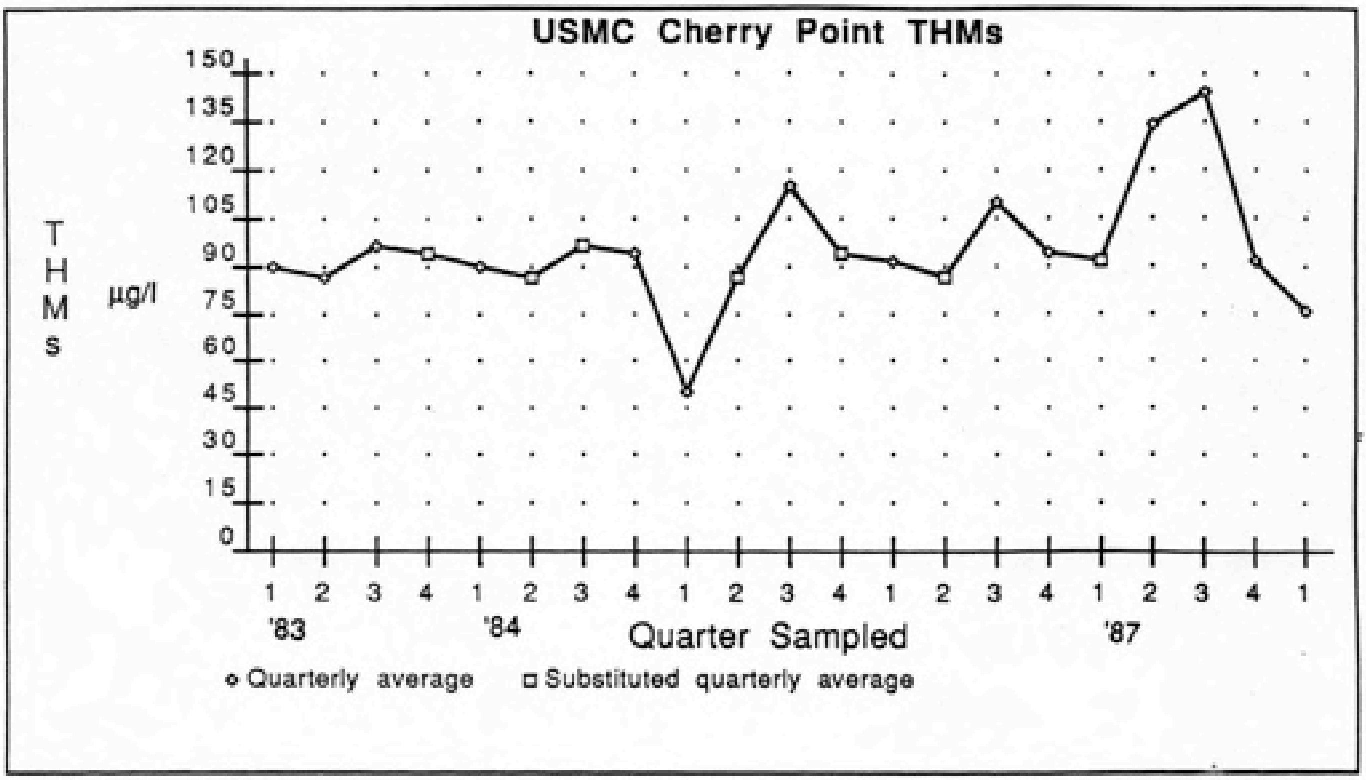
Plant: Thomasville			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0229020						
Population Served: 25000						
			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
04/20/88		44				
"		61				
"		61				
"		91	64		64	
01/27/88		66				
"		57				
"		48				
"		35	51		51	
10/27/87		60	60		60	
08/19/87		114				
"		154				
"		147				
"		150	141		141	
05/28/87		101				
"	Ω	177				
"	Ω	148				
"		140	141	120	120	Σ
03/02/87		45				
"		43				
"		44				
"		33	41		41	
12/10/86		26				
"		45				
"		38				
"		27	34		34	
08/13/86		111				
"		131				
"		101				
"		124	117		117	

Thomasville THM Records

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
04/17/86	71			
"	74			
"	77			
"	82	76		76
01/20/86	51			
"	67			
"	34			
"	72	56		56
10/29/85	69			
"	78			
"	86			
"	91	81		81
08/19/85	75			
"	93			
"	95			
"	82	86		
07/11/85	56			
"	76	66		79
05/07/85	76			
"	97			
"	91			
"	97	90		90
02/20/85	39			
"	41			
"	45			
"	51	44		44
11/06/84	74	74		74
08/29/84	107			
"	110			
"	117			
"	113	112		
07/11/84	73			
"	74	73		99

Thomasville THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
05/03/84		60				
"		72				
"		70				
"		71				
"		74				
"	Ω	74				
"	Ω	71				
"	Ω	70				
"	Ω	60	69	69	69	Σ
02/13/84		38				
"		73				
"		55				
"		55	55		55	
09/01/83		96				
"		102				
"		111				
"		122	108		108	
05/27/83		67				
"		80				
"		90				
"		85	80		80	
02/17/83		137				
"		108				
"		124				
"		129	124		124	
12/17/82		85				
"		74				
"		88				
"		77	81		81	
08/19/81		20				
"		20	20		20	



