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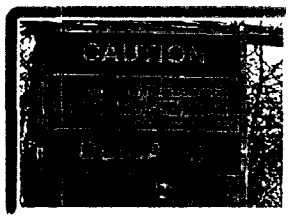
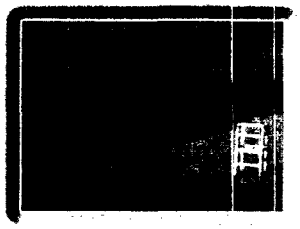
Progress Report 2

WATER QUALITY CHARACTERIZATION FOR THE WOONASQUATUCKET RIVER BASIN





Submitted to:

Rhode Island Department of Environmental Management

Submitted by:

The Louis Berger Group, Inc.

May 22, 2000

295 Promenade Street, Providence, Rhode Island
tel (401) 521 5980, www.berger.com

Rhode Island Department of Environmental Management

WATER QUALITY CHARACTERIZATION FOR THE WOONASQUATUCKET RIVER BASIN

PROGRESS REPORT 2

Submitted to:

Rhode Island Department of Environmental Management
Office of Water Resources
Att.: Mr. Chris Turner
235 Promenade Street
Providence, Rhode Island 02908

Submitted by:
The Louis Berger Group, Inc.
295 Promenade Street
Providence, RI 02908

in association with:
University of Massachusetts
Center of Marine Science and Technology
706 Rodney French Boulevard
New Bedford, MA 02744

May 22, 2000

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1.0 INTRODUCTION

1.1 Project Overview

The primary objective of this project is to conduct a comprehensive water quality characterization for the Woonasquatucket River watershed for the Rhode Island Department of Environmental Management (RIDEM). The project includes a description of the watershed, compilation of existing water quality data, data analysis and synthesis, identification of data gaps, and development and potential execution of water quality sampling plan. The purpose of the characterization is to provide RIDEM with the needed data and information to develop total maximum daily loads (TMDLs) for the Woonasquatucket River.

TMDLs are required under Section 303(d) of the Clean Water Act and USEPA's Water Quality Planning and Management Regulations (40 CFR Part 130). The goal of a TMDL is to quantify existing loadings to an impaired waterbody from point sources and non-point sources and to quantify necessary reductions in loadings to achieve water quality goals. The Woonasquatucket River has been identified as an impaired waterbody with a high priority for TMDL development.

The Project is divided into five tasks:

- Task 1: Problem Identification/Description of Watershed/Waterbody
- Task 2: Collection and Organization of Available Water Quality Data
- Task 3: Comprehensive Water Quality Characterization of the Woonasquatucket River Watershed
- Task 4: Identification of Data Gaps in the Water Quality Data
- Task 5: Development of a Water Quality Monitoring Plan.

A final report will be developed incorporating each of the five tasks into a single report at the conclusion of the project. The anticipated completion date for the study (Tasks 1 to 5) is the end of June.

1.2 Progress Report 2

This report is a progress report of the TMDL study. The following two sections contain the findings of Task 3 and 4.

- **Task 3:** The purpose of Task 3 was to analyze the relevant water quality data for the watershed that were collected during Task 2. Additional data were solicited as appropriate.

- **Task 4:** The purpose of Task 4 was to identify gaps in the data toward the goal of developing TMDLs for the watershed.

- **Upcoming Tasks:** The next activities consist of the development of a monitoring plan. The plan will entail information on sampling stations, frequency, analytical information, etc. The plan will also consider wet weather monitoring activities planned by NBC. Prior to developing the monitoring plan, we will discuss the concept for monitoring with RIDEM. An important aspect of this discussion will need to be the parameters that RIDEM plans to focus on for the development of TMDLs as well as the portion of the watershed that will be considered.

  Monitoring is scheduled to start this summer.

2.0 WOONASQUATUCKET RIVER WATERSHED

This section is an overview of the Woonasquatucket watershed. The section was presented in Progress Report 1.

3.0 EXISTING WATER QUALITY DATA FOR WOONASQUATUCKET WATERSHED

This section is a description of the available water quality data for the Woonasquatucket watershed. This description was presented in Progress Report 1. The description included appendices with original data. These appendices were modified and expanded slightly during the data synthesis as part of Task 3. Since the data in the appendices are needed to make decisions for the monitoring program, we submit separately two copies of revised Appendices.

Please note that appendices were also renumbered to simplify the process of referencing specific tables from the appendices in the main text of the report. Specifically, the appendices were changed as follows:

Previous Appendix number	*New Appendix number*
2-1	(now summarized in a one page table that will be incorporated in Section 2 of the main text of the Final Report)
3-1	1
3-2	2
3-3	3
3-4	4
3-5	5
3-6	6
3-7	7
3-8	8
3-9	9
3-10	10
3-11	11
3-12	12
3-13	13
3-14	14
n/a	15 (new appendix with USGS data from 1989)

4.0 WATER QUALITY CHARACTERIZATION OF THE WOONASQUATUCKET RIVER WATERSHED

4.1 Introduction

This section represents a summary of the available data for the Woonasquatucket River watershed. The data were summarized in a manner that will provide an overall understanding of the water quality in the watershed. Further, the data were examined to provide information toward the goal of developing TMDLs for specific parameters. Specifically, this synthesis is considered the first level of data synthesis to provide information for questions including the following:

- What are the main water quality impairments in the watershed?
- What are the main point and non-point sources of water quality impairment?
- What additional data are needed for specific parameters to allow for the development of TMDLs (Task 4; discussed in Section 5 of this report)?

This information will provide the basis for the monitoring plan to be developed in the next task.

Tables and graphs for specific parameters are attached at the end of the report. Please note that, in order to avoid confusion as a result of the larger number of graphs and tables, all tables were numbered as figures, rather than as a separate set of tables. However, reference made to tables in appendices are labeled as "Table A[followed by the appendix number, followed by the number of the table in the respective appendix]".

Disclaimer: Please note that the data synthesis in this report is only based on data that were collected and published by different sources. Since Berger staff were not involved in the sampling and laboratory analyses of these data, it is impossible to verify the accuracy of the data. In addition, detection limits and analytical methods varied to some extent in the different studies. In this synthesis we tried to compare only data that were analyzed using similar methods. Our quality control measures were limited to the identification of unexplained outliers in the data sets and obvious reporting inconsistencies. Similarly, some of the statistical averages that were generated in this report are based on a very small amount of available data. The reliability of the statistical averages generated in this report must be compared with the number of points in the data set. The number of data points is reported in appropriate tables in the text. In addition, the original data of reviewed studies are included in the Appendices and should be used of reference in case of questions.

4.2 Methodology

The existing data described in Section 3 (in Progress Report 1) were reviewed. The sampling locations of each of the studies are listed in Figure 4-1. Individual parameters for which data exist were summarized in Figure 4-2.

The available data consist of the following:

- Surface water quality data from the Woonasquatucket River from regular monitoring studies (independent of weather condition; Appendices 7, 9, 10, 11, and 14) and from targeted stormwater discharge investigations (Appendices 2, 3, 4). In addition, surface water quality data were collected as part of the investigation of the three main hazardous waste sites in the watershed (Davis Liquid Waste Site, Davis Landfill, the impoundments in the lower Woonasquatucket River and Centredale Manor Site; Appendices 1, 5, 9, and 12).

- Water quality data from the eight largest reservoirs (Appendix 6)

- Stormwater discharges from two drain pipes (W6 - Killingly Street; W23 - Providence Civic Center) (Appendix 13).

- Information on point sources such as Combined Sewer Overflows (CSO) and the effluent from the Smithfield Wastewater Treatment Facility (Section 2.9 in Progress Report 1).

- Sediment quality data from contaminated areas, namely the Davis Liquid Waste Site, the Davis Landfill, and the Centredale Manor Site (Appendices 1, 5, and 12).

- Fish tissue data from Esmond Dam, Centredale Manor, and Valley Street (Appendix 8).

- Benthic macroinvertebrate information from field screening during the summer (Section 3-15 in Progress Report 1). Information about the exact location of the screening location could not be obtained.

The quality control of the original data consisted mainly of the examination of outliers and inconsistencies. In case of uncertainties based on the data reports, we contacted the researchers involved in the data collection, as possible. These uncertainties included detection limits, analytical methods, analyzed fraction of the samples (e.g., dissolved versus total sample for metals), units (e.g., mg/l versus ug/l), reporting of nitrogen and phosphate data (mg/l NO_3 or NH_3 versus mg/l N; mg/l PO_4 versus P), specific sampling locations, sampling depth, etc.

Analyses that resulted in "not detected" were replaced by *"<[detection limit]"* when the detection limit was known.

Statistical analyses were limited to the determination of the mean, minimum and maximum concentration. For bacteriological data, the mean concentrations represent the geometric mean. The goal of the calculation of mean concentrations was to arrive at representative values. Representative value need to incorporate analytical results below the detection limit. Therefore, values reported as *"<[detection limit]"* were used as follows:

- In most cases, the detection limit was used in the summation for the mean concentrations. The resulting mean concentration was then reported as *"<[mean concentration]"*. For example, for the data string 80, 40, <40, <80, the reported mean concentration was <60.

- In selected cases where using the full value of the detection limit had only a minimal impact on the mean concentration, only 50% of the detection limit value was used in the summation for the mean concentration. For example, for the data string 80, 40, <4, 80, a value of 2 was used for the analytical result <4; the resulting mean was 51.

The waters of the Woonasquatucket River watershed are designated as Class B, B1, or B1{a}waters (see Section 2.4.3 and Figure 2-8 in Progress Report 1). Water quality data were compared to Rhode Island's water quality criteria for the respective classes, as appropriate; the criteria are listed Figures 4-3 to 4-6. For parameters, for which standards do not exist we used other indicator values, as appropriate.

The discussed data were separated into the following sections:

- Water quality of the reservoirs
- Water quality of the Woonasquatucket River (downstream of the reservoirs)
- Sediment and Water Quality at Contaminated Sites
- Biological information for the Woonasquatucket River

The discussion is then followed by a discussion of sources for elevated concentrations of contaminants and a summary.

4.3 Water Quality of the Reservoirs

The majority of the dams on the Woonasquatucket River are operated in the run-of-river mode with limited flow regulation. The only exception is the Stillwater Dam. RIDEM's Division of Fish and Wildlife operates the dam to maintain flow downstream for recreational and industrial users. Flow is also regulated to maintain water level below the spillway elevation due to the poor condition of the spillway structure. Flow is regulated through low-level outlets by opening and closing sluice gates.

The available water quality data for the major reservoirs were collected by volunteers of Watershed Watch, which is organized by URI, between 1993 and 1998 (see Appendix 6). These reservoirs consist of the following (see Figure 4-1 for location):

- Upper Sprague Reservoir
- Lower Sprague Reservoir
- Waterman Reservoir
- Slack Reservoir
- Stillwater Reservoir Southend
- Stillwater Reservoir
- Stillwater Pond
- Georgiaville Reservoir

The available data consist primarily of nutrients, chlorophyll, dissolved oxygen, pH and bacteriological data (fecal coliform and *E. coli*). Metal and organic compounds were not monitored for the reservoirs. The concentrations of the main parameters are summarized for the following parameters: pH, fecal coliform, dissolved oxygen, chlorophyll, Secchi depth, total nitrogen (at 1m), nitrate, total phosphorus, dissolved phosphorus, and trophic status (Figures 4-8 to 4-18).

4.3.1 pH

The mean pH values for the reservoirs vary between 6.6 and 6.9 (Figure 4-8). The lowest pH was measured in Waterman Reservoir with 5.9. The lowest ph was measured in Waterman Reservoir with 5.9 ; the highest pH was measured in Stillwater Reservoir with 7.5. The regulatory standard for pH is 6.5 to 9.0 or as naturally occurs.

4.3.2 Bacteriological Data

The reservoir monitoring data from URI Watershed Watch (1993 to 1998; Appendix 6) contain the only known fecal coliform monitoring data upstream of Stillwater Reservoir Dam. The patterns of the fecal coliform concentrations and E. coli concentrations measured in the eight reservoirs are similar. Furthermore, the Rhode Island water quality criteria currently are based on fecal and total coliform concentrations only. Therefore, only the fecal coliform concentrations are discussed.

Fecal coliform was detected in all eight reservoirs most of the time. However, with the exception of Slack Reservoir, the fecal coliform concentrations met Rhode Island's water quality criteria for swimming of 200 MPN/100 ml at all times; the highest measured value was 65 MPN/100 ml (Figure 4-9). Based on the data base, it appears that these lakes/reservoirs meet the Class B water quality criteria for fecal coliform.

In Slack Reservoir, the fecal coliform concentrations ranged between 4 MPN/100 ml and TNTC (too numerous to count). The highest measured concentration was 1,160 MPN/100 ml, exceeding the Rhode Island water quality standard. The geometric mean for the period (1994 to 1998) was >41 MPN/100 ml. It should be noted, however, that this value was calculated without consideration of two samples reported as too numerous to count (TNTC). In general, the samples taken in July and November were the higher concentrations. The source for pathogens may consist of discharges of runoff from the Town of Smithfield and Johnston. For example, an area adjacent to the reservoir in Johnston with medium density development is currently not sewered. High coliform concentrations could also be caused by high concentrations of ducks and other waterfowl. The Slack Reservoir drains into the Stillwater Reservoir (Southend) via the Stillwater River. The low fecal coliform concentrations in the Stillwater Reservoir (Southend) suggest that the bacteria either die off or are sufficiently diluted after discharge from the Slack Reservoir.

4.3.3 Nutrients and Related Parameters

The ecological health of the reservoirs within the Woonasquatucket River watershed are determined primarily by nutrient levels and to some extent by toxic contaminants (see Section 4.5 below). The nutrients relate directly to the trophic status of the reservoirs and manifest their ecological effect through dissolved oxygen levels, algal growth (related to chlorophyll *a* levels), biologically generated turbidity (related to Secchi depth) and watercolumn oxygen uptake, and particulate organic carbon levels (related to BOD). The primary data on the trophic status of the reservoirs was generated by the URI Watershed Watch (1993 to 1998; Appendix 6). However, data relating to the Stillwater Reservoir, Stillwater Pond and Georgiaville Pond collected by NBC (1998; Appendix 10) were also used. The NBC data were collected at or near the reservoir outlets and therefore do not include any data on the vertical structure of the watercolumn; however, these data should reflect euphotic zone conditions. Figures 4-10 to 4-18 summarize the key concentrations measured by URI Watershed Watch.

The reservoirs evaluated are all relatively shallow with maximum depths of less than 8 m. The deepest reservoir is Georgiaville Pond at 7.6 m; the shallowest one is Waterman Reservoir at 2.1 m. The maximum depths of the remaining reservoirs are between 3.5 and 4.6 m. Although macrophyte distribution data were not collected, these shallow reservoirs are susceptible to benthic plant production which can be significant in structuring the habitat and determining trophic status. These plants were not measured in the watercolumn sampling based on the available data.

The water samples analyses included total phosphorus (TP) which is a primary trophic state indicator in freshwater. The determination of the trophic state was based upon oligotrophic waters with a TP concentration of <10 ug/l, eutrophic waters with a TP concentration of >24 ug/l, and mesotrophic filling the middle interval with a TP concentration of 10 to 24 ug/l. Of the eight reservoirs investigated, only the Lower Sprague Reservoir showed consistent TP concentrations of ≥24 ug/l and by this classification method be deemed eutrophic (Figures 4-13 and 4-18). All of the other reservoirs appear to be generally mesotrophic. The TP data from the outlet of Stillwater Reservoir and Stillwater Pond and slightly downstream of Georgiaville Pond collected by NBC is consistent with the URI Watershed Watch data. However, TP is only one criterion for determining trophic status of open water systems. The other available water quality data also yield insight into the validity of the TP based classification.

The TP evaluation is strengthened if it can be confirmed that the reservoirs are phosphorus limited throughout the growing season. Some lakes undergo a late season nitrogen limitation which can result in a community shift to blue green algal dominance. Although much of the nitrate data is below detection, the detection limit (50 ug/l) was quite sufficient to be not limiting (Figure 4-14). The maximum values for each system in each year appear to be sufficient as to not limit phytoplankton, although the temporal trend cannot be judged. However, the ratio of total nitrogen to total phosphorus indicates that on average the reservoirs are phosphorus limited. Average ratios for the eight reservoirs range from 19 to 41 (wt/wt of N/P) compared

to an approximate algal constitution of 7. While this ratio method on total N and P is imperfect, the result is consistent with our general expectation for relatively undeveloped watersheds.