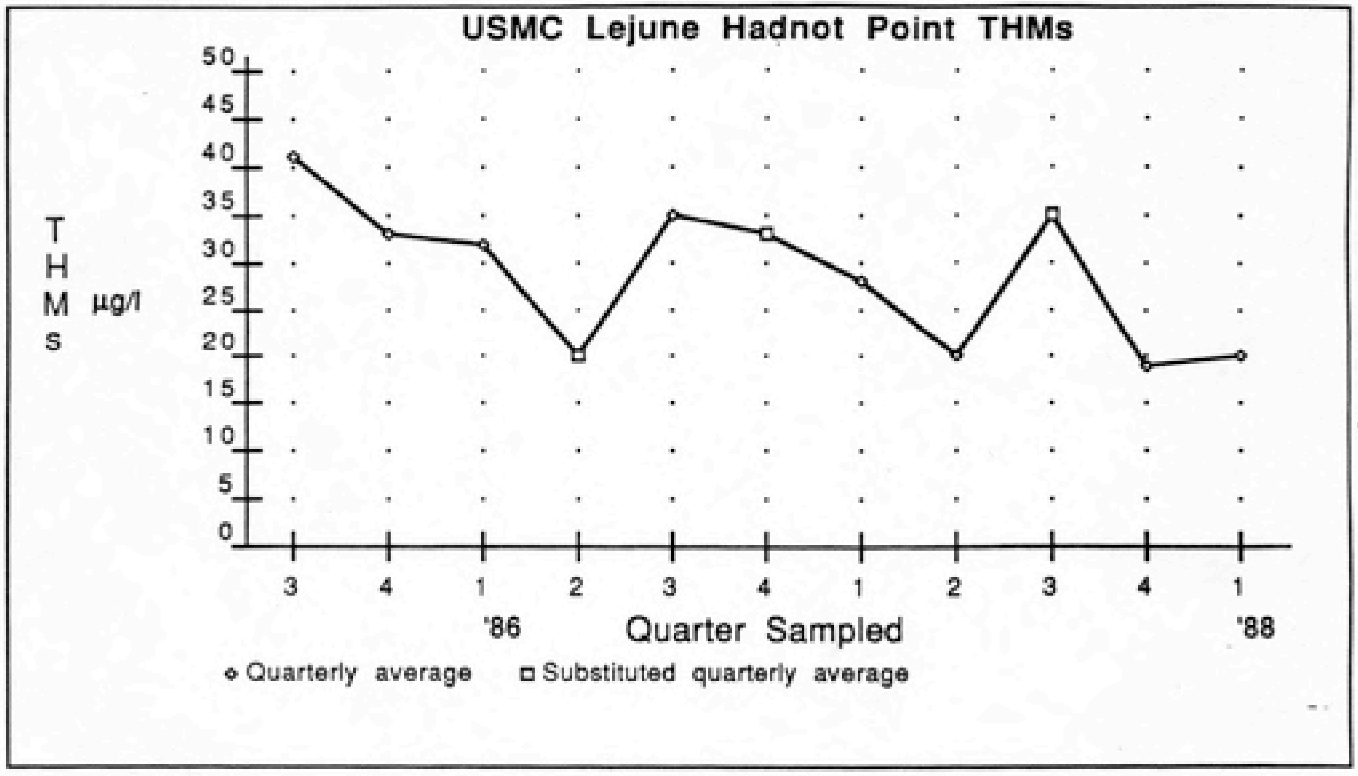
USMC Cherry Point THMs
THMs
µg/l
150
135
120
105
90
75
60
45
30
15
0
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
Quarter Sampled
'87
Quarterly average
Substituted quarterly average

Plant: USMC Cherry Point			Ω-measurement discarded for adjusted average calculation			
			Σ-quarterly average calculation included an adjusted value			
PWID: 0425035						
Population Served: 29000						
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
01/27/88		67				
"		82				
"		68				
"		73	72			
01/19/88		76				
"		80				
"		85				
"		79	80		76	
12/22/87		79				
"		76				
"		80				
"		85	80			
11/04/87	Ω	131				
"	Ω	95				
"	Ω	94				
"	Ω	97				
10/15/87		131				
"		95				
"		94				
"		97	104		92	Σ
07/01/87		181				
"		130				
"		128				
"		136	144		144	
05/18/87		136				
"		126				
"		126				
"		147	134		134	
12/18/86		81				
"		86				
"		88				
"		120	94		94	