Chlorophyll *a* is a measure of the phytoplankton biomass within the euphotic zone of the reservoirs. Although chlorophyll levels are typically more temporally variable in lakes than TP, they yield more direct evidence of ecosystem health and are more directly linked to nutrient related water quality. The chlorophyll data clearly support the eutrophic classification of the Lower Spague Reservoir. In 4 of the 5 years of available data, chlorophyll concentrations reached 20 ug/l, with a maximum of 41 ug/l. The average concentration for this system, 7.4 ug/l, is likely low due to undersampling of the spring bloom (sampling started in May), and captures instead the low biomass period which generally follows this bloom each year. It is possible that the fall bloom, which is likely the largest bloom of the year, is also undersampled as sampling did not continue past late October each year. Of the remaining reservoirs, only Stillwater Reservoir showed periodically high chlorophyll levels, but only at its southern end and with significant interannual variation. The chlorophyll data appear to support the eutrophic and mesotrophic classifications based on TP.

Dissolved oxygen concentrations are consistent with mesotrophic and eutrophic systems. It appears that the reservoirs, although shallow, may periodically stratify. Slack and Georgiaville Reservoirs, for which surface and bottom data for dissolved oxygen are available (Appendix Tables A6-13 and A6-21), clearly show stratification events; during these events the bottom dissolved oxygen is significantly depleted. Low oxygen or anoxic conditions indicate mesotrophic or eutrophic conditions. However, more information on stratification is required on all of the systems as it is a major determinant of the sensitivity of a water body to changes in nutrient loading.

Secchi depths were generally at or just above the reservoir bottoms. However, given the shallow nature of these systems, the Secchi depth data indicate a relatively high degree of turbidity. The turbidity was consistent with the chlorophyll *a* concentrations. Since the compensation depth for phytoplankton and many benthic plants is generally below the Secchi depth, it appears that there is sufficient light over most of the bottom of these reservoirs to support plant growth. This observation indicates that macrophytes need to be considered in any nutrient sensitivity or TMDL analysis of these systems.

In general, the reservoirs are showing mesotrophic conditions (expect for the Lower Sprague Reservoir which is eutrophic). This finding is consistent with their relatively undeveloped watersheds. Regionally, most of the open waters are currently mesotrophic.

4.4 Water Quality in the Woonasquatucket River

Water quality data for the Woonasquatucket River for sections upstream of the Stillwater Reservoir were not located. The only exceptions were limited data for Nine Foot Brook and Latham Brook that were collected as part of the investigation of hazardous waste sites in the subwatersheds of these brooks; these data are discussed in Section 4.5 below. Therefore, the discussion of the water quality of the Woonasquatucket River is focused on the river segment between Stillwater Reservoir and the mouth of the river at Water Place Park, hereafter referred to as "lower Woonasquatucket River".

Station locations for "dry weather studies" are presented in Figure 4-19. Dry weather studies were studies that were not specifically designed to evaluate the discharges during rainstorm. Most of the data were collected during dry weather, although some of the data from individual sampling events may have been affected at times by rainfall during days prior to sampling. To the extent possible, we tried to identify such data in the discussion below.

Station locations of studies that were specifically designed to monitor the effect of rainstorms are presented in Figure 4-21. These studies consist of the studies presented in Appendices 2, 3, 4, 12, and part of 14.

Aside from the graphs and tables attached in the Appendices, we summarized available data for specific key data sets as follows:

- The statistical information (mean, minimum, maximum) of the major surface water quality parameters with more than just a few measurements is presented in tables for dry weather conditions. The number of data that were analyzed is summarized in Figure 4-20. Data on this figure are listed based on their position along the river course; upstream locations are listed first, downstream locations last.

- The statistical information (mean, minimum, maximum) of the major surface water quality parameters with more than just a few measurements is presented in tables for wet weather conditions. The number of data that were analyzed is summarized in Figure 4-22. Data are also listed from upstream to downstream.

- Nutrient and metal data were collected by NBC in 1998 at stations along the Woonasquatucket River from Stillwater Reservoir to the mouth of the river. The graphs consist of (1) the individual measurements from each sampling event and of (2) the mean, minimum and maximum values, as appropriate. Please note that the detection limit was used for values below the detection limit.

- Data collected by River Rescue over several years (1990 to 1994; Appendix 7) were collected at two stations (W1: Valley Street and W2 Route 44). These long term data records provide information of the variability for specific parameters at each of the two stations over time. The NBC (1998) data provide good regional coverage, but were only collected during one summer and fall.

- Data collected by NBC between 1997 and 1999 for fecal coliform in the lowermost segment of the river. These data provide good information of the variability of fecal coliform concentrations in the river over time.

The graphs and tables (both graphs and tables are numbered as figures) are attached after the text organized by parameter to allow for comparisons of the data during different conditions and times. Also, a list of all the figures is provided with the figure section.

4.4.1 Water Temperature and pH

The water temperature in the lower Woonasquatucket River ranges from 27 degrees Celsius in the summer to zero degrees in the winter (Figures 4-24 to 4-25b). The mean pH was measured by NBC (1998) at approximately 7 (Figures 4-25c and 4-25d).

4.4.2 Total Suspended Sediment

Total suspended sediment (TSS) data are available in Appendices 2, 3, 4, 7, 10 and 13; data are summarized in Figures 4-26 for dry weather and Figure 4-27 for wet weather. NBC's (1998) detection limit of 5 mg/l was inadequate for detection of TSS concentrations. The River Rescue data (Figures 4-28 and 4-29) indicate that dry weather TSS concentrations are typically below 2 mg/l. The TSS concentrations in the river water increase sharply during wet weather conditions with mean concentrations ranging between 5 and 19 mg/l during the period of rainfall (Figure 4-27). In the stormwater outfalls W6 and W23, the highest concentrations were 198 and 366 mg/l, respectively.

4.4.3 Bacteriological Data

Fecal coliform concentrations were determined by NBC during the summer of 1998 between the Stillwater Reservoir and the mouth of the river. NBC also has been conducting regular monitoring for fecal coliform

between Manton Avenue and the mouth of the river. Fecal coliform data are further available from the Smithfield Wastewater Treatment Plant, and from River Rescue (Kerr and Lee, 1996) at two stations. Fecal coliform concentrations during wet weather were measured by URI (Wright et al., 1991; URI, 1992) and by CDM (1989). Fecal coliform data for CSOs is summarized in Table 2-13 in Progress Report 1. Fecal coliform graphs and tables are presented in Figures 4-30 to 4-37.

- Dry Weather

During dry weather, the lower Woonasquatucket River violates Class B and B1 fecal coliform criteria between Georgiaville Pond and the mouth of the river (Figures 4-30, 4-32 and 4-33). The highest concentrations were measured in the river segment impacted by CSOs with the highest concentrations downstream of CSO OF-049. OF-049 is the most significant CSO in the watershed in terms of volume and peak discharge. Assapumpset Brook (NBC-1998 Station WR-7a) also violates fecal coliform criteria with a geometric mean of 1,420 MPN/100 ml. The highest dry weather concentrations were measured by NBC (1998) at Stations WR-15 and WR-16 near the mouth of the river; please note that these two stations are tidally influenced.

During the NBC-1998 survey, the fecal coliform concentration in the effluent of the Smithfield Wastewater Treatment Facility (Station WR-4) was always below 100 MPN/100 ml (possibly a result of chlorination of the effluent). In fact, the concentrations were always lower than the concentrations in the Woonasquatucket River upstream and downstream of the WWTF (Figure 4-32). The concentrations in the river gradually increased again downstream from the effluent inflow.

The geometric mean coliform concentrations of the effluent as measured by the Smithfield Wastewater Treatment Facility was 27 MPN/100 ml, which met the RIPDES permit limits of a monthly average concentrations of 200 MPN/100 ml and a maximum concentrations of 400 MPN/100 ml. However, the maximum monthly fecal coliform average of 914 MPN/100 ml exceeded the standard.

The highest maximum fecal coliform concentrations in the river were measured by NBC (1997-1999) as part of the fecal coliform monitoring program (Appendix 14). The fecal coliform concentrations reached up to 2,300,000 MPN/100 ml. This monitoring program is conducted throughout the entire year, not just during the summer as NBC (1998). The concentrations gradually increased between upstream station S-9 (Manton Avenue) and downstream station S-7 (Exchange Street). The mean concentration for dry weather conditions were 112 MPN/100 ml at Station S-9, 307 MPN/100 ml at Station S-8A (Olneyville Square), 930 MPN/100 ml at Station S-8B (Valley Street), 882 MPN/100 ml at Station S-8, and 1470 MPN/100 ml at Station S-7 (Figure 4-30).

The comparison between data from 1997 to 1999 for Stations S-7 to S-9 indicates that there is not a consistent seasonal pattern in the coliform concentrations at these stations (Figure 4-34 to 4-36). In 1997, the concentrations were generally highest during the summer and fall; in 1998, the concentrations were slightly higher in spring; and in 1999, the concentrations were generally highest during late summer and early fall. This patterns appears to be unrelated to the daily river discharge rate (Figure 4-37), but is instead influenced by stormwater runoff and CSO discharges (Appendix 14; Table 2-12 in Progress Report 1).

Dry weather fecal coliform data from the NBC summer 1998 and 1997/98 studies showed good agreement at the common locations. Average levels at WR-8 and S-9 of 183 and 112 MPN/100 ml; WR-11 and S-8a of 610 and 307 MPN/100 ml; WR-13 and S-8B of 675 and 930 MPN/100 ml; WR-14 and S-8 of 705 and 882 MPN/100 ml; and WR-16 and S-7 of 1,584 and 1,469 MPN/100 ml, respectively. This suggests that dry weather coliform levels are relatively consistent and relatively well documented, particularly for the lower river. Generally, the fecal coliform concentrations were highest in the lowermost sections of the river apparently as a result of dry weather inflows from either CSO discharges or other urban surface water inflows.

Dry weather data are also available from 5 sampling events in 1987 (CDM, 1989; Stations R1 to R4; Appendix 2). The concentrations at Stations R2 and R3 were high compared to the fecal coliform concentrations collected by NBC (1997-1999) at nearby stations (Figure 4-30). The concentrations of Station R1 and R4, however, were within the range of the NBC data.

- Wet Weather

During wet weather, the river violates fecal coliform criteria both upstream and downstream of CSOs. Wet weather data collected during rainstorms are available from the segment between Manton Dam (Station R1) and the mouth of the river. Fecal coliform concentrations in every wet weather study conducted increased from dry weather concentrations generally about 5 fold, with more than 10 fold increases being observed for individual stations and storms (Figure 4-31). Generally, the fecal coliform concentrations were highest in the lowermost sections of the river as a result of CSO discharges. High fecal coliform concentrations were still detected during the 24-hour period after rainfall had ended; thereafter, the concentrations generally decreased again to dry weather concentrations.

The mean concentration for wet weather conditions were measured by NBC (1997-1999) from 363 MPN/100 ml at Station S-9; 1,480 MPN/100 ml at Station S-8A (Olneyville Square); 10,700 MPN/100 ml at Station S-8B (Valley Street); 5,200 MPN/100 ml at Station S-8; and 8,100 MPN/100 ml at Station S-7 (Figure 4-31).

One of the sampling events conducted by NBC during the summer of 1998 may be considered a wet weather event. Rain fell prior and during the sampling date of August 19 (August 17: 0.71 inches; August 18: 0.45 inches; August 19: 0.20 inches). Although the heaviest rain fell two days prior to sampling, fecal coliform concentrations during this event were uniformly high at most of the river stations, exceeding 1,000 MPN/100 ml (Figure 4-32).

4.4.4 Nutrients and Related Parameters

Some of the key data on nutrients and related parameters considered in this discussion were summarized in graphs and tables. Dissolved oxygen data were summarized in Figures 4-38 to 4-42; nutrient data were summarized in Figures 4-43 to 4-67; and phosphorus data were summarized in Figure 4-68 to 4-77.

Overall, it appears that water exiting Georgiaville Pond is of relatively high quality and exerts the predominant control on the nutrient levels in the Woonasquatucket River between Georgiaville Pond and the Smithfield WWTF. The generally low nutrient levels in the Georgiaville Pond outflow suggests that the upper watershed is either a relatively low source of nutrients and/or the reservoirs are intercepting the nutrient load before releasing the water to the lower Woonasquatucket River.

The major feature in the nutrient field of the lower river is the Smithfield WWTF, with higher concentrations of nitrogen (N) and phosphorus (P) throughout the river below versus above the facility. Additional nitrogen and phosphorus inputs below the Manton Mill Pond Dam have a periodic effect; however, the most dramatic response in the river reach below this dam is on nitrate levels possibly related to wet weather inflows. However, the effect does not appear to be due solely to CSO inputs as the increase begins above the first CSO.

Examining individual data sets reveals that the river has a relatively uniform nutrient field on any given date. This is evidenced by the generally constant concentrations of all nitrogen and phosphorus species. During dry weather, the nutrient load from the WWTF typically results in an increase of the TN and TP concentrations in downstream waters. The general increase in TP below versus above the WWTF is on average about 2-3 fold to the Allendale Pond Dam, with only modestly higher levels in the river below the Manton Dam (on the order of 50%). In contrast, total nitrogen concentrations throughout the river below the WWTF is more than twice

as high as in the upper reaches (WR-3, WR-3a). However, nutrient levels are relatively "flat" within the upstream and downstream river reaches. This further suggests that TN and TP are generally transported through the river into the Providence River rather than being removed, although biological cycling is clearly taking place. It should be noted that this pattern of significantly higher N and P levels in waters downstream versus upstream of the WWTF was observed in all available data sets.

There appears to be a significant periodic input of nitrogen, most likely as nitrate, between Lymansville Dam and WR-8 (about 0.2 miles below the Lymansville Dam). The input was most dramatically seen in the August 12, 1998 post-rain event and July 29, 1998 dry weather event sampled by NBC (1998). The source does not appear to be from direct wastewater or CSO discharges, as these sources usually contain both N and P and the major increase in these events was in nitrate only. However, surface runoff cannot be ruled out. A groundwater source is unlikely since it would tend to be relatively constant, although it would tend to be enriched in nitrate over ammonium, organic N, or phosphorus.

The Woonasquatucket River from the Capron Dam to the Providence River appears to have sufficient levels of inorganic nitrogen (primarily as nitrate) to not be limiting to algal production. While this meets with common ecological theory on nutrient limitation in freshwater, it is not clear if the inorganic phosphorus levels are similarly high. The limited ortho-phosphate data (CDM, 1987) collected during dry weather indicate that phosphorus also should not be limiting phytoplankton production. Levels were typically >10 ug/l during dry weather. River Rescue (Kerr and Lee, 1996) also measured ortho-phosphate levels at 2 sites in the river (Stations W2 and W1). While the average ortho-phosphate levels were 76 and 34 ug/l for the upstream and downstream stations, respectively, the averages could be misleading without considering seasonal variability. During the 3 years of study, there were clear summer maxima in ortho-phosphate at these stations with values exceeding 200 ug/l each year. These levels should not be limiting to phytoplankton growth. However, during winter, the levels were more than 10 fold lower and may limit algal growth. Based upon these data it is presently unclear if another factor is controlling algal growth in the lower river, such as light, flow, etc. It is even less clear if the impoundments within the lower river, some of which are clearly eutrophic, will be further eutrophied by additional phosphorus inputs. Total phosphorus levels within the river are generally modest, with average levels below the Manton Dam of <15 ug/l in the mesotrophic range. This contrasts with the reach below the WWTF which generally had eutrophying TP levels.

The eutrophic nature of the river below the WWTF is clearly seen in the phosphorus levels and the low dissolved oxygen and the up to 6 mg/l diurnal swing in concentration within Greystone Mill Pond. Reduced oxygen levels predominate the river from the WWTF to the Lymansville Dam (RIDEM, 1999). These conditions are consistent with the observed algal blooms and floating algal mats during summer. Given their reduced turnover rates and potential periodic stratification, the impoundments along the lower river appear to be more nutrient impacted than the main river channel. Although the river reach below the Greystone Mill Dam and the Allendale Pond appears to show reduced habitat health due to the WWTF nutrient load and likely other local inputs as well. However, except for the region within the WWTF effect, oxygen conditions within the lower river generally have not been found to be significantly depressed. Habitat quality in the lower river is most likely controlled by physical processes, organic matter loading, and possibly toxic contaminants in some regions (see below). The single benthic assessment conducted within the CSO reach of the river showed modest habitat degradation, consistent with the observed water quality measures.

Wet weather conditions typically increased the levels of inorganic nitrogen (both nitrate and ammonium) and total phosphorus. Ammonium and TP tended to show greater increases than nitrate system wide, consistent with the CSO inputs and other stormwater flows. The increases found in the CDM investigation were generally 10% to 50%. However, given the increased concentration and increased flow, it is clear that an increase in N and P loading occurs during wet weather. This increased loading is not only from CSOs, since CDM's sites are located only as far upstream as Manton Dam.

The increased loading of nutrients and organic matter to the river during wet weather does not appear to result in a low dissolved oxygen response. Although the data are very limited, it appears that even within the CSO reach of the river, 3-5 days after the rain event, there is no significant reduction in the well oxygenated conditions which existed prior to rainfall (URI, 1990). This suggests that the river may have a relatively high assimilative capacity within this reach, since organic matter is clearly being loaded into the river (and likely being produced in situ as well) as evidenced by the large and significant increase in fecal coliform after a rainfall.

4.4.5 Metals

The regulatory standards for most heavy metals vary depending on the hardness of the water. The hardness measured by the various studies ranged between 19 and 64 mg/l as $CaCO_3$ in the freshwater portion of the river (Figure 4-78). Generally, the mean hardness varies between 20 and 30 mg/l between Stillwater Reservoir and Manton Mill Dam, and between 30 and 40 mg/l from Manton Mill Dam to the tidal section of the river. The hardness of Assapumpset Brook was measured with 50 mg/l.

The data set for metals with the most stations along the Woonasquatucket River was collected by NBC (1998). River Rescue collected a large number of samples from 1990 to 1993 from two stations; these samples included analyses of total metals. Station W1 (Valley Street) is identical with NBC-1998 Station WR-13; Station W2 (Route 44) is identical with NBC-1998 Station WR-6.

Heavy metal data are also available from CDM (1989), although the detection limits are inadequate for the evaluation of compliance with standards, and the detection of sources of contamination; essentially all values were below the detection limit. Therefore, with the exception of zinc, these data were not considered, but are still contained in the data tables.

Additional data are available from the URI studies during rainstorms (Appendices 3, 4 and 13).

Following is a discussion by parameter. For the purpose of this discussion, the concentrations measured in the river by the various studies are compared to Rhode Island's chronic criteria for a hardness of 25 mg/l. Some of the key data on metals considered in this discussion were summarized in graphs and tables in the back of the report as follows:

Cadmium	Figures 4-79 to 4-86
Chromium	Figures 4-87 to 4-94
Copper	Figures 4-95 to 4-102
Lead	Figures 4-103 to 4-110
Nickel	Figures 4-111 to 4-118
Silver	Figures 4-119 to 4-120
Zinc	Figures 4-121 to 4-126

Data tables list chronic and acute criteria for a hardness of 25, 35, and 45 mg/l.

- **Cadmium**

The *dissolved cadmium* concentrations measured by NBC (1998) were largely below the detection limit of 0.3 ug/l (Figure 4-81); the chronic criteria for dissolved cadmium with a hardness of 25 mg/l is 0.4 ug/l. During the sampling event of August 19, cadmium concentrations reached 0.8 ug/l downstream of Station WR-07 which exceeded regulatory standards.

The highest dissolved cadmium concentration was measured with 1.6 ug/l at Station WR-1 during the wet weather event on August 12, 1998. However, it is possible that the data for Stations WR-1 to WR-7 from this sampling event reflect a laboratory error for three reasons: (1) The concentrations drop sharply to below detection at all stations downstream of Station WR-7; (2) the total cadmium concentration for Stations WR-1 to WR-7 was below the detection limit of 0.3 ug/l with the exception of Station WR-1 where it was only 0.5 ug/l (in other words, the dissolved cadmium fraction was much greater than total cadmium); and (3) the same questionable pattern exists for the same sampling event for dissolved nickel.

The *total cadmium* concentrations throughout the river stations varied between the detection limit (0.3 ug/l) and 2 ug/l (Figure 4-82). There is no consistent pattern between upstream and downstream stations.

The monthly average total cadmium concentration discharged in the effluent from the Smithfield WWTF was <0.52 ug/l; the highest recorded daily maximum concentration was 3 ug/l. Cadmium concentrations of the effluent measured by NBC (Station WR-4) indicated that the WWTF was not a prominent source of cadmium.

Total cadmium concentrations measured by River Rescue reached 0.4 ug/l at both stations (W1 and W2) with the exception of one measurement at Station W1 at 3.0 ug/l. This high concentration was measured at a time of dry weather conditions (see Appendix 7). The mean cadmium concentration was 0.11 ug/l at Station W2 and 0.18 ug/l at Station W1.

Wet weather cadmium concentrations in the river are only available from one station (Station WOON; Wright et, 1991). The mean total and dissolved cadmium concentrations did not increase in a consistent manner during rainstorms; cadmium only increased during the first rainstorm, reaching 0.7 ug/l in one of the samples (Appendix 3).

Increases in cadmium concentrations from highway runoff during storms were observed by Thiem et al. (1999). In both investigated stormwater outfalls (W6 and W23), total cadmium correlated closely with total lead during several of the storms (Figure 4-80). Highest total cadmium concentrations were measured as 3.7 ug/l in both W6 and W23.

- **Chromium**

The *dissolved chromium* (chromium III) concentrations measured by NBC (1998) ranged between the detection limit (0.8 ug/l) and 13 ug/l; most of the concentrations were below 4 ug/l (Figure 4-89). The concentrations met the chronic criteria for dissolved chromium III (57 ug/l at a hardness of 25 mg/l).

The *total chromium* concentrations along the river varied between the detection limit (0.8 ug/l) and 14 ug/l; most of the concentrations were below 7 ug/l (Figure 4-90). Generally, the total chromium concentrations increased slightly downstream of Station WR-9.

Chromium is not monitored by the Smithfield WWTF. The NBC data of the effluent (Station WR-4) indicates that the WWTF is not a prominent source of chromium.

Total chromium concentrations measured by River Rescue reached 2.5 ug/l at Station W2 and 4.2 ug/l at Station W1. Most of the concentrations were below 1.5 ug/l. The mean chromium concentration was 0.76 ug/l at Station W2 and 0.85 ug/l at Station W1. The highest concentrations were measured on April 1 1991 at both stations; weather conditions during and prior to sampling were dry.

During wet weather, the mean total chromium concentration in the Woonasquatucket River increased from 2.8 ug/l to 4.2 ug/l with a maximum of 5.4 ug/l (Station WOON; Figure 4-88).

In stormwater outfalls W6 and W23, the highest total chromium concentrations during storms were measured at 30 and 93 ug/l, respectively (Figure 4-88). The total chromium concentrations in the outfalls generally correlated with the rainfall pattern.

- **Copper**

The *dissolved copper* concentrations measured by NBC (1998) ranged between the detection limit of 2.1 ug/l and 26 ug/l (Figure 4-97). The highest concentration was measured at Station WR-7b (at Lymansville Dam). Generally, the dissolved copper concentrations increased slightly at the downstream stations. Most of the dissolved copper concentrations along the river were below 5.0 ug/l. The chronic criteria for dissolved copper is 3.5 ug/l for a hardness of 25 mg/l. Therefore, several of the samples exceeded this criteria.

The *total copper* concentrations along the river ranged between the detection limit of 2.1 ug/l and 15 ug/l (Figure 4-98). Generally, the total copper concentrations were higher than the dissolved copper concentrations.

The monthly average total copper concentration discharged in the effluent from the Smithfield WWTF was 14.7 ug/l; the highest recorded daily maximum concentration was 123 ug/l. The NBC data of the effluent (Station WR-4) clearly demonstrate that the WWTF is a source for copper in the river. The mean dissolved copper concentrations at Station WR-4 was 13.9 ug/l ranging only narrowly between 11.0 and 15.3 ug/l. The effluent limit for copper is 3.3 ug/l for the monthly average and 5.4 ug/l for the daily maximum. Most of the copper discharged by the WWTF is dissolved copper as reflected in the total copper concentrations which are only slightly higher than the dissolved copper concentrations.

Total copper concentrations measured by River Rescue reached 13 ug/l at Station W2 and 21 ug/l at Station W1. Most of the concentrations were below 10 ug/l. The mean copper concentration was 4.7 ug/l at Station W2 and 4.2 ug/l at Station W1. The high concentrations of 21 ug/l at Station WR1 was measured one day after rainfall of 0.48 inches. Other high concentrations, however, do not correspond to the rainfall patterns during days prior to sampling.

During wet weather, the mean dissolved copper concentration in the Woonasquatucket River increased from 9.0 ug/l to 9.8 ug/l at Station WOON with a maximum concentration of 33.2 ug/l (Figure 4-96). The mean total copper concentration in the Woonasquatucket River increased during wet weather from 3.8 ug/l to 4.6 ug/l at Station WOONUP, from 10.8 ug/l to 14.5 ug/l at Station WOON, and from 3.9 ug/l to 9.4 ug/l at Station WOONDN. The highest total copper concentration during a storm was measured at 35 ug/l.

In stormwater outfalls W6 and W23, the highest total copper concentrations during storms were measured as 87 and 84 ug/l, respectively (Figure 4-96). The total copper concentrations generally correlated with the rainfall pattern (Appendix 13).

- **Lead**

The *dissolved lead* concentrations measured by NBC (1998) ranged between 1.9 (detection limit) and 5 ug/l for most of the sampling events (Appendix 10). The only exception are the data collected on October 7, 1998. These data are higher by almost an order of magnitude. The concentrations for the river stations WR-1 to WR-14 were approximately 15 ug/l; for Stations WR-15 and WR-16, the dissolved lead concentrations were 56 ug/l and 62 ug/l, respectively. It is likely that the dissolved lead concentrations from October 7 reflect a laboratory error because (1) the total lead concentration for all river stations were well below the dissolved lead concentration, and (2) because of the sharp contrast to the dissolved lead concentrations measured in the samples from the other sampling events.

Figure 4-105 represents the dissolved lead concentrations without the October 7, 1998 data. The highest dissolved lead concentrations were measured at Stations WR-15 and WR-16, which may be related to the wet weather during the sampling event on August 12, 1998. However, Figure 4-105 demonstrates that most of the lead measurements were below the detection limit. The chronic criteria for dissolved lead is 0.5 ug/l for a hardness of 25 mg/l and 0.8 ug/l for a hardness of 35 mg/l, which is well below the detection limit of 1.9 ug/l. Therefore, it is not possible to determine what percentage of NBC's dissolved lead measurements below the detection limit exceeded the chronic criteria.

The *total lead* concentrations along the river generally varied between the detection limit (1.9 ug/l) and 30 ug/l (Figure 4-106). The highest concentration was measured at Station WR-13 (Valley Street) on October 7, 1998 with 30 ug/l. All other concentrations were below 16 ug/l.

The monthly average total lead concentration discharged in the effluent from the Smithfield WWTF was 3.6 ug/l; the highest recorded daily maximum concentration was 26 ug/l. NBC (Station WR-4) did not detect dissolved and total lead concentrations in the effluent above the detection limit of 1.9 ug/l. However, due to the inadequate detection limit it is not possible to determine to what extent the WWTF effluent affects the dissolved lead concentration in the river.

Total lead concentrations measured by River Rescue reached 6 ug/l at Station W2 and 10 ug/l at Station W1. Most of the concentrations were below 5 ug/l. The mean lead concentration was 1.8 ug/l at Station W2 and 3.2 ug/l at Station W1. As is the case for other metals, there is no clear correlation with rainfall conditions during or prior to sampling. For example, the highest concentration of 10.1 ug/l was measured during dry weather while the second highest lead concentration was measured on a day with 0.37 inches of rainfall.

During wet weather, the mean dissolved lead concentration in the Woonasquatucket River increased from 1.2 ug/l to 3.7 ug/l at Station WOON with a maximum concentration of 8.6 ug/l (Figure 4-104). The mean total lead concentration increased during wet weather from 1.1 ug/l to 3.1 ug/l at Station WOONUP, from 3.7 ug/l to 13.2 ug/l at Station WOON, and from 1.6 to 10.5 ug/l at Station WOONDN. The highest total lead concentration during a storm was measured at 28.6 ug/l.

In stormwater outfalls W6 and W23, the highest total lead concentrations during storms were measured as 95 and 206 ug/l, respectively. As for the other metals, the total lead concentrations generally correlated with the rainfall pattern (Appendix 13).

- **Mercury**

Data for mercury in the Woonasquatucket River are not available with the exception of a total of four samples collected by the U.S. Geological Survey in Dyerville and in Esmond during two sampling events (Appendix 15). Concentrations of total recoverable mercury were below the detection limit of 0.10 ug/l in all samples. The chronic criteria for dissolved mercury is 0.012 independent of hardness.

Total mercury is measured in the effluent of the Smithfield WWTF. The monthly average was below the detection limit of 0.48 ug/l; the highest daily maximum was 2.4 ug/l.

- **Nickel**

The *dissolved nickel* concentrations measured by NBC (1998) ranged between 1.9 ug/l (detection limit) and 19 ug/l, although most of the concentrations were below 6 ug/l (Figure 4-113). The concentrations were generally higher at the stations furthest downstream. All concentrations meet regulatory standards; the chronic criteria for dissolved nickel at a hardness of 25 mg/l is 49 ug/l.

The comparatively high dissolved nickel concentrations collected on August 12, 1998 between Station WR-1 and WR-7 may be the result of a laboratory error for the same reasons discussed under dissolved cadmium above.

The *total nickel* concentrations along the river ranged between the detection limit (1.9 ug/l) and 21 ug/l (Figure 4-114). Most of the concentrations were below 5 ug/l. As for the dissolved fraction, the concentrations were slightly higher at the downstream stations, particularly at stations WR-15 and WR-16.

The monthly average total nickel concentration discharged in the effluent from the Smithfield WWTF was 20 ug/l; the highest recorded daily maximum concentration was 86 ug/l. NBC (Station WR-4) measured dissolved and total nickel concentrations in the effluent between 1.9 ug/l (detection limit) and 5 ug/l.

Total nickel concentrations measured by River Rescue reached 5 ug/l at Station W2 and 9 ug/l at Station W1. Most of the concentrations were below 4 ug/l. The mean nickel concentration was 2.0 ug/l at Station W2 and 2.3 ug/l at Station W1. As for the other metals there is no clear correlation with rainfall conditions during or prior to sampling.

During wet weather, the mean dissolved nickel concentration in the Woonasquatucket River did not increase (Figure 4-112). The mean total nickel concentration in the Woonasquatucket River increased only at the Station WOONDN; the maximum concentration measured during the storms reached 22 ug/l. At the other two stations (WOON, WOONUP), the mean nickel concentration before and during the storm.

In stormwater outfalls W6 and W23, the highest total nickel concentrations during storms were measured at 37 and 34 ug/l, respectively.

- **Silver**

Dissolved silver in the Woonasquatucket River was only detected at Stations WR-14 (Atwells Avenue) and WR-16 (Exchange Street) (Figure 4-119); the detection limit was 0.8 ug/l. The acute criteria for dissolved silver is 0.3 ug/l at a hardness of 25 mg/l and 0.6 ug/l at a hardness of 26 mg/l; there is no chronic criteria.

The *total silver* concentrations were also mostly below the detection limit of 0.8 ug/l (Figure 4-120). Total silver was measured in a few samples with concentrations of up to 1.4 ug/l.

The monthly average total cadmium concentration discharged in the effluent from the Smithfield WWTF was <0.89 ug/l; the highest recorded daily maximum concentration was 3 ug/l. Silver was detected in the effluent by NBC (Station WR-4). Dissolved and total silver was detected in two samples each at concentrations of up to 1.4 ug/l.

Wet weather data for silver are not available.

- **Zinc**

The *dissolved zinc* concentrations measured in the Woonasquatucket River by NBC (1998) ranged between the detection limit (1.9 ug/l) and 30 ug/l (Figure 4-123). The lowest concentrations were measured at Stations WR-1 to WR-3, upstream of the Smithfield WWTF (WR-4). The effluent from the WWTF had dissolved zinc concentrations of approximately 50 ug/l which noticeably increased the zinc concentration downstream of the WWTF. All dissolved zinc measurements in the river met the regulatory standards; the chronic criteria for dissolved zinc is 32 ug/l for a hardness of 25 mg/l.

However, it is conceivable that during periods of low flow conditions, the high zinc concentration in the

effluent from the WWTF increases the dissolved zinc concentration in the river to concentrations above the chronic criteria. The monthly average total zinc concentration measured by the WWTF in their effluent was 40 ug/l; the highest recorded daily maximum concentration was 379 ug/l.

The *total zinc* concentrations along the river ranged between the detection limit (1.9 ug/l) and 44 ug/l. Total zinc concentrations measured by NBC in the WWTF effluent were similar to the dissolved zinc concentration (Figure 4-124).

There are no dissolved zinc data for wet weather. Total zinc concentrations measured in the river by CDM (1989) increased by up to a factor of 2 (Figure 4-122). Total zinc concentrations measured in stormwater outfalls W6 and W23 reached 700 and 1,000 ug/l, respectively.