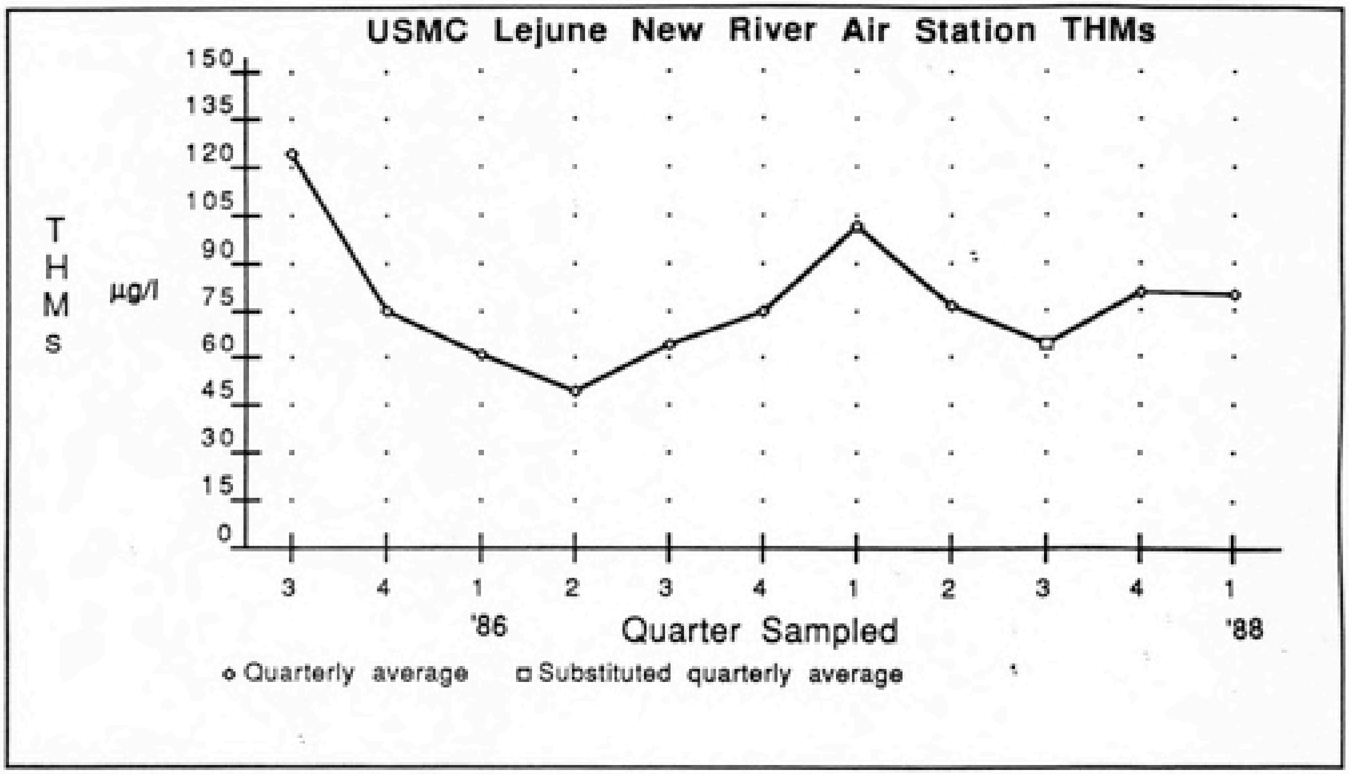
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
09/11/86		92				
"		97				
"		106				
"		162	114			
07/14/86		89				
"		102				
"		91				
"		144	106		110	
03/04/86		105				
"		84				
"		82				
"		89	90			
01/15/86		97				
"		88				
"		88				
"		101	93		92	
09/03/85		127				
"		177				
"		106				
"		157	142			
07/31/85		121				
"		94				
"		91				
"		98				
"		97				
"		97				
"		125				
"		95	102		115	
02/20/85		40				
"		52				
"	Ω	253				
"		58	101	50	50	Σ
12/10/84	Ω	117				

USMC Cherry Point THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
12/07/84		91				
"		117				
"		85				
"		82				
"	Ω	85				
"	Ω	82				
"	Ω	91	90	94	94	Σ
02/20/84		108				
"		81				
"		80				
"		92	90		90	
09/22/83		89				
"		91				
"		90				
"		118				
"	Ω	118				
"	Ω	89				
"	Ω	90				
"	Ω	91	97	97	97	
06/27/83		104				
"		82				
"		83				
"		78	87		87	
01/24/83		90				
"		92				
"		75				
"		92				
"		101	90		90	


USMC Lejune Hadnot Point THMs
THMs µg/l
50
45
40
35
30
25
20
15
10
5
0
3
4
1
2
3
4
1
2
3
4
1
'86
Quarter Sampled
'88
Quarterly average
Substituted quarterly average

Plant: USMC Hadnot Point			Ω-measurement discarded for adjusted average calculation		
			Σ-some measurements(Ω) discarded before calculating average		
PWID: 0467041					
Population Served: 32134					
			Unadjusted	Adjusted	Quarterly
Date of		TTHM's	Average Reading	Average Reading	Average Reading
Sampling		µg/l	µg/l	µg/l	µg/l
03/24/88		19	19		
02/10/88		22	22		20
10/07/87		19	19		19
06/29/87		17	17		
06/22/87		17	17		
04/07/87		26	26		20
01/30/87		28	28		28
09/16/86		39	39		
07/16/86		31	31		35
01/28/86		32	32		32
10/30/85		33	33		33
08/05/85		42			
"		43			
"		44			
"		42			
"		44			
"		39			
"		45			
"		30	41		41