4.4.6 Organic Compounds

- **Hydrocarbons**

Total petroleum hydrocarbon (TPH) concentrations were measured by NBC at all station on July 29, 1998. Concentrations at all stations was below the detection limit of 1 mg/l. Only a few samples collected at Lincoln Lace & Braid (Station 9aa to ac) and Riverside Mills (Station WR-10a) contained TPH at concentrations between 1 and 3 mg/l (Table A10-1 in Appendix 10).

Wet weather measurements of hydrocarbons were conducted by Thiem et al. (1999). TPH concentrations measured in stormwater outfall W6 ranged from 34 to 1,154 mg/l; TPH concentrations measured in stormwater outfall W23 ranged from 2 to 535 mg/l. In the Woonasquatucket River, TPH concentrations measured by URI (1989) during two storm showed a distinct increase in TPH at the beginning of the storm (see graphs in Appendix 3). Oil and grease measurements by CDM (1989), however, did not indicate a trend of higher concentrations during rainstorms.

- **PCBs, Dioxins, Pesticides, VOCs, SVOCs**

Volatile organic compounds were analyzed in water samples collected by NBC in the summer of 1998. Samples were collected at Stations WR-7 (Allendale Avenue), WR-7c (Theta Properties), WR-10 (Merino Park), and WR-10a (Riverside Mills); data reports are enclosed in Appendix 10.

The analyses detected only a few VOCs at concentrations close to the detection limits. Methyl tert-butyl ether and cis-1,2-dichloroethene were detected at all four stations at 1 or 2 ug/l. In addition, trichloroethene and tetrachloroethane were detected at Station WR-7c at the detection limit of 1 ug/l.

Polyaromatic hydrocarbons and PCBs were measured by URI (1989) during two storms (Appendix 3). Total PAH and total PCB concentrations were highest at the beginning of the storm, suggesting that the concentrations are affected by the initial runoff ("first flush"). Measured total PAH concentrations during the two storms ranged from 0.31 to 2.38 ug/l; measured total PCB concentrations ranged from 0.01 to 0.30 ug/l.

Data on dioxins and pesticides in the water column of the Woonasquatucket River were not available.

4.5 Sediment and Water Quality at Contaminated Sites

4.5.1 Davis Liquid Waste Site (CDM, 1986)

The Davis Liquid Waste Site is located in the drainage area of Latham Brook, which drains into the Stillwater Reservoir. Sediment and surface water samples on-site and off-site indicated that the waste site affected the water quality of Latham Brook at the time of the study.

Detailed flow rates of Latham Brook were measured by CDM (1986) at a location close to the waste site. Flow data are not available from the mouth of Latham Brook prior to entering Stillwater Reservoir.

Contaminants found on-site in the surface water and sediment consisted of volatile organic compounds, semivolatile organic compounds (referred to by CDM as extractable organic compounds), and inorganic compounds as follows (see Appendix 1):

- *Volatile Organic Compounds (VOCs):* The most frequently detected VOCs were trans-1,2-dichloroethylene, 2-butanone, 1,1,-trichloroethane, tetrachloroethylene, toluene, and total xylenes.

- *Semivolatile Organic Compounds (SVOCs):* The most prominent SVOCs were 1,2-dichlorobenzene, bis (2-ethyl)phthalate and di-n-octyl phthalate.

- *Pesticides:* Two pesticide compounds were detected at trace amounts (alpha-BHC and gamma-BHC[lindane]).

- *PCBs:* Not detected.

- *Inorganic Compounds:* In the surface water, the maximum on-site concentrations of seven elements (calcium, iron, lead, manganese, magnesium, nickel, sodium, and zinc) exceeded the typical ranges (typical ranges as defined in Cleland and Kingsbury, 1977). The highest on-site lead concentration was 155 ug/l; arsenic, cadmium, chromium and nickel were not detected. In the sediment, the maximum on-site concentrations of five elements (copper, lead, mercury, manganese, and zinc) exceeded typical ranges (as defined in Bohn, 1979).

The contaminants found off-site were a subset of the contaminants found on the site. The concentrations in Latham Brook decreased with increasing distance from the site. CDM (1986) attributed the reduction in part to volatilization and dilution. VOCs were detected as far downstream from the site as 1.1 miles upstream from Stillwater Reservoir; the sample was collected at a time of a high flow rate in Latham Brook. SVOCs were detected in a few offsite samples at low concentrations. Concentrations of inorganic compounds offsite were generally within typical ranges (Appendix Table A1-4). For example, at the mouth of Latham Brook at the Stillwater Reservoir, the highest lead concentration was measured at 5.8 ug/l, which is similar to the background concentration in the brook upstream of the site of 5.9 ug/l. Arsenic, cadmium, chromium, mercury, nickel and zinc were not detected at the mouth.

These data suggest that the contamination was limited to the Latham Brook to the vicinity of the waste site. The impact on the water quality of the Stillwater Reservoir and other downstream areas of the Woonasquatucket watershed appeared to be small or minimal. However, this conclusion is based on a small number of samples. CDM (1986) collected surface water samples only at three times (November/December 1984, April 1985, and August 1985). As stated in CDM (1986), there may be times when contamination travels further downstream. Data about concentrations of organic and inorganic compounds are not available for Stillwater Reservoir.

The impact assessment conducted by CDM concluded that several of the VOCs (specifically toluene and total xylenes) and inorganic compounds (specifically lead, nickel, and zinc) may threaten the aquatic life in the drainage area of the Davis Liquid Waste site. CDM concluded further that "the generally increased concentration of these and other chemicals which have been measured in sediment may pose additional risks to benthic organisms and will continue to be a source of contamination for surface water." (p. 6-43).

Since 1985, the site has been undergoing remediation, as described in Section 2.9.7 of Progress Report 1. Remediation included removal of drums and tires, excavation and treatment of soil, and dredging of sediment. However, given the high concentrations of several compounds detected at the site in the past (CDM, 1986), we recommend to collect samples from Latham Brook for analysis of parameters for which TMDLs are to be developed. Samples should be collected specifically during wet weather conditions.

4.5.2 Davis GSR Landfill (CDM, 1994)

The Davis GSR Landfill is located in the drainage area of Nine Foot Brook, which drains into the Waterman Reservoir. CDM (1994) calculated that the site discharges approximately 0.7% of the total runoff of Nine Foot Brook entering Waterman Reservoir, and 0.35% of all surface water flow entering Waterman Reservoir.

Flow measurements collected by CDM (1994) on 12 occasions were compared to the long-term record for the Nipmuc River gage near Harrisville, Rhode Island. The Nipmuc River and the Nine Foot Brook have similar land use characteristics and rainfall patterns. Discharge rates are provided by CDM (1994) for the landfill site and for the mouth of the Nine Mile Brook prior to entering Waterman Reservoir (Appendix 5).

CDM (1994) collected sediment and water quality samples along Nine Foot Brook upstream and downstream of the landfill. In addition, samples were collected from an Unnamed Brook to the west of Nine Foot Brook which also receives runoff from the landfill; this brook discharges into Nine Foot Brook less than half a mile downstream of the landfill.

The data indicate that the landfill affected the water quality of the Nine Foot Brook. Contaminants detected in the water and sediment samples consisted of volatile organic compounds, semivolatile organic compounds, and inorganic compounds as follows:

- *Volatile Organic Compounds (VOCs):* VOCs were infrequently detected. Low concentrations of less than 10 ug/l were detected in a few water samples for acetone, methylene chloride, 2-butanone, and toluene. In the sediments, VOCs were also measured infrequently. The highest concentrations were measured for acetone, 2-butanone, and toluene.

- *Semivolatile Organic Compounds (SVOCs):* SVOCs were also infrequently detected. Only 4-methylphenol was detected in a few water samples at concentrations of less than 10 ug/l. In the sediments, SVOCs were detected in some of the collected sediment samples. Highest concentrations were measured for 1,4-dichlorobenzene, 4-methylphenol, naphthalene, 2-methylnaphthalene, bis(2-ethylhexyl)phthalate, fluoranthene, pyrene, and benzo(a)pyrene.

- *Pesticides:* One pesticide (4,4'-DDT) was detected in one water sample at a concentrations of 0.1 ug/l. In the sediments, pesticides were detected in some of the collected samples. It appeared that pesticides had accumulated downgradient of standing water at the site. Some of the pesticides were apparently contributed by the former apple orchard near the site. The highest concentrations were detected for 4,4'-DDD, 4,4'-DDT, alpha-chlordane, and gamma-chlordane.

- *PCBs:* PCBs were not detected in the surface water. In the sediment, Arochlor-1254 and 1260 were detected in a few samples at low concentrations.

- *Inorganic Compounds - Surface water:* The maximum concentrations of inorganic compounds detected in the surface water upstream and downstream of the Davis Landfill are summarized in Figure 4-127. Downstream stations are separated into stations along Nine Foot Brook and the Unnamed Brook. Data for Station SW-17 on Nine Foot Brook (see Appendix 5 for location) are summarized separately as this station is located furthest downstream.

  The hardness measured in the upstream samples ranged from 23 to 81 mg/l; the hardness measured for the stations downstream from the landfill ranged from 13 to 215 mg/l.

  Inorganic compounds that were detected downstream of the landfill but were not detected upstream of the landfill included antimony, beryllium, cobalt, mercury, nickel, silver, thallium, vanadium, and cyanide. Of these, the compounds that exceeded the ambient water quality standard were antimony, beryllium, mercury, silver, and thallium.

  Inorganic compounds that were detected downstream as well as upstream of the landfill included arsenic, chromium, copper, and selenium. In addition, high concentrations of iron and lead were detected in several samples downstream. The maximum total lead concentration was 171 ug/l. Elevated concentrations were also detected for aluminum and zinc in some of the downstream samples. Lead, zinc, arsenic and copper exceeded the water quality standards.

  The only heavy metals that were detected at Station SW-17, located furthest from the landfill were lead and zinc at background concentrations. Total lead was detected in one of the two samples at 3.3 ug/l; total zinc was measured at 21 ug/l. These concentrations were similar to the upstream background concentrations of 4.3 ug/l for total lead and 16.7 ug/l for total zinc.

- *Organic and Inorganic Compounds in the Sediment:* CDM (1994) also collected sediment samples at the same stations as the surface water samples (see Appendix 5). Compounds detected at these stations consisted of the same heavy metals and other compounds also found in the surface water. The concentrations varied considerably at the different sampling stations. However, many of the measured compounds exceeded background concentrations. Generally, the concentrations in the sediment decreased with increasing distance from the landfill.

In summary, the water quality data demonstrate that the Davis GSR Landfill is a source of primarily metals as well as a number of organic compounds to Nine Foot Brook. The extent to which these compounds entered the Waterman Reservoir is not known based on these limited data. Surface water quality samples collected at Station SW-17 furthest from the landfill contained only lead and zinc at detectable levels. The two samples at Station SW-17 did not contain any organic compounds at detectable levels.

In addition, the landfill has been remediated in recent years, and the top of the landfill is stabilized with 3 to 6 inches of cover. The site was removed from the NPL in August 1999. However, given the fact that elevated concentrations of metals and organic compounds existed at the landfill, this site may still be a source for water quality impacts downstream. Therefore, we recommend to include the site into monitoring (particularly for wet weather conditions) for parameters for which TMDLs are to be developed.

4.5.3 Sediment of Seven Dams in the Woonasquatucket River (USEPA, 1998)

Sediment quality data were collected by the USEPA (1998) from seven dams (Esmond Dam, Allendale Dam, Lymansville Dam, Manton Dam, Dyerville Dam, Olneyville Dam, and Lonigan Dam). Data are included in Appendix 9. Contaminants detected in these dams consisted the following:

- *Metals and Total Cyanide:* Several metals were detected above ecologically significant screening values, the Lower Effect Level (LEL) and the Severe Effects Level (SEL). These metals were cadmium, chromium, copper, iron, lead, manganese, mercury, nickel, and zinc (Figure 4-128). The detected concentrations also exceeded the background levels of priority pollutants in Rhode Island soils (RIDEM, 1995b). USEPA (1998) determined, however, that only the Dyerville site had the potential for acute toxilogical impacts. At all seven dams, cyanide concentrations in the sediment were very low.

- *PCBs:* PCBs were detected at each dam site (Table A9-3). The highest total PCB concentrations were measured at the Lymansville Dam and Dyerville Dam sites with over 1,000 ug/kg. The predominant PCB compound was Aroclor-1254.

- *Pesticides:* Pesticides were detected at each dam site (Appendix Table A9-3). The predominant pesticides were alpha chlordane, gamma chlordane, 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, and dieldrin.

- *Dioxins:* Dioxins were detected at all seven dam sites. The concentrations were significantly higher at the Allendale Dam and Lymansville Dam sites than at the other five dam sites.

- *Polycyclic Aromatic Hydrocarbons (PAHs):* PAHs were detected at all seven dam sites at concentrations above the LEL (Appendix Table A9-4). The concentrations varied for individual PAHs. The highest total PAH concentration was measured at the Allendale Dam with 67,300 ug/kg. The lowest concentration was measured at the Dyerville Dam with 18,400 ug/kg.

The sediment data indicated that the majority of the ecological risk at the measured sites was caused by organic compounds (PAHs, PCBs, dioxin). The USEPA (1998) suggested further that the inorganic fraction in the sediments "would pose little if any immediate acute [ecological] risk" (p. D-6). Human health risks from the contaminated sediment were considered low (USEPA, 1998).

Water samples from the river were not collected by USEPA (1998), therefore the impact of the contaminants on the water quality in the river is not known. USEPA (1998), however, recommended water quality sampling for future work.

4.5.4 Centredale Manor Property (Roy F. Weston, 1999)

Soil and sediment samples were collected as part of an Expanded Site Inspection (ESI) for the Centredale Manor Site. Samples were collected from as far upstream as Esmond Dam to as far downstream as Water Place Park in Providence. The samples were tested for dioxins, HCX, SVOCs, pesticides, PCBs, and TOC; data are included in Appendix 12. Varying concentrations of these compounds were detected in many samples as follows (Figure 4-129):

- *Semivolatile Organic Compounds (SVOCs):* The highest concentrations of VOCs were detected in Esmond Dam (Station SD-37), Centredale Manor (Station SS-04), Allendale Dam (Stations SD-20 to 25), Valley Street (Station SD-03), and at Water Place Park (Station SD-01). One of the SVOCs most commonly detected throughout the river was bis(2-ethylhexyl)phthalate.

- *Pesticides:* The highest pesticide concentrations were detected in Esmond Dam (Station SD-37), Centredale Manor (Stations SD-30; SS-02), Allendale Dam (Station SD-22), Lymansville Dam (Stations SD-11,14), and at Water Place Park (Station SD-01). The total pesticide concentrations at these stations ranged between 30 and 80 ug/kg. Pesticides were also detected at other stations throughout the area of investigation at concentrations below 20 ug/kg. The most commonly detected pesticides were 4,4'-DDD, 4,4'-DDE, 4,4'-DDT, alpha-chlordane, gamma-chlordane, and methoxychlor.

- *PCBs:* PCBs were only detected adjacent to the Greystone Mill (Station SD-33), Centredale Manor (Station SD-30), and at Allendale Dam (Stations SD-20, 22 to 25, and 29). This distribution suggests that the Centredale Manor site was the primary source. PCBs were not detected downstream of the Allendale Dam.

- *Dioxins:* The highest dioxin concentrations were detected at Centredale Manor (Stations SS-4 to 6, and SD-27, 29, 30), Allendale Dam (Stations SD-20 to 25), and in the wetland just downstream of Allendale Dam (Station SD-18).

In summary, the highest concentrations of the analyzed organic compounds were detected at the Centredale Manor Site, particularly at the drainage channel adjacent to the property (Station SD-30). This channel flows into the Woonasquatucket River approximately 0.3 miles downstream from the property. Concentrations were also high in the Allendale Dam. This impoundment was located just downstream of the property allowing contaminants to settle out of the water column.

The source of the contamination around the Centredale Manor site is historic industrial activity. Specifically, between 1943 and 1971, a drum recycling facility reportedly operated at the property (Roy F. Weston, 1999). Drums investigated in the early 1980s reportedly contained solvents, caustics, PCBs, and ink wastes. Heavy metals were potentially associated with the industrial wastes; metal concentrations were not analyzed as part of the investigation by Roy F. Weston (1999), however.

Also, water samples from the river were not collected by Roy F. Weston (1999). The degree of potential leaching of the contaminants into the Woonasquatucket River and thus the impact on the water quality in the river is not known.

4.6 Biological Data for the Woonasquatucket River

4.6.1 Fish Tissue Analyses (USEPA, 1996)

The USEPA (1996) collected fish tissues in the river at two stations in the Woonasquatucket River. At the Valley Street site (WR1), tissues were tested in sunfish; at the Smith Street site, tissues were tested in eel. At both sites, tissues contained metals (cadmium, chromium, copper, lead, mercury, nickel, zinc), pesticides, and PCBs (see Appendix Table A8-2). USEPA (1998) determined that potential cancer and non-cancer risks exist from the ingestion of fish or eels mainly from PCBs, mercury and lindane.

This study did not include the collection of water quality data or information on sources for contamination.

4.6.2 Fish Tissue Analysis (Pace Analytical, 1999a, 1999b)

The Rhode Island Department of Health commissioned a study of fish tissues in the Woonasquatucket River at Centredale Manor and Esmond Dam (Pace Analytical, 1999a,b). At both sites, tissues contained dioxins (PCDDs), dibenzofurans (PCDFs), and PCBs (see Appendix Table A8-2). The risk to human health was not assessed in these studies. Also, this study did not include the collection of water quality data or information on sources for contamination.

4.6.3 Benthic Macroinvertebrate Analysis (Gould, 1998)

Roger Williams University has conducted annual surveys of the macrofauna between 1991 and 1997 (Gould, 1998). Based on a Biological Protocol after Plafkin et al (1989), the river was classified as "Moderately Impaired". The protocol is based on land use, local erosion, physical characteristics of the stream, channelization, canopy cover, sediment types, and substrate components. The investigation detected traces

of glue and oil in the substrate. As for the fish tissue studies, this analysis also did not include the collection of water quality data or information on sources for impairment.

4.7 Summary and Discussion of Sources

The water quality, sediment and biological data provide the following information about the Woonasquatucket River watershed:

- **Upper Woonasquatucket River Watershed**

The studies by CDM (1996, 1994) indicated that the Davis Landfill and the Davis Liquid Waste Site were a source of contamination for the Nine Foot Brook and Latham Brook subwatersheds, respectively. Contaminants detected at the Davis Landfill consisted primarily of inorganic compounds including heavy metals; contaminants detected at the Davis Liquid Waste Site consisted primarily of VOCs and SVOCs. Data of two studies suggested further that the impact of the contamination was limited to the respective brooks, but the number of samples collected were limited at both sites. However, remediation of both sites in recent years suggests that the degree of contamination that existed at the time of these studies has since decreased and hence the impact on the respective brooks has decreased as well. Information on the present-day water quality of the two brooks is not available.

Water quality data from the upper watershed of the Woonasquatucket River (upstream of the reservoirs) are not available with the exception of older data for the Nine Foot Brook and Latham Brook. As a result, "natural background" concentrations for water quality parameters in the watershed are not available from upstream of the reservoirs.

- **Reservoirs**

Fecal coliform concentration only exceeded the Rhode Island water quality standards in Slack Reservoir at times. pH values in the reservoirs reflect slightly acidic conditions.

In general, the reservoirs are showing mesotrophic conditions (expect for the Lower Sprague Reservoir which is eutrophic). This finding is consistent with their relatively undeveloped watersheds. Regionally, most of the open waters are currently mesotrophic.

Dissolved oxygen concentrations are consistent with mesotrophic and eutrophic systems. It appears that the reservoirs, although shallow, may periodically stratify. Slack and Georgiaville Reservoirs, for which surface and bottom data for dissolved oxygen are available, clearly show stratification events; during these events the bottom dissolved oxygen is significantly depleted.

- **Lower Woonasquatucket River Watershed**

Fecal coliform concentrations exceed the water quality standard frequently along the entire length of the river between Georgiaville Reservoir and the mouth of the river. The concentrations are highest during wet weather conditions, particularly in the lowermost section of the river that is influence by CSOs.

Nutrient concentrations within the lower Woonasquatucket River are primarily controlled by the quality of the waters discharging from the Stillwater and Georgiaville Ponds, the WWTF discharge and sources below the Lymansville or Manton Dams. No data is available on the river above Stillwater Reservoir. The nutrient levels within the river are relatively low above the WWTF inflow, but are consistently 2-3 fold higher throughout the river below the WWTF. The degradation of nutrient related ecological health of the river relating to the WWTF appears to be within the river reach between the WWTF and the Lymansville Pond.

The habitat quality within this reach is defined in summer by low dissolved oxygen levels and algal blooms. Within the final river reach, oxygen levels remain high and nutrient levels are stable and even decline slightly.

High inorganic nitrogen and phosphorus levels within this reach during summer suggest the potential for high algal production, but also production related to some other factor. Other nutrient sources are likely stormwater runoff from point sources (including CSOs) and non-point sources. High nitrate concentrations were measured after a rainstorm by NBC (1998) at Manton Avenue, Dyerville Complex and Merino Park (Stations WR-8 to 10). The cause of the elevated concentrations during this sampling event is not known.

The dissolved oxygen concentrations along the river generally met the water quality standards with the exception of the segment of the river downstream of the Smithfield WWTF. However, data are limited due to the need for early morning sampling. The data collected by RIDEM indicate extreme oxygen shifts (up to 6 mg/l) occur at some sites.

Heavy metals that frequently exceeded the Rhode Island water quality criteria in the lower segment of the Woonasquatucket River consisted of cadmium, copper, and lead. The extent to which lead exceeded the criteria is limited by the high detection limit of 1.9 ug/l in the NBC (1998) data; the chronic criteria for lead is 0.5 ug/l for a hardness of 25 mg/l. Similarly, the detection limit for silver was 0.8 ug/l; the acute criteria is 0.3 ug/l for a hardness of 25 mg/l. Dissolved mercury data are not available for the river.

The Smithfield WWTF is a source for specifically copper and zinc. Other metals discharged by the WWTF consist of lead, mercury, nickel, and silver, although the concentrations measured by NBC (1998) were low or below the detection limit (mercury was nor monitored by NBC.

The second source for metals identified from the data consists of non-point source runoff. The concentrations of heavy metals increased in the river during storms. Concentrations were generally higher in the lowermost section of the river (NBC, 1998) possibly reflecting the higher urban density and the influence of CSOs. Aside from stormwater outfalls W6 and W23 (Thiem et al., 1999), the available data are not adequate to pinpoint individual point sources, however. The water quality data available from the river do not identify a distinct source of metals other than the Smithfield WWTF.

The role of reservoirs and background concentrations in the upstream segment of the watershed is not known. Metal concentrations that exceeded the water quality criteria in some of the samples collected at the Stillwater Reservoir Dam (NBC-1998 Station WR-1) consisted of cadmium, copper, and lead.

Water quality data in the Woonasquatucket River for organic compounds (VOCs, SVOCs, pesticides, PCBs, and dioxins) are very limited or absent. While sources for organic compounds exist in the river in the form of contaminated sediments at the Centredale Manor site and in the river sediments downstream from the site, the impact on the water quality is not known.

5.0 GAPS IN THE WATER QUALITY DATA

This section consists of a discussion of gaps in available data needed for the development of TMDLs. This discussion is preliminary at this time and depends on a number of factors and decisions by RIDEM, including the following:

- *Area:* The area for which TMDLs are to be developed needs to be defined. Initial discussions with RIDEM suggest that the focus area will be the river segment between Stillwater Reservoir and the mouth of the Woonasquatucket River.

- *Parameters:* Parameters for which TMDLs are to be developed need to be determined. At this time, the most baseline data are available for fecal coliform, nutrients and heavy metals. Relevant baseline data for organic compounds are very limited or absent.

- *Implementation:* The overall approach envisioned by RIDEM for the implementation of TMDLs needs to be establish. This approach will determine what load allocations will be developed for specific sources. As a result, this approach will influence the collection of additional data.

- *Impact of CSOs:* Given the fact that the impact of the CSOs on the water quality in the Woonasquatucket River will be mitigated by NBC's CSO Abatement Program, we recommend that TMDLs should be developed for "post-CSO-abatement" conditions. This recommendation needs to be discussed and evaluated in more detail with RIDEM.

Therefore, this section represents a listing of observations of obvious missing data. However, we anticipate that this section will be expanded and/or refined after RIDEM's review of Progress Report 2 and after subsequent discussions with RIDEM in the following few weeks.

5.1 Data Gaps for TMDLs for the Reservoirs

In addition to reservoirs where no (or virtually no) data has been collected like the Upper Sprague Reservoir, Stamp Pond and Reaper Pond, insufficient data has been collected to determine TMDLs on the 7 systems for which watercolumn data for more than 1 year has been collected by URI Watershed Watch. The most critical data gaps are as follows:

1. *Macrophyte distribution and abundance of the reservoirs:* Given the shallow nature of the reservoirs (7 out of 8 have maximum depths of less than 4.6 m), algal and rooted benthic plants may proliferate. These plants affect both the nutrient and oxygen conditions within the waters and help to structure the overall habitat.

2. *Additional sampling of watercolumn parameters to capture the spring and fall blooms:* These blooms can be important in casting the overall organic production and bottom water dissolved oxygen conditions during the summer period (especially in stratified ponds). The present data appear to generally miss these events.

3. *Better determination of the depth of the summer euphotic zone of the reservoirs:* High resolution profiles of the ponds in summer should be undertaken to determine the stratified interval (if any), where appropriate (i.e., not in Waterman Reservoir which is <2.6 meters deep).

4. *Better detection limits in the water quality samples:* In the existing database, both nitrogen and phosphorus showed many values at or below detection. For the nitrate levels within the reservoirs

almost all of the data were below detection, yet this information is important for determining if the systems are always phosphorus limited.

5. *Macroinvertebrate assessments:* These assessments should be undertaken in both the reservoirs and river in order to better classify the habitat. These assessments are important to determine both the TMDLs and for predicting likely changes if nutrient source reductions are implemented.

6. *Data from the Upper Woonasquatucket River:* No data is available from the Woonasquatucket River above Stillwater Reservoir.

7. *Other sources of loading to the reservoirs:* Insufficient data is available on the nutrient loadings from the surface water inflows to Stillwater Reservoir and Georgiaville Pond.

5.2 Data Gaps for TMDLs for the Lower Woonasquatucket River

Missing data and issues that could be addressed during follow-up investigations for the lower Woonasquatucket River (Stillwater Reservoir the river mouth) consist of the following. As stated above, the significance of individual gaps depend on a variety of factors that will need to be discussed with RIDEM.

8. *Background concentrations of metals in the upper Woonasquatucket watershed:* Background data should be collected during dry weather to determine the contribution from natural sources. Samples should be collected in the upper Woonasquatucket watershed upstream of the reservoirs in areas where potential impacts from human activities are minimal.

9. *Present effect of the Davis Liquid Waste Site and the Davis Landfill on the water quality in the reservoirs:* The impact of the remediated Davis Liquid Waste Site and the Davis Landfill should be investigated, specifically during wet weather. Potential sampling locations could be a station just downstream of each site and at the mouth of Latham Brook and Nine Foot Brook, respectively.

10. *Influence of reservoirs on the metals concentration in the lower segment of the Woonasquatucket River:* The concentrations of metals at the Stillwater Dam exceeded the water quality criteria. It is a concern that the sediments of Stillwater Pond may be releasing metals, possibly linked to oxic/anoxic processes. Possible increases in a sediment release of metals related to increased or decreased nutrient enrichment of the pond system needs to be considered in a TMDL analysis. Therefore, the role of inputs to the reservoirs and chemical processes within the reservoirs should be evaluated to assess the reservoirs as potential sources for elevated metals and nutrient concentrations in the lower Woonasquatucket River.

11. *Dry weather data for dissolved lead and silver:* The data set with the greatest spatial coverage was collected by NBC in 1998. However, NBC's detection limit for dissolved lead was 2 to 4 times higher (depending on hardness) than the chronic criteria. For dissolved silver, the detection limit was up to 3 times higher. Therefore, if lead and silver are to be considered for TMDLs, additional data during dry and wet weather should be collected and analyzed at appropriate detection limits. We suggest to collect samples at the same stations as NBC-1998 to allow for intercomparisons between the data.

12. *Smithfield Wastewater Treatment Facility:* The WWTF conducts regular water quality monitoring of its effluent. However, given the impact of its effluent on the water quality in the river, the effluent should be included as one of the sampling stations in future monitoring programs. Data to be collected should include dissolved metals; the WWTF only monitors for total metals.

13. *Missing data for mercury and organic compounds:* There are currently no adequate data on the concentration of mercury and organic compounds in the river during both dry and wet weather. If

TMDLs are to be developed for these constituents, dry and wet weather data need to be collected with adequate spatial coverage (i.e., several stations along the river) and temporal coverage (i.e., at different times to assess the variability over time). Data collected should include wet weather conditions which we suspect represent worst-case conditions.

14. *Major point sources aside from CSOs, W6 and W23:* At this time, we assume that TMDLs will be developed for "post-CSO-abatement" conditions. Aside from CSOs, stormwater discharge data are only available for stormwater outfalls W6 and W23 (Thiem et al., 1999). These data demonstrate the importance of wet weather discharges for the loading of metals, nutrients, and coliform to the river. We recommend to identify additional major stormwater outfalls and determine the loading from these pipes during storms. This determination should include the measurement of discharge rates.

    If TMDLs are to be developed for existing conditions in the river which include discharges from CSOs (i.e., "pre-CSO-abatement" conditions), stormwater discharges from the major CSOs should also be monitored, specifically for the parameters for which TMDLs are to be developed. The loadings of fecal coliform from CSOs is well documented. However, data on the input of metals and nutrients from CSOs along the Woonasquatucket River are very limited.

15. *Wet weather data for the river for metals:* Wet weather data for metals, nutrients, and fecal coliform with adequate spatial coverage are currently not available. We understand that NBC is planning to conduct such monitoring this summer. We consider it an excellent opportunity to integrate NBC's monitoring plans with RIDEM's plans. We suggest to meet with NBC in the next few weeks after RIDEM's data needs have been finalized to compare details of each other plans and to develop an approach that serves both NBC's and RIDEM's needs. This approach would include adequate detection limits, adequate spatial coverage of sampling station, adequate sampling frequency, appropriate parameters, detailed definition of "wet weather conditions", logistical arrangements, etc.

16. *High metal concentrations in impoundments:* At this time, the significance of the elevated metal concentrations in the sediments of the impoundments downstream of the Georgiaville Reservoir (USEPA, 1998) on the water quality in the river is not known.

17. *Metals Recycling:* Metals Recycling owns and operates an auto salvage yard on Celia Street in Johnston north of Route 6 near the Providence Johnston line. RIDEM has issued the facility a Notice of Violation stemming from solid waste violations due to elevated levels of PCBs and metals from auto fluff storage piles. RIDEM is currently investigating potential pollutant loadings associated with runoff from the facility. The discharge is to a small culverted tributary which combines with RIDOT stormwater outfall W6. It is unclear if sampling conducted by URI was affected by Metals Recycling or consisted soley of highway runoff. A RIPDES Permit application for the site is pending and has not yet been issued. The impact on the water quality in the river should be examined.

18. *Flow data:* Flow data throughout the watershed for the calculation of loads are very limited. Flow data only exist from the USGS gaging station in Centerdale. Flow rates should be determined from other locations along the Woonasquatucket River and its tributaries in the watershed for the calculation of loads. Flow measurements should be collected simultaneously throughout the watershed during varying discharge conditions and compared to the flow rates at the USGS station.

19. *Nutrient load from Georgiaville Pond to the River:* The river between Georgiaville Pond and the Smithfield WWTF appears to be dominated by the water quality in the outflow from Pond. Nitrogen and phosphorus levels from the NBC surveys do not indicate any significant nutrient inputs through this river reach. Since the nutrient load from the entire upper watershed must cross the Georgiaville Dam, a temporary gauge tied to the USGS gauge and flow weighted sampling of nutrients (and metals) would

provide an important basis for TMDL analysis of the lower river. The concentration data would also provide a good indicator of the reach between Georgiaville Pond and the Smithfield WWTF.

20. *Macrophyte distribution and abundance within the riparian zone:* Macrophytes are important in structuring river habitat and for interpreting macroinvertebrate and fish census data. Macrophytes can be both nuisance species and indicators of trophic status.

21. *Macroinvertebrate assessments:* These should be undertaken in both the reservoirs and river in order to better classify the habitat. These assessments are important to determining both the TMDLs and for predicting likely changes if nutrient source reductions are implemented.

22. *Nutrient inputs and river health:* The levels of both inorganic N and P appear to be sufficient to support algal growth within the lower river. However, the inorganic P data are relatively sparse. River Rescue documented a large seasonal shift in ortho-phosphate which may indicate a shift from P to light limitation (or other limitation). Ortho-phosphate level in summer were very high, >200 ug/l. Understanding if additional P inputs will tend to increase eutrophication within the lower river is an important underpinning of any nutrient TMDL analysis.