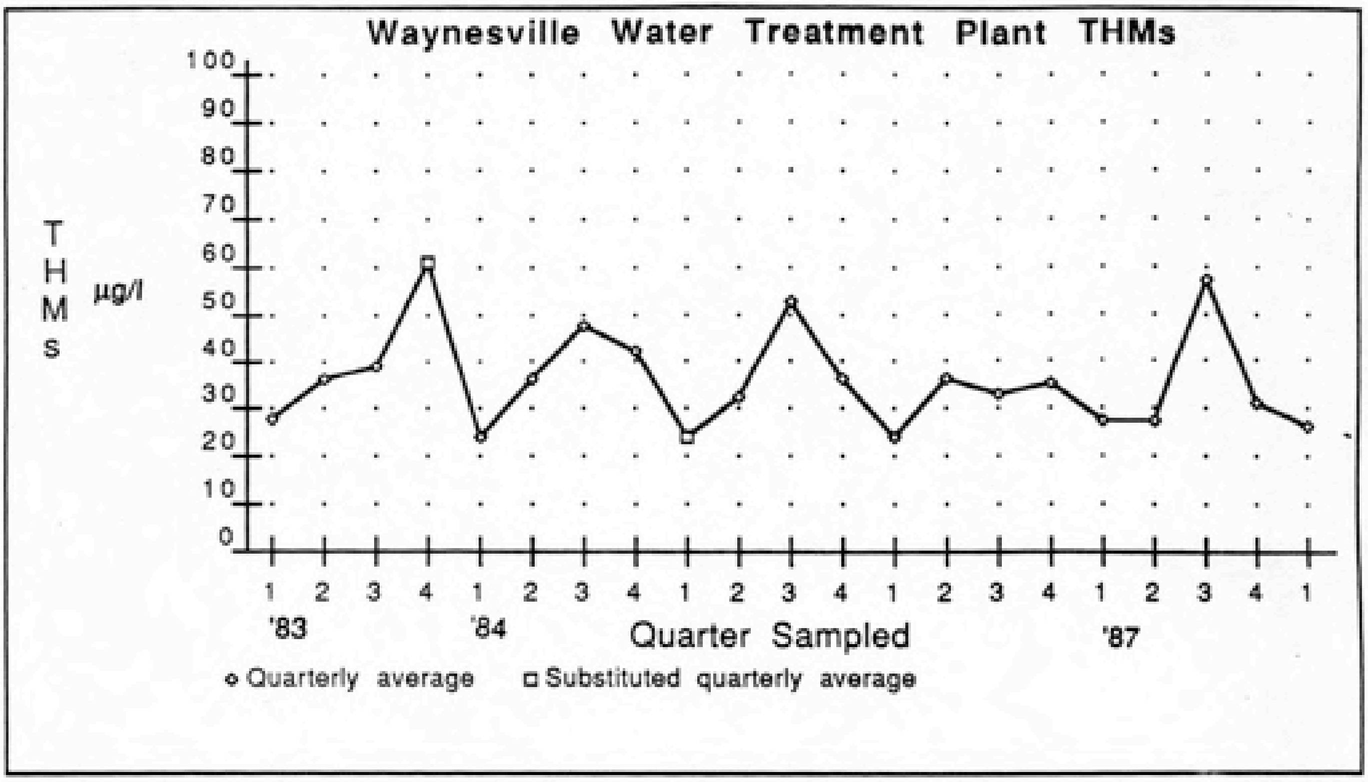

USMC Lejune New River Air Station THMs
150
135
120
105
90
75
60
45
30
15
0
T H M s
µg/l
3 4 1 2 3 4 1 2 3 4 1
'86
Quarter Sampled
'88
Quarterly average
Substituted quarterly average

Plant: USMC Lejune - New River Air Station			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0467042						
Population Served: 10315						
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
03/24/88		70				
"		86				
"		82				
"		78				
"		45	90			
02/10/88	Ω	49				
"	Ω	90				
"	Ω	99				
"	Ω	97				
"	Ω	100	109			
01/14/88		49				
"		100				
"		97				
"		99				
"		90	87		80	Σ
10/07/87		44				
"		78				
"		88				
"		110				
"		87	81		81	
06/29/87	Ω	39				
"	Ω	70				
"	Ω	87				
"	Ω	69				
"	Ω	112	75			
06/22/87		39				
"		69				
"		87				
"		70				
"		112	75			

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
04/07/87		68				
"		12				
"		100				
"		92				
"		124	79		77	Σ
01/30/87		108				
"		125				
"		120				
"		62				
"		97	102		102	
11/05/86		44				
"		78				
"		88				
"		87				
"		76	75		75	
07/16/86		37				
"		82				
"		65				
"		63				
"		71	64		64	
04/01/86		29				
"		56				
"		43				
"		57				
"		60	49		49	
01/28/86		63				
"		59				
"		69				
"		35				
"		78	61		61	
10/30/85		41				
"		87				
"		86				
"		74				
"		86	75		75	

USMC Lejune New River Air Station THM Records

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
08/05/85	55			
"	81			
"	81			
"	82			
"	77			
"	138			
"	159			
"	154			
"	112			
"	145			
"	137			
"	126			
"	125			
"	128			
"	140			
"	154			
"	131			
"	141			
"	158			
"	158	124		124

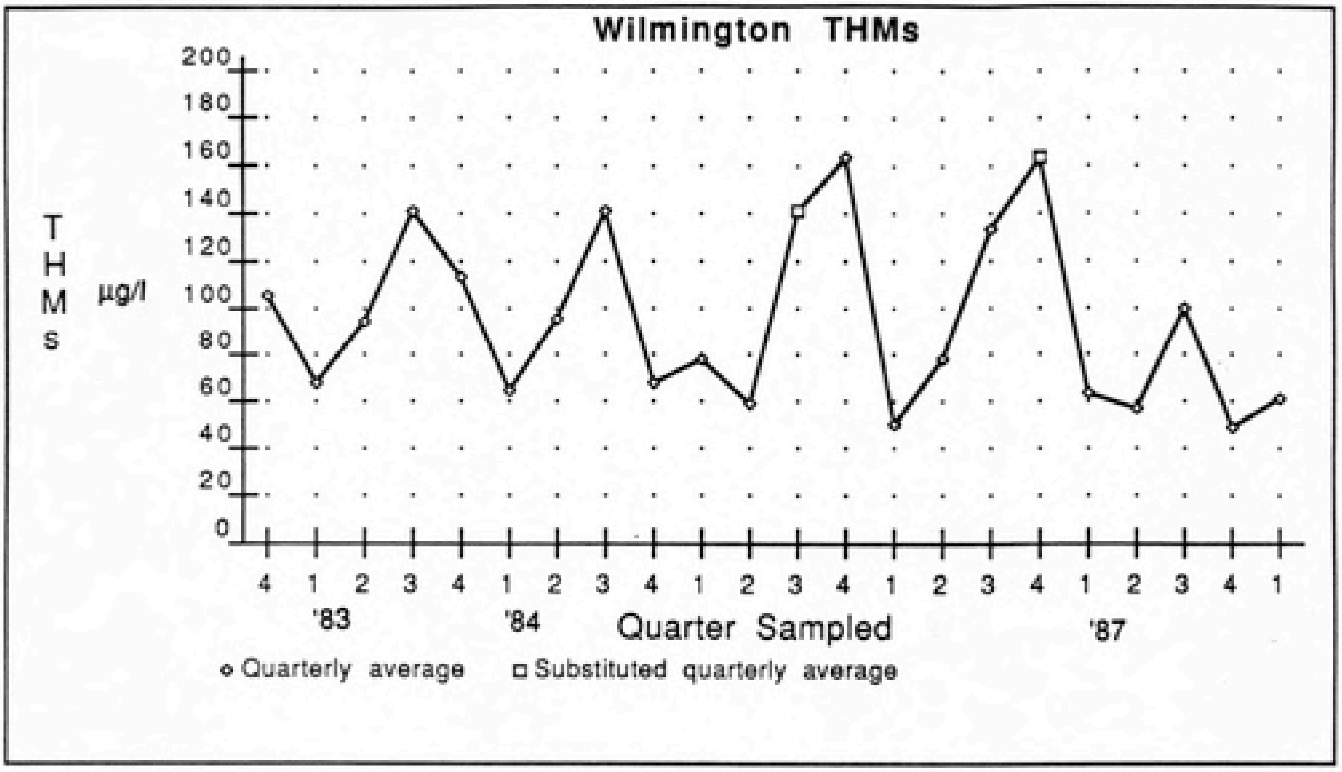

Waynesville Water Treatment Plant THMs
THMs µg/l
100
90
80
70
60
50
40
30
20
10
0
1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
'87
Quarter Sampled
Quarterly average
Substituted quarterly average

Waynesville Water Treatment Plant THM Records

Plant: Waynesville		Ω-measurement discarded for adjusted average calculation		
		Σ-some measurements(Ω) discarded before calculating average		
PWID: 0144010				
Population Served: 16000				
		Unadjusted	Adjusted	Quarterly
Date of Sampling	TTHM's µg/l	Average Reading µg/l	Average Reading µg/l	Average Reading µg/l
03/09/88	26	26		26
12/01/87	31	31		31
08/17/87	57	57		57
05/29/87	27	27		27
03/10/87	27	27		27
10/29/86	35	35		35
08/13/86	33	33		33
05/14/86	36	36		36
03/12/86	24	24		24
12/02/85	36	36		36
08/26/85	53	53		53
05/13/85	38	38		
04/04/85	27	27		32
11/16/84	42	42		42
08/20/84	48	48		48
06/06/84	36	36		36
01/20/84	24	24		24
08/10/83	33			
"	40			
"	45			
"	39	39		39