23. *Seasonal shifts in nutrient levels:* The process underlying the apparent 10 fold increase in ortho-phosphate in summer needs to be determined. Possible mechanisms of increased load coupled with decreased flow (dilution) and insufficient algal uptake need to be examined.

24. *Algae:* There are presently very limited data on the distribution of chlorophyll and macro-algae within the river. RIDEM has documented algal blooms within the region of the Smithfield WWTF on a qualitative basis.

25. *Wet weather data for nutrients:* As for metals, the data are very limited on the response of the river to increased nutrient and organic matter input after a rain event. What is the ecosystem response?

26. *Estuarine TMDL:* The Woonasquatucket River discharges its nutrients into an estuary which may be nitrogen not phosphorus limited. Any assessment of nutrient TMDL's for the river should also consider the potential downstream effects on the estuarine waters.

27. *River transport model:* The dilution, transformation, and evaluation of source/sinks within the lower River would be greatly enhanced by a hydrodynamic based model. The model would greatly enhance the identification of missing sources of metals or nutrients along discrete river reaches.

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Figure 4-1

Sampling Locations of Reviewed Studies in Woonasquatucket River Watershed

Data Appendix	Author	Study	Station No. (4)	Station Location	Sampling Event Date(s)	Comments
1	Davis Liquid Waste Site	CDM	(various)	over 30 surface water and sediment stations on disposal site and off site (mainly in Latham Brook watershed	1984 to 1986	
2	Dry/Wet Weather Sampling	CDM	R1	1,000 feet downstream of Manton Dam	4/28/87	
			R2	upstream of Manton Avenue and Overflow 053	5/11/87	
			R3	Valley Street	8/27/87	
			R4	Atwells Avenue	9/29/87	
					10/27-28/87	
3	Dry/Wet Weather Sampling	University of Rhode Island Wright et al., 1991	WOON	Valley Street	Oct. 22-26, 1988	
					May 10-15, 1989	
					June 10-12, 1989	
4	Dry/Wet Weather Sampling	University of Rhode Island URI, 1992	WOONUP	Manton Avenue	5/29 - 6/2, 1990	
			WOONDN	Valley Street	6/29-6/30, 1990	
					7/11 - 7/16, 1990	
					9/22-9/24, 1990	
5	Davis (GSR) Landfill	CDM, 1994	(various)	22 surface water and sediment stations on landfill and off site (including Nine Foot Brook	May 1992	
					October 1992	
6	Lakes Monitoring Program	URI Watershed Watch	(GP)	Georgiaville Pond	1993 to 1998	(3)
			(SP)	Stillwater Pond		
			(SR)	Stillwater Reservoir	Chemistry: up to 18 times	
			(SR-S)	Stillwater Reservoir Southend		
			(SLR)	Slack Reservoir		
			(LSR)	Lower Sprague Reservoir	In-situ monitoring: 61 to 142 times	
			(USR)	Upper Sprague Reservoir		
			(WR)	Waterman Reservoir		
7	Rhode Island Urban Rivers	River Rescue	W1	Valley Street	62 times between 1990 and 1994	
			W2	Route 44 crossing in North Providence		
8	USEPA	Fish Tissue Sampling	WR1	Valley Street	5/13/96	
			WR2	Smith Street		
	RI Dept. of Health /Pace Analytical	Fish Tissue Sampling	(RIDOH-1)	Centerdale Manor	5/24/99	
			(RIDOH-2)	Esmond Dam		
9	USEPA	Water Quality and River Sediment Study	DAM001	Esmond Dam	Oct. 23-24, 1997	(1)
			DAM002	Allendale Dam		
			DAM003	Lymansville Dam		
			DAM004	Manton Dam		
			DAM005	Dyerville Dam		
			DAM006	Olneyville Dam		
			DAM007	Lonigan Dam		

Figure 4-1

Sampling Locations of Reviewed Studies in Woonasquatucket River Watershed

Data Appendix	Author	Study	Station No. (4)	Station Location	Sampling Event Date(s)	Comments
10	Narragansett Bay Commission	Water Quality Testing, Woonasquatucket River Summer 1998	WR-1	Stillwater Reservoir Dam	7/15/98	
			WR-2	Bridge on Capron Road	7/22/98	
			WR-3	Sri Chimroy Peace bridge	7/29/98	
			WR-3a	Bridge on Esmond Mill Drive	8/5/98	
			WR-4	Smithfield WWTF	8/12/98	
			WR-5	Bridge on Greystone Street	8/19/98	
			WR-6	Centerdale Bridge #18	8/24/98	
			WR-7	Bridge on Allandele Ave	10/7/98	
			WR-7a	Assapumpset Brook		
			WR-7b	Lymansville Dam		
			WR-8	Manton Avenue Bridge		
			WR-9	Dyerville Complex		
			WR-9aa	Lincoln Lace & Braid (adj. to former landfill)		
			WR-9ab	Lincoln Lace & Braid (opposite buried railcar)		
			WR-9ac	Lincoln Lace & Braid (downstream of former sluiceway)		
			WR-10	Merino Park, Heath Street		
			WR-10a	Riverside Mills		
			WR-11	Footbridge in Olneyville		
			WR-12	Bridge on Delanie Street		
			WR-13	Valley Street Bridge		
			WR-14	Bridge on Atwells Avenue		
			WR-15	Bridge on Bath Street		
			WR-16	Bridge on Exchange Street		
11	RIDEM	Dissolved Oxygen and Nutrient Data Collection on the Woonasq. River (continuous monitoring)	(LP)	Lymansville Pond	9/1-10/98	
			(EMD)	Esmond Mill Drive	7/13-22/99	
			(GP)	Greystone Pond	7/13-22/99	
12	Thiem et al. (URI)	I-95 Stormdrain Retrofit Demonstration Project	W6	Killingly Street Interchange, Stormwater Outfalls	5/12/94	
			W23	Providence Civic Center, Stormwater Outfalls	2/4/95	
					5/14/95	
					9/19/95	
13	Roy F. Weston	Expanded Site Inspection Centerdale Manor Site	>50 stations	stations located between Upper Esmond Da	9/9/98	
				(upstream) and Water Place Park (downstream)	1/15/99	
					1/27/99	
14	Narragansett Bay Commission	Fecal Coliform Monitoring	S-9	Manton Avenue	1997: 27 events	
			S-8A	Olneyville Square Almacs	1998: >21 events	
			S-8B	Valley Street	1999: >22 events	
			S-8	Atwells Avenue		
			S7	Exchange Street		
15	U.S. Geological Survey	Analysis for Water Resources Data Report	(USGS-1)	Dyerville (exact location not known)	4/22-25/88	
			(USGS-2)	Esmond (exact locat not known)	8/2-3/88	
Main Text	Smithfield Wastewater Treatment Facility	Smithfield Sewer Authority	(WWTF)	Effluent prior to entering the Woonasquatucket River	At least 60 times from 1994 to 1998	(2)
--	Gould, 1998	Bioassessment Screening of RI Freshwater Benthic Macroinvertebrates		n/a	1991 - 1997 once a year	

(1) Samples were collected in the center of the channel at the deep holes near the outlets of all seven dams by wading or Jon boat.
(2) Some of the parameters are monitored daily; other parameters are monitored only monthly.
(3) Details of the locations in each reservoir are provided in Table A6-1 in Appendix 6.
(4) Station names in brackets are names that were assigned during this data synthesis; original studies did not have numbers for these stations.

Figure 4-2

Summary of Available Data for the Woonasquatucket River Watershed

	CDM: Davis Liquid Waste Site		CDM: Dry/Wet Weather Sampling		URI: Wet Weather Study 1	URI: Wet Weather Study 2	CDM:: Davis (GS) Landfill		URI Lakes Monitoring	River Rescue: Water *Quality*	USEPA: Fish Tissues	Pace Analytical: Fish Tissues	USEPA: River Sediment/ Water Quality Study		NBC: Water Quality, Summer 1998	RIDEM: Continuous DO Monitoring	RF Weston: Centerdale Manor Site	Thiem et al: Stormdrain Project	NBC: Fecal Coliform Monit.	USGS: Water Resources Data	Smithfield WWTF	Gould: Bioassessment Screening for Benthic Macroinvertebrates
Appendix No.	1		2		3	4	5		6	7	8		9		10	11	12	13	14	15	Main text	Main text
	1984 -1986		1987	1987	1988 -1989	1990	1992		1993 - 1998	1990 - 1994	1996	1999	1997	1997	1998	1998 - 1999	1998 - 1999	1994 - 1995	1997 -1999	1988	1994 - 1998	1991 - 1997
No. of Stations	>30		4	4	1	2	22		8	2	2	2	7	7	21	3	>50	2	5	2	1	1
Surface Water Samples/Stations	●		●		●	●	●			●			●		●	●		●	●	●	●	
Lake Water Samples									●													
Sediment Samples		●		●										●			●					
Fish Tissues / Benthic Macroinvertebrates											●	●										
Dry Weather	●		●		●	●	●			●			●		●	●			●	●	●	
Wet Weather			●		●	●										●		●	●			
Flow Data					●	●	●											●		●	●	
Concentrations	●	●	●	●	●	●	●	●	●	●	●	●	●		●		●	●	●	●	●	
Loads					●	●												●			●	
Mean Trophic Status									●													
In-situ Parameters, Solids, BOD, Chlorophyll																						
pH			●						●	●			●		●	●		●		●	●	
Alkalinity									●											●		
Temperature			●			●			●	●			●		●	●				●		
Dissolved Oxygen			●			●			●	●					●	●				●		
Oxygen Saturation										●										●		
Conductivity						●							●					●		●		
Secchi Depth									●						●							
BOD			●		●	●									●						●	
COD																				●		
Chlorophyll									●													
Total Solids			●	●																●		
Total Volatile Solids			●	●														●				
Total Suspended Solids			●		●	●				●					●			●			●	
Nutrients																						
Nitrite, dissolved			●	●						●											●	
Nitrate, dissolved			●	●	●	●			●	●					●			●		●	●	
Ammonia, dissolved			●	●	●					●					●					●	●	
Dissolved Organic Nitrogen										●												
Dissolved Inorganic Nitrogen										●												
Total Dissolved Nitrogen										●												
Total Nitrogen									●						●							
Total Kjehldahl Nitrogen															●							
Dissolved Inorganic Phosphorus (Phosphate)					●	●				●								●				
Dissolved Organic Phosphorus										●												
Total Dissolved Phosphorus									●	●												
Particulate Phosphorus										●												
Total Phosphorus			●	●						●					●					●	●	
Total Organic Carbon														●								
Bacteriological Parameters																						
Total Coliform			●	●																●		
Fecal Coliform			●	●	●	●			●						●			●	●	●	●	
Enterococci					●																	
E. coli					●				●													
PCBs, Dioxin, and Other Organic Compounds																						
PCBs	●	●			●						●	●		●			●					
Dioxins												●		●			●					
Furans												●										
Volatile Organic Compounds	●	●																				
Semi-Volatile Compounds (incl. PAHs)					●									●			●	●				
Pesticides	●	●			●						●			●			●					
Oil and Grease			●	●																●		
Total Petroleum Hydrocarbons					●										●			●				
Phenol																				●		
Inorganic Compounds, Totals																						
Aluminum							●	●						●						●		
Antimony														●								
Arsenic	●	●					●	●						●								
Barium							●	●						●								
Beryllium														●								
Calcium	●	●					●	●		●				●	●			●				
Cadmium	●	●	●	●	●					●	●			●	●			●		●	●	
Chloride									●									●				
Chromium	●	●	●	●	●		●	●		●	●			●	●			●		●		
Cobalt														●								
Copper	●	●	●	●	●	●	●	●		●	●			●	●			●		●	●	
Cyanide				●										●							●	
Iron	●	●					●	●						●				●		●		
Lead	●	●	●	●	●	●	●	●		●	●			●	●			●		●	●	
Magnesium	●	●					●	●		●				●	●			●				
Manganese	●	●					●	●						●						●		
Mercury	●	●									●			●						●	●	
Nickel	●	●	●	●	●	●				●	●			●	●			●		●	●	
Potassium							●	●														
Selenium							●	●						●								
Silver															●					●	●	
Sodium	●	●					●	●	●									●		●		
Thallium							●	●						●								
Vanadium														●								
Zinc	●	●	●	●			●	●			●			●	●			●		●	●	
Inorganic Compounds, Dissolved																						
Aluminum							●															
Arsenic							●															
Barium							●															
Cadmium					●										●							
Calcium							●													●		
Chloride																				●		
Chromium					●		●								●							
Copper					●		●								●							
Iron							●															
Lead					●		●								●							
Magnesium							●													●		
Manganese							●															
Mercury																						
Nickel					●										●							
Potassium							●													●		
Selenium							●															
Silver															●							
Sodium																				●		
Sulfate																				●		
Thallium							●															
Zinc							●								●							
Other Parameters																						
Hardness										●					●							
Chlorine Residual			●																		●	

● E.P. Toxicity Test Characteristics
● Not clear if the data represent total or dissolved concentrations.

Figure 4-3

RIDEM - Class Specific Criteria

Criterion	CLASS B and B1
Dissolved Oxygen	Cold Water Fish Habitat - Dissolved oxygen content of not less than 75% saturation, based on a daily average, and an instantaneous minimum dissolved oxygen concentration of at least 5 mg/l. For the period from October 1st to May 14th, where in areas identified by the RI Division of Fish and Wildlife as cold water fish spawning in areas the following criteria apply: For species whose early life stages are not directly exposed to the water column (i.e., early life stages are intergravel), the 7 day mean water column dissolved oxygen concentration shall not be less than 8 mg/l. for species that have early life stages exposed directly to the water column, the 7 day mean water column dissolved oxygen concentration shall not be less than 6.5 mg/l and the instantaneous minimum dissolved oxygen concentration shall not be less than 5.0 mg/l.
Color and Turbidity	None in such concentrations that would impair any usages specifically assigned to this class. Turbidity not to exceed 10 NTU over natural background.
Fecal Coliform Bacteria (MPN/100ml)	Not to exceed a geometric mean value of 200 and not more than 20% of the samples shall exceed a value of 500.
pH (Standard Units)	6.5 - 9.0 or as naturally occurs.
Temperature Increase	The temperature increase shall not raise the temperature of the receiving waters above the recommended limit on the most sensitive receiving water use nor cause the growth of undesirable or nuisance species of biota and in no cases exceed 83 degrees F. Heated discharges into designated coldwater habitats shall not raise the temperature above 68 degrees F outside an established thermal mixing zone. In no case shall the temperature of the receiving water be raised more than 4 degrees F.
Chemical Constituents	a. None in concentrations or combinations that could be harmful to humans or fish and wildlife for the most sensitive and governing water class use, or unfavorably alter the biota, or which would make the waters unsafe or unsuitable for fish and wildlife or their propagation, impair the palatability of same, or impair waters for any other existing or designated use. None in such concentrations that would exceed the Water Quality Criteria and other guidelines. b. The ambient concentration of a pollutant in a water body shall not exceed the Ambient Water Quality Criteria and Guidelines for the protection of aquatic organisms from acute or chronic effects, unless the criteria or guidelines are modified by the Director based on results of bioassay tests conducted in accordance with the terms and conditions provided in the RIDEM Site Specific Aquatic Life Water Quality Criteria Development Policy.
Nutrients	a. Average Total Phosphorus shall not exceed 0.025 mg/l in any lake, pond, kettlehole or reservoir, and average Total P in tributaries at the point where they enter such bodies of water shall not cause exceedance of this phosphorus criteria, except as naturally occurs, unless the Director determines, on a site-specific basis, that a different value for phosphorus is necessary to prevent cultural eutrophication. b. None in such concentration that would impair any usages specifically assigned to said Class, or cause undesirable or nuisance aquatic species associated with cultural eutrophication, nor cause exceedance of the criterion of (a) above in a downstream lake, pond, or reservoir. New discharges of wastes containing phosphates will not be permitted into or immediately upstream of lakes or ponds. Phosphates shall be removed from existing discharges to the extent that such removal is or may become technically and reasonable feasible.

Figure 4-4

Dissolved Metals Criteria

	Acute Criteria (ug/l)			Chronic Criteria (ug/l)		
	Hardness (mg/l as $CaCO_3$)			Hardness (mg/l as $CaCO_3$)		
Metal	**25.0**	**35.0**	**45.0**	**25.0**	**35.0**	**45.0**
Aluminum	750.0	750.0	750.0	87.0	87.0	87.0
Antimony	450.0	450.0	450.0	10.0	10.0	10.0
Arsenic	360.0	360.0	360.0	190.0	190.0	190.0
Cadmium	0.8	1.2	1.6	0.4	0.5	0.6
Chromium III	176.3	232.3	285.3	57.2	75.3	92.6
Chromium VI	15.0	15.0	15.0	10.0	10.0	10.0
Copper	4.6	6.3	8.0	3.5	4.6	5.7
Lead	13.9	20.3	26.8	0.5	0.8	1.0
Mercury	2.1	2.1	2.1	0.012	0.012	0.012
Nickel	438.1	582.3	720.3	48.7	64.7	80.0
Silver	0.3	0.6	0.9	-	-	-
Zinc	35.4	47.0	58.2	32.3	42.9	53.1

-' = no criteria recommendation

Figure 4-5

Criteria for Ammonia

	Acute Criteria (mg/l as N)[1]	Chronic Criteria (mg/l as N)[2]		
		Temperature (C)		
pH		**10.0**	**15.0**	**20.0**
6.5	48.8	8.9	6.5	4.7
7	36.1	7.9	5.7	4.2
7.5	19.9	5.8	4.2	3.1

[1]Ammonia criteria for acute and chronic is based upon criteria with early life stage absent.

[2]Chronic ammonia criteria is temperature and pH dependant.

Figure 4-6

RIDEM Ambient Water Quality Criteria and Guidelines

Parameter	Aquatic Life Criteria		Carcinogen (2)	Human Health Criteria (ug/l)	
	Acute (ug/l)	Chronic (ug/l)		Class A Waters Waters & Fish Consumption	All other waters Fish consumption only
ACENAPHTHENE	85	1.9	no	1200	2700
ACROLEIN	2.9	0.06	no	320	780
ACRYLONITRILE	378	8.4	yes	0.59	6.6
ALDRIN	3	-	yes	1.30E-03	1.40E-03
ALUMINUM *(1)*	750	87		-	-
AMMONIA	(See Table 4-5)		no	-	-
ANTIMONY	450	10	no	14	4300
ARSENIC	360	190	yes	50	50
ASBESTOS (fibers/l)	-	-	yes	7.00E+06	
BENZENE	265	5.9	yes	12	710
BENZIDINE	-	-	yes	1.20E-03	5.40E-03
BERYLLIUM	7.5	0.17	yes	-	-
CADMIUM	(See Table 4-4)		no	-	-
CARBON TETRACHLORIDE	1365	30	yes	2.5	44
CHLORDANE	2.4	0.0043	yes	5.70E-03	5.90E-03
CHLORINE	19	11			
CHLORINATED BENZENES					
CHLOROBENZENE	795	18	no	680	21,000
HEXACHLOROBENZENE	-	-	yes	7.50E-03	7.70E-03
1,2,4-trichlorobenzene	7.5	1.7		-	-
1,2,3,5-tetrachlorobenzene	321	7.1		-	-
pentachlorobenzene	13	0.28		-	-
CHLORINATED ETHANES					
1,2-DICHLOROETHANE	5900	131	yes	3.8	990
1,1,1-TRICHLOROETHANE	-	-	no	-	-
1,1,2-TRICHLOROETHANE	900	20	yes	6	420
HEXACHLOROETHANE	49	1.1	yes	19	89
1,1,2,2-TETRACHLOROETHANE	466	10	yes	1.7	110
1,1,1,2-TETRACHLOROETHANE	980	22		-	-
PENTACHLOROETHANE	362	8		-	-
CHLORINATED PHENOLS					
2,4,6-TRICHLOROPHENOL	16	0.36	yes	21	65
2-CHLOROPHENOL	-	-	no	120	400
4-CHLOROPHENOL	192	4.3		-	-
2,4,5-TRICHLOROPHENOL	23	0.51		-	-
2,3,4,6-TETRACHLOROPHENOL	7	0.16		-	-
2,3,5,6-TETRACHLOROPHENOL	8.5	0.19		-	-
4-CHLORO-2-METHYLPHENOL	15	0.32		-	-
2,4-DICHLORO-6-METHYLPHENOL	22	0.48		-	-
CHLOROALKYL ETHERS					
BIS(2-CHLOROETHYL)ETHER	-	-	yes	0.31	14
BIS(2-CHLOROISOPROPYL)ETHER	-	-	no	1400	1.70E+05
CHLOROFORM	1445	32	yes	57	4700
1-CHLORONAPHTHALENE	80	1.8		-	-
2-CHLORONAPHTHALENE	-	-	no	1700	4800
2-CHLOROPHENOL	129	2.9	no	-	-
CHROMIUM III	(See Table 4-4)		no	-	-
CHROMIUM VI	15	10	no	-	-
COPPER	(See Table 4-4)		no	1300	-
CYANIDE	22	5.2	no	700	2.20E+05
4,4-DDT	1.1	0.001	yes	5.90E-03	5.90E-03
4,4-DDE	-	-	yes	5.90E-03	5.90E-03

Table 4-6 (cont.)

Parameter	Aquatic Life Criteria		Carcinogen (2)	Human Health Criteria (ug/l)	
	Acute (ug/l)	Chronic (ug/l)		Class A Waters Waters & Fish Consumption	All other waters Fish consumption only
4,4-DDD	-	-	yes	8.30E-03	8.40E-03
DICHLOROBENZENES					
1,2-DICHLOROBENZENE	79	1.8	no	2700	1.70E+04
1,3-DICHLOROBENZENE	390	8.7	no	400	2600
1,4-DICHLOROBENZENE	56	1.2	no	400	2600
DICHLOROBENZIDINES					
3,3-DICHLOROBENZIDENE	-	-	yes	0.4	0.77
DICHLOROETHYLENES					
1,1-DICHLOROETHYLENE	580	13	yes	0.57	32
2,4-DICHLOROPHENOL	101	2.2	no	93	790
1,3-DICHLOROPROPYLENE	-	-	no	10	1700
DIELDRIN	2.5	0.0019	yes	1.40E-03	1.40E-03
1,2-TRANS-DICHLOROETHYLENE	-	-	no	700	-
2,4-DIMETHYLPHENOL	106	2.4	no	540	2300
DICHLOROPROPANES					
1,1-DICHLOROPROPANE	1150	26		-	-
1,2-DICHLOROPROPANE	2625	58	yes	5.2	390
1,3-DICHLOROPROPANE	303	6.7		-	-
DINITROTOLUENES					
2,4-DINITROTOLUENE	1550	34	yes	1.1	91
2,3-DINITROTOLUENE	17	0.37		-	-
2,3,7,8-TCDD (Dioxin)	-	-	yes	1.30E-07	1.40E-07
1,2-DIPHENYLHYDRAZINE	14	0.31	yes	0.4	5.4
ENDOSULFAN (alpha, beta)	0.22	0.056	no	0.93	2
ENDOSULFAN (sulfate)	-	-	no	0.93	2
ENDRIN	0.18	0.0023	no	0.76	0.81
ENDRIN ALDEHYDE	-	-	no	0.76	0.81
ETHYLBENZENE	1600	36	no	3100	2.90E+04
FLUORANTHENE	199	4.4	no	300	370
HALOMETHANES					
BROMOFORM	1465	33	yes	43	3600
BROMOMETHANE (methyl bromide)	-	-	no	48	4000
CHLORODIBROMOMETHANE	-	-	yes	4.1	340
CHLOROMETHANE (methyl chloride)	-	-	yes	-	-
METHYLENE CHLORIDE	9650	214	yes	47	1.60E+04
DICHLOROBROMOMETHANE	-	-	yes	2.7	220
4-BROMOPHENYL PHENYL ETHER	18	0.4		-	-
HEPTACHLOR	0.52	0.0038	yes	2.10E-03	2.10E-03
HEPTACHLOR EPOXIDE	0.52	0.0038	yes	1.00E-03	1.10E-03
HEXACHLOROBUTADIENE	-	-	yes	4.4	500
HEXACHLOROCYCLOPENTADIENE	0.35	0.008	no	240	1.70E+04
HEXACHLOROCYCLOHEXANE					
Alpha BHC	-	-	yes	0.04	0.13
Beta BHC	-	-	yes	0.14	0.46
Gamma BHC (Lindane)	2	0.08	yes	0.19	0.63
ISOPHORONE	5850	130	yes	84	6000
LEAD	(See Table 4-4)		no	-	-
MERCURY	2.1	0.0122	no	0.14	0.15
NICKEL	(See Table 4-4)		no	610	4600
NAPHTHALENE	115	2.6		-	-
NITROBENZENE	1350	30	no	17	1900
NITROPHENOLS					
2,4-DINITROPHENOL	31	0.69	no	70	1.40E+04
4,6-DINITRO-2-METHYL PHENOL					
(4,6-dinitro-o-cresol)	-	-	no	13.4	765
4-NITROPHENOL	-	-		-	-

Table 4-6 (cont.)

Parameter	Aquatic Life Criteria		Carcinogen (2)	Human Health Criteria (ug/l)	
	Acute (ug/l)	Chronic (ug/l)		Class A Waters Waters & Fish Consumption	All other waters Fish consumption only
2,4,6-TRINITROPHENOL	4235	94		-	-
NITROSAMINES					
N-NITROSODI-N-PROPYLAMINE	-	-	yes	0.05	14
N-NITROSODIMETHYLAMINE	-	-	yes	6.90E-03	81
N-NITROSODIPHENYLAMINE	293	6.5	yes	50	160
PENTACHLOROPHENOL *(5)*	0.04835	0.030523	yes	2.8	82
PHENOL	251	5.6	no	2.10E+04	4.60E+06
PHTHALATE ESTERS					
BUTYL BENZYL PHTHALATE	85	1.9	no	3000	5200
BIS(2-ETHYLHEXYL)PHTHALATE	555	12	yes	1.80E+04	5.90E+04
DI-n-BUTYL PHTHALATE	-	-	no	2700	1.20E+04
DIETHYL PHTHALATE	2605	58	no	2.30E+04	1.20E+05
DIMETHYL PHTHALATE	1650	37	no	3.13E+05	2.90E+03
POLYCHLORINATED BIPHENYLS *(3)*	-	0.014	yes	4.40E-04	4.40E-04
POLYCYCLIC AROMATIC HYDROCARBON	-	-	yes	0.028	0.31
ANTHRACENE	-	-	no	9600	1.10E+05
FLUORENE	-	-	no	1300	14000
PYRENE	-	-	no	960	1.10E+04
SELENIUM	20	5	no	-	-
SILVER	(See Table 4-4)		no	-	-
TETRACHLOROETHYLENE	240	5.3	yes	8	88.5
THALLIUM	46	1	no	1.7	6.3
TOLUENE	635	14	no	6800	2.00E+05
TOXAPHENE	0.73	0.0002	yes	7.30E-03	7.50E-03
TRICHLOROETHYLENE	1950	43	yes	27	810
VINYL CHLORIDE	-	-	yes	20	5250
ZINC	(See Table 4-4)		no	-	-

- = no criteria recommendation

(1) Freshwater criteria for aluminum are for water with pH between 6.5 and 9.
(2) Carcinogens calculated at 10^{-5} risk.
(3) Polychlorinated Biphenyls criteria apply to the following:
PCB 1016, PCB 1248, PCB 1242, PCB 1232, PCB 1254, PCB 1260, PCB 1221
(4) Polycyclic aromatic hydrocarbons criteria apply to the following:
indeno(1,2,3-cd)pyrene
dibenzo(ah)anthracene
benzo(a)anthracene
benzo(a) pyrene
benzo(b)fluoranthene
benzo(k)fluoranthene
chrysene
(5) Pentachlorophenol based on pH = 6.

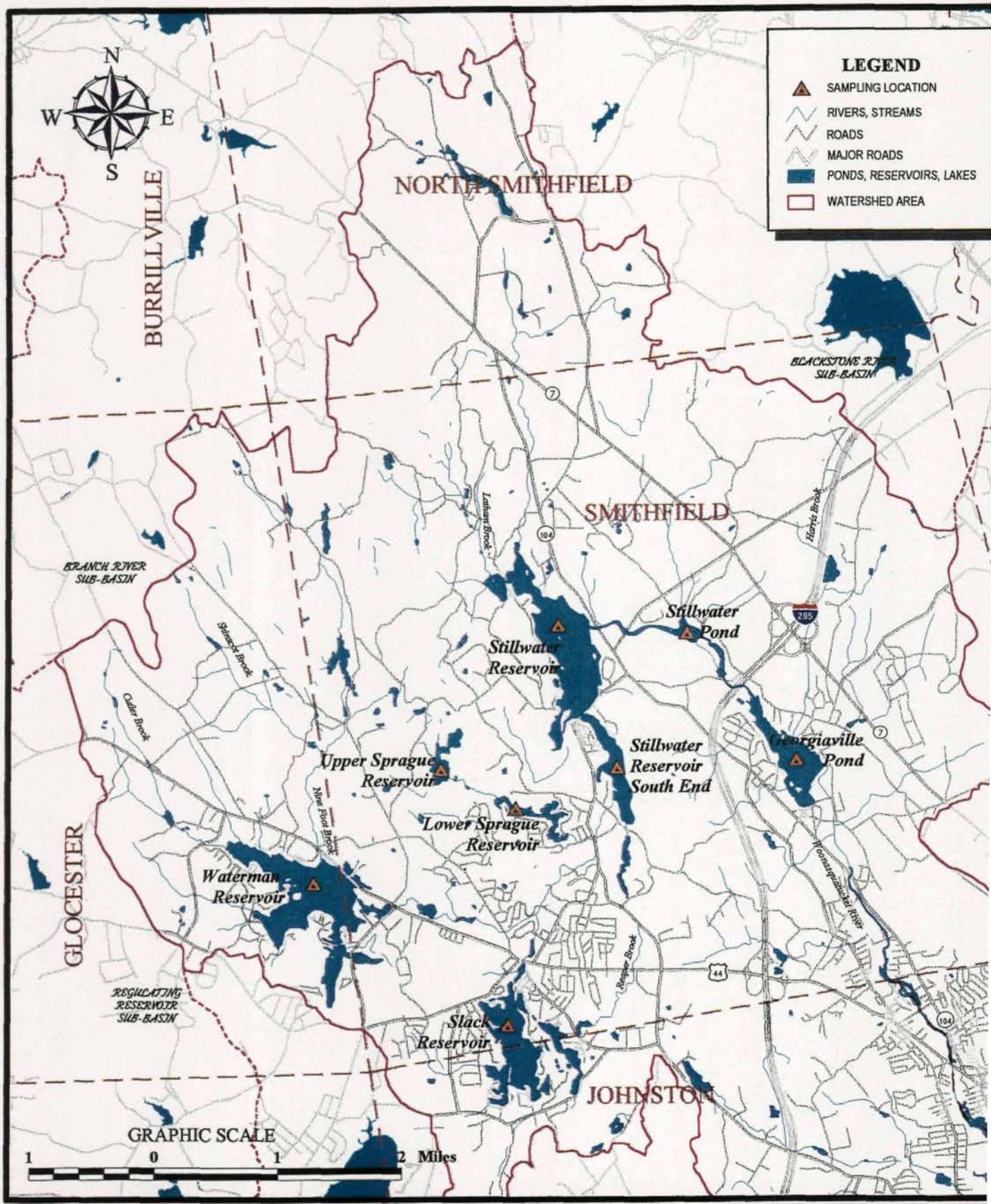

Figure 4-7

LAKES / RESERVOIRS SAMPLING STATIONS

SURFACE WATER QUALITY

The Louis Berger Group, Inc. | Source: RIGIS, RIDEM | File: LA162.apr | May 2000 | Rhode Island DEM

Figure 4-8

pH - Reservoirs

Reservoir		All Years (1993-1998)	1993	1994	1995	1996	1997	1998
UPPER SPRAGUE RESERVOIR	**Mean**	**6.6**	**6.6**					
	Minimum	*6.3*	*6.3*					
	Maximum	*6.9*	*6.9*					
LOWER SPRAGUE RESERVOIR	**Mean**	**6.6**		**6.6**	**6.8**	**6.8**	**6.3**	**6.6**
	Minimum	*6.1*		*6.3*	*6.4*	*6.5*	*6.1*	*6.3*
	Maximum	*7.2*		*6.9*	*7.2*	*7.1*	*6.6*	*6.8*
WATERMAN RESERVOIR	**Mean**	**6.6**	**6.6**	**6.8**	**6.7**	**6.7**	**6.2**	**6.3**
	Minimum	*5.9*	*6.3*	*6.7*	*6.2*	*6.4*	*5.9*	*6.0*
	Maximum	*7.2*	*7.2*	*7.1*	*7.1*	*7.0*	*6.5*	*6.8*
SLACK RESERVOIR	**Mean**	**6.9**		**6.9**	**6.8**	**6.9**	**7.0**	**6.9**
	Minimum	*6.1*		*6.7*	*6.1*	*6.8*	*6.5*	*6.5*
	Maximum	*7.4*		*7.1*	*7.3*	*7.0*	*7.4*	*7.1*
STILLWATER RESERVOIR SOUTH END	**Mean**	**6.6**		**7.0**		**6.7**	**6.3**	**6.5**
	Minimum	*6.0*		*6.7*		*6.5*	*6.0*	*6.2*
	Maximum	*7.2*		*7.2*		*7.2*	*6.5*	*6.8*
STILLWATER RESERVOIR	**Mean**	**6.8**	**7.0**	**6.9**	**7.1**	**6.7**	**6.5**	**6.8**
	Minimum	*6.0*	*6.4*	*6.8*	*6.8*	*6.5*	*6.0*	*6.6*
	Maximum	*7.5*	*7.5*	*7.1*	*7.4*	*7.1*	*6.8*	*6.9*
STILLWATER POND	**Mean**	**6.7**		**7.2**		**6.8**	**6.3**	**6.4**
	Minimum	*6.1*				*6.6*	*6.1*	*6.2*
	Maximum	*6.9*				*6.9*	*6.6*	*6.7*
GEORGIAVILLE POND	**Mean**	**6.8**	**7.1**	**6.6**	**7.0**	**6.7**	**6.5**	**7.0**
	Minimum	*6.3*	*7.0*	*6.4*	*6.6*	*6.5*	*6.3*	*6.5*
	Maximum	*7.3*	*7.3*	*6.8*	*7.3*	*7.0*	*6.7*	*7.3*