Waynesville Water Treatment Plant THM Records

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
04/20/83	39			
"	35			
"	36			
"	36	36		36
02/14/83	21			
"	29			
"	30			
"	33	28		28
12/08/82	55			
"	56			
"	68			
"	64	61		61



Wilmington THMs
THMs µg/l
200
180
160
140
120
100
80
60
40
20
0
4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1
'83
'84
Quarter Sampled
'87
Quarterly average
Substituted quarterly average

Plant: Wilmington

Ω-measurement discarded for adjusted average calculation

Σ-some measurements(Ω) discarded before calculating average

PWID: 0465010

Population Served: 52612

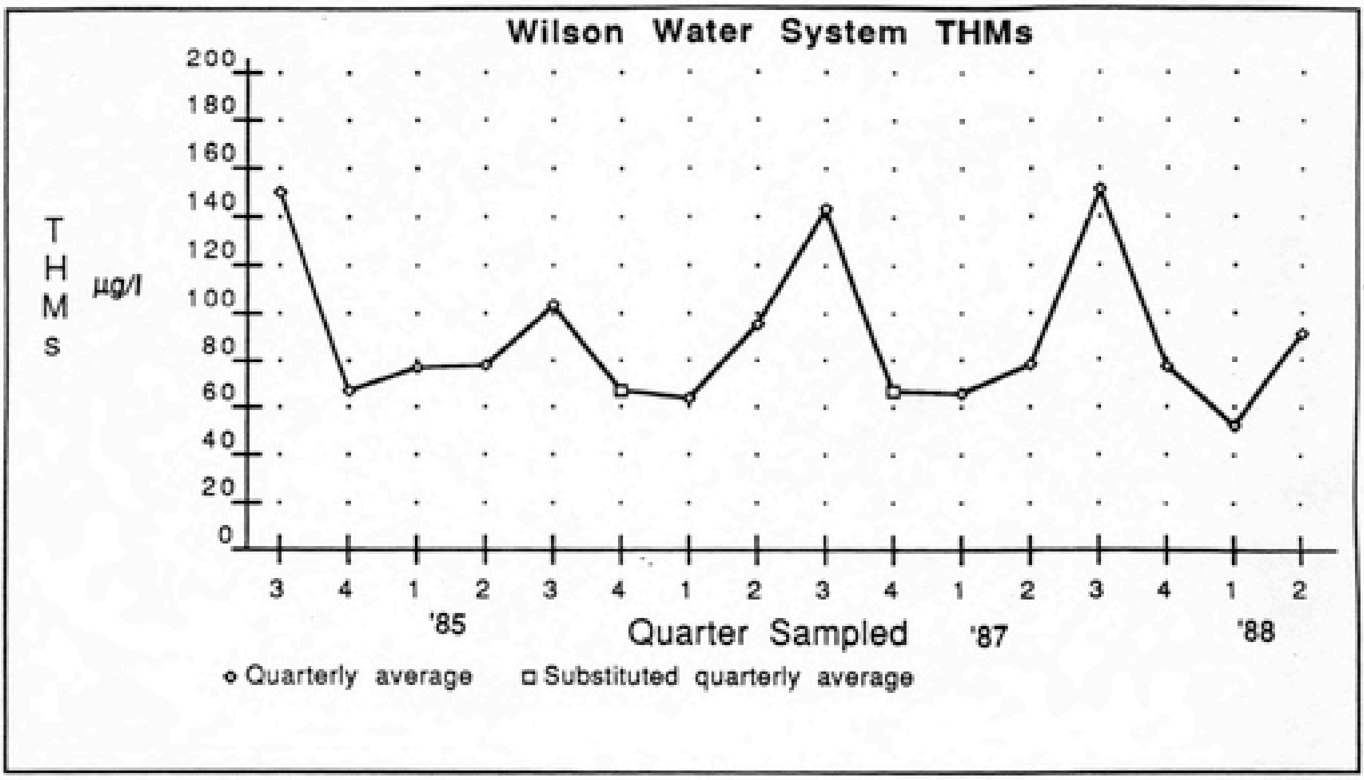
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
03/28/88		71				
"		73				
"		76				
"		81				
"	Ω	98				
"		54				
"		61				
"		69				
"		28				
"	Ω	9				
"		54				
"		60	61	63		
02/11/88		43				
"	Ω	7				
"		55	35	49	61	Σ
12/23/87		44				
•		34				
•		52				
•		65	49			
12/21/87		100				
•		34				
•		52				
•		44				
•		65				
•		47				
•		14				
•		5				
•		52				
•		50				
•		48				
•		73	49		49	Σ

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
09/30/87		86				
"		103				
"	Ω	13				
"	Ω	28				
"		98				
"		122				
"		120				
"		110				
"		118				
"		139	94	112		
09/29/87		121	121			
08/31/87		93				
"		61				
"		63				
"		65	70		100	Σ
06/09/87		46				
"		47				
"		59				
"		77	57		57	
03/09/87		54				
"		53				
"		59				
"		69	59			
01/08/87		58				
"		59				
"		66				
"		83	66		63	
09/09/86	Ω	127				
"	Ω	128				
"	Ω	130				
"	Ω	149	133			
09/08/86		127				
"		128				
"		130				
"		149	133		133	
05/14/86		65				
"		85	75			

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
04/23/86	89	89		
04/14/86	74	74		78
02/10/86	47			
"	38			
"	42			
"	39	41		
01/10/86	67			
"	49			
"	50			
"	54			
"	67	58		50
10/07/85	154			
"	191			
"	152			
"	155	163		163
06/27/85	71			
"	60			
"	52			
"	54	59		59
03/01/85	98			
"	73			
"	69			
"	71	78		78
12/12/84	59			
"	67			
"	61			
"	85	68		68
09/21/84	138			
"	157			
"	138			
"	133	141		141
04/26/84	97			
"	101			
"	95			
"	88	95		95

Wilmington THM Records

Date of Sampling	TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
02/13/84	74			
"	65			
"	58			
"	59			
"	74			
"	59			
"	65			
"	58	64		64
12/07/83	117			
"	118			
"	109			
"	110	113		113
09/28/83	132			
"	131			
"	138			
"	163	141		141
05/03/83	95			
"	89			
"	105			
"	88	94		94
02/03/83	64			
"	65			
"	67			
"	75	68		68
11/03/82	90			
"	100			
"	97			
"	137	106		106


Wilson Water System THMs
THMs µg/l
200
180
160
140
120
100
80
60
40
20
0
3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'85
Quarter Sampled
'87
'88
Quarterly average
Substituted quarterly average

Plant: Wilson Water System			Ω-measurement discarded for adjusted average calculation			
			Σ-some measurements(Ω) discarded before calculating average			
PWID: 0498010						
Population Served: 38500						
			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
04/21/88		78				
"		79				
"		94				
"		95				
"		102				
"		100				
"		95				
"		89	91		91	
03/04/88	Ω	47				
"	Ω	52				
"	Ω	48				
"	Ω	43				
"	Ω	46				
"	Ω	52				
"	Ω	57				
"	Ω	67	52			
02/26/88		47				
"		52				
"		48				
"		43				
"		46				
"		52				
"		57				
"		67	52		52	Σ
12/15/87	Ω	63				
"	Ω	67				
"	Ω	81				
"	Ω	89				
"	Ω	97				
"	Ω	76				
"	Ω	72				
"	Ω	72	77			

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
12/08/87		72				
"		76				
"		97				
"		89				
"		67				
"		72				
"		63	77			
12/04/87		81	81		77	Σ
08/24/87	Ω	150				
"	Ω	142				
"	Ω	127				
"	Ω	133				
"	Ω	150				
"	Ω	161				
"	Ω	171				
"	Ω	171	151			
08/17/87		127				
"		142				
"		150				
"		133				
"		150				
"		161				
"		171				
"		171	151		151	Σ
04/16/87	Ω	46				
"	Ω	44				
"		52				
"		72				
"		96				
"		87				
"		104				
"		58	70	78	78	Σ
03/16/87		38				
"		38				
"		36				
"		37				
"		51				
"		54				
"		73				
"		41	46			

Wilson Water System THM Records

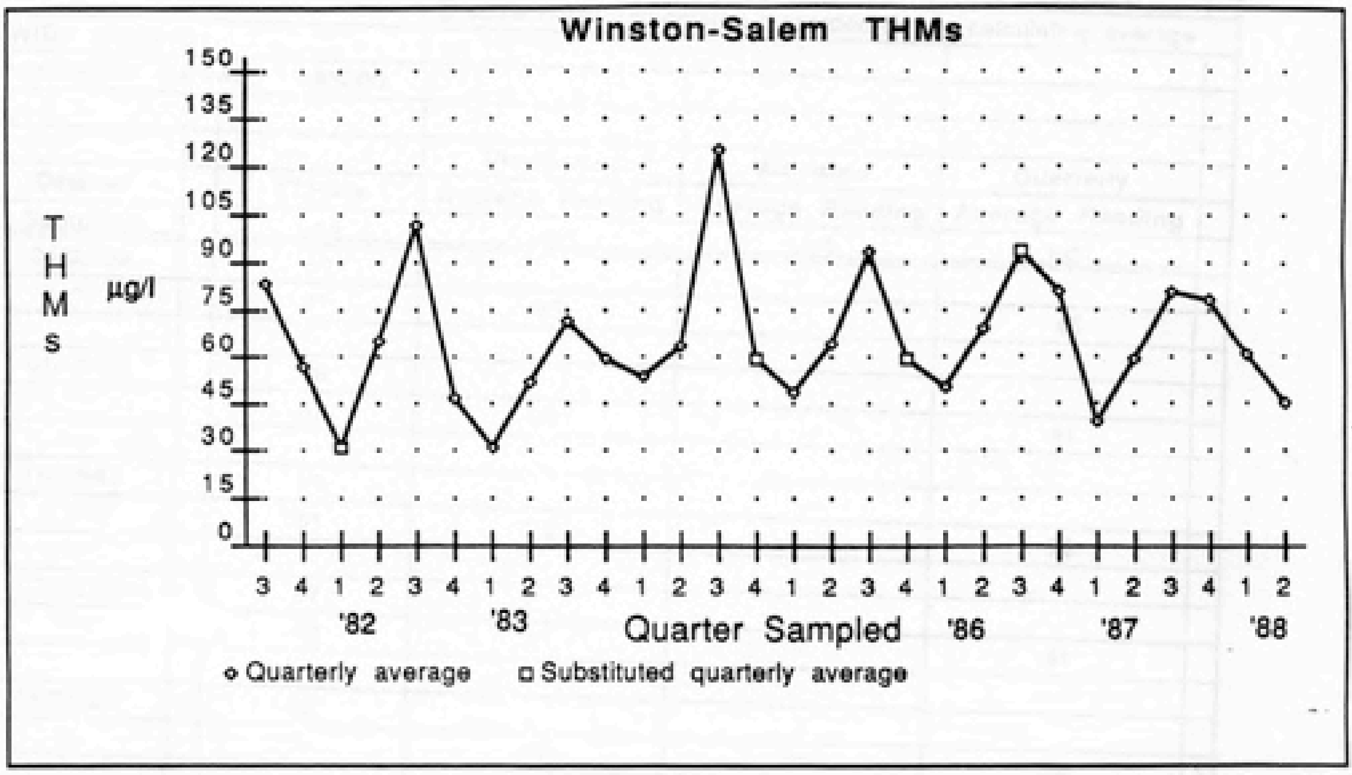
Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
01/02/87		69				
"		72				
"		77				
"		87				
"	Ω	121				
"		104				
"		112				
"		99	93	89	66	Σ
08/07/86		138				
"		114				
"		133				
"		146				
"		158				
"		154				
"		150				
"		151	143		143	
05/23/86		82				
"		81				
"		93				
"		113				
"		96				
"		105				
"		106	96			
05/13/86		85	85		95	
03/28/86		47	47			
03/26/86		36				
"		38				
"		51				
"		40				
"		53				
"		54				
"		45	45			

Wilson Water System THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l
01/14/86		90			
"		58			
"		57			
"		81			
"		73			
"		92			
"		99			
"		93	80		63
07/26/85		163			
"		122			
"		67			
"		91			
"		92			
"		108			
"	Ω	11	93	107	
07/16/85		81	81		103
04/05/85		67			
"		68			
"		93			
"		67			
"		69			
"		85			
"		89			
"		87	78		78
02/28/85		77			
"		81			
"		81			
"		50			
"		68			
"		81			
"		93			
"		85	77		77
12/06/84		51	51		

Wilson Water System THM Records

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
12/03/84		77				
"		90				
"	Ω	108				
"		61				
"		56				
"		62				
"		72	75	70	67	Σ
09/06/84		148				
"		138				
"		165	150		150	


Winston-Salem THMs
150
135
120
105
90
75
60
45
30
15
0
T H M s
µg/l
3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2 3 4 1 2
'82
'83
Quarter Sampled
'86
'87
'88
Quarterly average
Substituted quarterly average

Winston-Salem THM Records

Plant: Winston-Salem

Ω-measurement discarded for adjusted average calculation

Σ-some measurements(Ω) discarded before calculating average

PWID: 0234010

Population Served: 185000

Date of Sampling		TTHM's ug/l	Unadjusted Average Reading ug/l	Adjusted Average Reading ug/l	Quarterly Average Reading ug/l	
04/08/88		50				
"		41	45		45	
01/13/88		66				
"		57	61		61	
10/08/87		95				
"		61	78		78	
07/23/87		67				
"		96	81		81	
05/07/87	Ω	90				
"		59	74	59	59	Σ
02/02/87		49				
"		30	39		39	
10/13/86		94				
"		68	81		81	
05/30/86		63				
"		75	69		69	
03/10/86		57				
"		37	47			
01/03/86		74				
"		31	52		50	
09/26/85		61				
"		126	93		93	
05/09/85		73				
"		55	64		64	
01/28/85		40				
"		23	31			

Date of Sampling		TTHM's µg/l	Unadjusted Average Reading µg/l	Adjusted Average Reading µg/l	Quarterly Average Reading µg/l	
01/03/85		45				
"		84	64		48	
09/28/84		125				
"	Ω	610	367	125	125	Σ
05/15/84		62				
"		65	63		63	
03/08/84		64				
"		43	53		53	
12/08/83		69				
"		50	59		59	
09/26/83		63				
"		81	72		72	
06/07/83		53				
"		52	52		52	
02/15/83		44				
"		19	31		31	
11/17/82		48				
"		47	47		47	
08/11/82		102				
"	Ω	1	51	102	102	Σ
05/13/82		70				
"		60	65		65	
11/13/81		61				
"		60				
"		64				
"		73				
"		68				
"		53				
"		39				
"		40	57		57	

			Unadjusted	Adjusted	Quarterly	
Date of		TTHM's	Average Reading	Average Reading	Average Reading	
Sampling		µg/l	µg/l	µg/l	µg/l	
09/28/81		91				
"		88				
"		89				
"		89				
"		94				
"		75				
"		71				
"		67	83		83	