Figure 4-9

Fecal Coliform Concentration (MPN/100 ml) - Reservoirs

Reservoir		All Years (1993-1998)	1993	1994	1995	1996	1997	1998
UPPER SPRAGUE RESERVOIR	**Mean**		8					
	Minimum		2					
	Maximum		32					
LOWER SPRAGUE RESERVOIR	**Mean**	10		15	14	6	11	7
	Minimum	0		14	7	0	10	1
	Maximum	50		16	50	40	13	36
WATERMAN RESERVOIR	**Mean**	5	3	4	3	8	5	9
	Minimum	1	2	1	1	3	1	8
	Maximum	19	4	8	11	15	19	11
SLACK RESERVOIR	**Mean**	>41			167	15	31	38
	Minimum	4		8	24	10	4	7
	Maximum	TNTC		TNTC	1,160	28	194	960
STILLWATER RESERVOIR SOUTH END	**Mean**	8		12	6	8	5	11
	Minimum	0		7	4	4	0	1
	Maximum	50		26	8	20	50	46
STILLWATER RESERVOIR	**Mean**	2	2	2	2	4	1	2
	Minimum	0	0	0	2	1	0	0
	Maximum	13	4	13	2	10	2	4
STILLWATER POND	**Mean**	7		7		4	9	10
	Minimum	0				3	0	3
	Maximum	65				4	65	26
GEORGIAVILLE POND	**Mean**	5	2	15	4	2	5	11
	Minimum	0	1	11	2	0	5	8
	Maximum	26	3	26	8	7	5	19

Note: Mean Concentration is expressed as geometric mean.

Criteria (Class B & B1)
Geometric Mean - 200 MPN/100ml
80th Percentile - 500 MPN/100 ml

Figure 4-10

Dissolved Oxygen Concentrations at the Surface (mg/l) - Reservoirs

Reservoir		All Years (1993-1998)	1993	1994	1995	1996	1997	1998
UPPER SPRAGUE RESERVOIR	**Mean**							
	Minimum							
	Maximum							
LOWER SPRAGUE RESERVOIR	**Mean**							
	Minimum							
	Maximum							
WATERMAN RESERVOIR	**Mean**							
	Minimum							
	Maximum							
SLACK RESERVOIR	**Mean**	**8.0**				**7.8**	**7.8**	**8.3**
	Minimum	*6.6*				*6.6*	*7.0*	*7.2*
	Maximum	*10.0*				*9.2*	*9.2*	*10.0*
STILLWATER RESERVOIR SOUTH END	**Mean**							
	Minimum							
	Maximum							
STILLWATER RESERVOIR	**Mean**							
	Minimum							
	Maximum							
STILLWATER POND	**Mean**							
	Minimum							
	Maximum							
GEORGIAVILLE POND	**Mean**	**7.6**	**5.9**	**6.8**	**6.9**	**8.0**	**9.0**	**7.9**
	Minimum	*2.5*	*3.6*	*2.5*	*7.4*	*7.0*	*7.7*	*7.0*
	Maximum	*10.0*	*9.5*	*9.9*	*9.9*	*9.8*	*10.0*	*9.2*

Regulatory Standard: *Instantaneous minimum dissolved oxygen concentration of at least 5 mg/l.*

Figure 4-11

Dissolved Oxygen Concentrations at the Bottom (mg/l) - Reservoirs

Reservoir		All Years (1993-1998)	1993	1994	1995	1996	1997	1998
UPPER SPRAGUE RESERVOIR	**Mean**							
	Minimum							
	Maximum							
LOWER SPRAGUE RESERVOIR	**Mean**							
	Minimum							
	Maximum							
WATERMAN RESERVOIR	**Mean**							
	Minimum							
	Maximum							
SLACK RESERVOIR	**Mean**	**6.3**				**7.2**	**6.9**	**5.3**
	Minimum	*0.0*				*3.0*	*3.2*	*0.0*
	Maximum	*9.5*				*9.5*	*9.2*	*9.3*
STILLWATER RESERVOIR SOUTH END	**Mean**							
	Minimum							
	Maximum							
STILLWATER RESERVOIR	**Mean**							
	Minimum							
	Maximum							
STILLWATER POND	**Mean**							
	Minimum							
	Maximum							
GEORGIAVILLE POND	**Mean**	**4.3**	**6.7**	**5.4**	**5.5**	**1.6**	**4.6**	**3.9**
	Minimum	*0.0*	*3.1*	*1.2*	*1.9*	*0.0*	*0.3*	*0.0*
	Maximum	*10.0*	*9.8*	*9.8*	*9.8*	*7.8*	*10.0*	*9.9*

Regulatory Standard: *Instantaneous minimum dissolved oxygen concentration of at least 5 mg/l.*

Figure 4-12

Dissolved Phosphorus Concentration (ug/l P) - Reservoirs

Reservoir		All Years (1993-1998)	1993	1994	1995	1996	1997	1998
UPPER SPRAGUE RESERVOIR	**Mean**		<5					
	Minimum		<5					
	Maximum		<5					
LOWER SPRAGUE RESERVOIR	**Mean**	<6		<11	<5	<5	<5	<5
	Minimum	<5		<5	<5	<5	<5	<5
	Maximum	23		23	6	5	5	<5
WATERMAN RESERVOIR	**Mean**	<5		<5	<5	<5	<5	<5
	Minimum	<5		<5	<5	<5	<5	<5
	Maximum	<5		<5	<5	<5	<5	<5
SLACK RESERVOIR	**Mean**	<5		<5	<5	<5	<6	<6
	Minimum	<5		<5	<5	<5	<5	<5
	Maximum	10		<5	<5	<5	10	8
STILLWATER RESERVOIR SOUTH END	**Mean**	<5		<5	<5	<5	<5	<5
	Minimum	<5		<5	<5	<5	<5	<5
	Maximum	5		<5	<5	<5	5	<5
STILLWATER RESERVOIR	**Mean**	<6	<8	<5	<5	<5	<6	<5
	Minimum	<5	<5	<5	4	<5	<5	<5
	Maximum	13	13	<5	<5	<5	10	<5
STILLWATER POND	**Mean**	<5		<5		<5	<5	<5
	Minimum	<5				<5	<5	<5
	Maximum	5				<5	5	<5
GEORGIAVILLE POND	**Mean**	<5	<5	<5	<5	<5	<5	<5
	Minimum	<5	<5	<5	<5	<5	<5	<5
	Maximum	<5	<5	<5	<5	<5	<5	<5

Regulatory Standard: Average *Total* Phosphorus concentation of 25 ug/l P for lakes, ponds, and reservoirs.

Figure 4-13

Total Phosphorus Concentration at 1 m Depth (ug/l P) - Reservoirs

Reservoir		All Years (1993-1998)	1993	1994	1995	1996	1997	1998
UPPER SPRAGUE RESERVOIR	**Mean**		10					
	Minimum		9					
	Maximum		11					
LOWER SPRAGUE RESERVOIR	**Mean**	31		41	33	24	24	33
	Minimum	16		20	31	18	16	19
	Maximum	72		72	37	32	32	44
WATERMAN RESERVOIR	**Mean**	12	11	13	10	10	13	14
	Minimum	5	9	9	5	5	12	12
	Maximum	16	13	15	14	13	14	16
SLACK RESERVOIR	**Mean**	16		17	13	16	17	15
	Minimum	10		14	10	15	14	11
	Maximum	20		19	16	16	20	20
STILLWATER RESERVOIR SOUTH END	**Mean**	15		12	15	16	18	13
	Minimum	8		10	15	9	10	8
	Maximum	32		14	15	25	32	16
STILLWATER RESERVOIR	**Mean**	13	15	12	11	12	14	13
	Minimum	6	9	11	6	11	6	12
	Maximum	27	21	12	17	12	27	14
STILLWATER POND	**Mean**	14		16		12	12	16
	Minimum	7				7	7	7
	Maximum	25				18	15	25
GEORGIAVILLE POND	**Mean**	10	10	13	10	11	8	10
	Minimum	4	8	11	7	10	4	4
	Maximum	14	12	17	13	11	11	14

Regulatory Standard: Average *Total* Phosphorus concentation of 25 ug/l P for lakes, ponds, and reservoirs.

Figure 4-14

Nitrate Concentration (ug/l N) - Reservoirs

Reservoir		All Years (1993-1998)	1993	1994	1995	1996	1997	1998
UPPER SPRAGUE RESERVOIR	**Mean**		**<50**					
	Minimum		*<50*					
	Maximum		*<50*					
LOWER SPRAGUE RESERVOIR	**Mean**	**<108**		**<60**	**<127**	**<95**	**<155**	**<103**
	Minimum	*<40*		*<50*	*<50*	*<50*	*<40*	*<40*
	Maximum	*270*		*70*	*190*	*175*	*270*	*230*
WATERMAN RESERVOIR	**Mean**	**<68**	**<70**	**<75**	**<50**	**<67**	**<87**	**<58**
	Minimum	*<50*	*<50*	*<50*	*<50*	*<50*	*<40*	*<40*
	Maximum	*180*	*110*	*100*	*<50*	*100*	*180*	*95*
SLACK RESERVOIR	**Mean**	**<99**		**<95**	**<95**	**<160**	**<103**	**<88**
	Minimum	*<40*		*<50*	*<50*	*<50*	*<103*	*<40*
	Maximum	*385*		*140*	*185*	*385*	*210*	*160*
STILLWATER RESERVOIR SOUTH END	**Mean**	**<59**		**<50**	**<50**	**<56**	**<82**	**<57**
	Minimum	*<50*		*<50*	*<50*	*<50*	*<40*	*<40*
	Maximum	*165*		*<50*	*<50*	*70*	*165*	*100*
STILLWATER RESERVOIR	**Mean**	**<72**	**<50**	**<50**	**<70**	**<50**	**<70**	**<72**
	Minimum	*<50*	*<50*	*<50*	*<50*	*<50*	*<40*	*<40*
	Maximum	*145*	*<50*	*<50*	*110*	*<50*	*130*	*145*
STILLWATER POND	**Mean**	**<59**		**<50**		**<50**	**<68**	**78**
	Minimum	*30*				*<50*	*<40*	*55*
	Maximum	*125*				*<50*	*125*	*100*
GEORGIAVILLE POND	**Mean**	**<68**	**<50**	**<60**	**<70**	**<55**	**<82**	**93**
	Minimum	*<50*	*<50*	*<50*	*<50*	*<50*	*<40*	*60*
	Maximum	*165*	*<50*	*80*	*90*	*65*	*165*	*125*

Regulatory Standard: –

Figure 4-15

Total Nitrogen Concentration at 1 m Depth (ug/l N) - Reservoirs

Reservoir		All Years (1993-1998)	1993	1994	1995	1996	1997	1998
UPPER SPRAGUE RESERVOIR	**Mean**							
	Minimum							
	Maximum							
LOWER SPRAGUE RESERVOIR	**Mean**	**578**	**260**	**668**	**645**	**615**	**645**	**633**
	Minimum	*510*		*510*	*610*	*595*	*620*	*530*
	Maximum	*1,470*		*1.470*	*680*	*635*	*670*	*740*
WATERMAN RESERVOIR	**Mean**	**374**	**275**	**337**	**413**	**420**	**350**	**450**
	Minimum	*220*	*220*	*300*	*355*	*340*	*270*	*420*
	Maximum	*500*	*330*	*360*	*470*	*500*	*390*	*470*
SLACK RESERVOIR	**Mean**	**393**		**475**	**415**	**425**	**500**	**543**
	Minimum	*345*		*440*	*345*	*420*	*420*	*400*
	Maximum	*690*		*510*	*483*	*430*	*570*	*690*
STILLWATER RESERVOIR SOUTH END	**Mean**	**364**		**307**	**280**	**458**	**400**	**373**
	Minimum	*250*		*250*		*415*	*290*	*280*
	Maximum	*500*		*340*		*500*	*460*	*460*
STILLWATER RESERVOIR	**Mean**	**335**	**375**	**293**	**360**	**430**	**212**	**340**
	Minimum	*77*	*240*	*170*	*350*	*380*	*77*	*280*
	Maximum	*510*	*510*	*370*	*370*	*480*	*310*	*390*
STILLWATER POND	**Mean**	**376**		**290**		**333**	**333**	**547**
	Minimum					*290*	*280*	*320*
	Maximum					*275*	*370*	*980*
GEORGIAVILLE POND	**Mean**	**406**	**255**	**380**	**320**	**575**	**377**	**530**
	Minimum	*230*	*230*	*300*		*480*	*260*	*420*
	Maximum	*720*	*280*	*460*		*670*	*480*	*720*

Regulatory Standard: –

Figure 4-16

Chlorophyll Concentration (ug/l) - Reservoirs

Reservoir		All Years (1993-1998)	1993	1994	1995	1996	1997	1998
UPPER SPRAGUE RESERVOIR	**Mean**							
	Minimum							
	Maximum							
LOWER SPRAGUE RESERVOIR	**Mean**	**7.4**		**7.4**	**7.0**	**8.5**	**4.2**	**7.9**
	Minimum	*1.1*		*2.3*	*1.6*	*4.1*	*1.7*	*1.1*
	Maximum	*40.7*		*33.5*	*19.9*	*21.3*	*9.6*	*40.7*
WATERMAN RESERVOIR	**Mean**							
	Minimum							
	Maximum							
SLACK RESERVOIR	**Mean**	**4.1**		**3.8**	**3.3**	**5.4**	**4.5**	**3.1**
	Minimum	*0.4*		*1.3*	*1.5*	*1.7*	*0.4*	*1.3*
	Maximum	*13.4*		*6.2*	*5.7*	*11.4*	*12.1*	*13.4*
STILLWATER RESERVOIR SOUTH END	**Mean**	**5.6**		**5.1**	**4.9**	**6.1**	**8.5**	**2.5**
	Minimum	*0.5*		*2.4*	*0.5*	*1.3*	*1.7*	*0.9*
	Maximum	*31.8*		*7.9*	*10.3*	*15.8*	*31.8*	*6.2*
STILLWATER RESERVOIR	**Mean**	**2.9**	**1.5**	**3.7**	**3.4**	**4.0**	**2.7**	**1.2**
	Minimum	*0.1*	*0.3*	*1.7*	*0.3*	*1.3*	*0.8*	*0.1*
	Maximum	*11.3*	*2.7*	*6.1*	*7.8*	*11.3*	*7.1*	*2.4*
STILLWATER POND	**Mean**	**4.1**			**2.4**	**6.8**	**2.5**	**2.4**
	Minimum	*0.0*			*2.3*	*2.1*	*0.0*	*0.9*
	Maximum	*16.3*			*2.6*	*16.3*	*7.9*	*5.3*
GEORGIAVILLE POND	**Mean**	**2.9**	**1.2**	**2.6**	**3.2**	**3.0**	**4.6**	**2.1**
	Minimum	*0.8*	*0.8*	*1.3*	*1.3*	*1.3*	*1.9*	*1.4*
	Maximum	*7.6*	*1.7*	*4.2*	*6.3*	*6.1*	*7.6*	*3.8*

Regulatory Standard: --

Figure 4-17

Secchi Depth (m) - Reservoirs

Reservoir		All Years (1993-1998)	1993	1994	1995	1996	1997	1998
UPPER SPRAGUE RESERVOIR	**Mean**							
	Minimum							
	Maximum							
LOWER SPRAGUE RESERVOIR	**Mean**	**2.3**		**2.6**	**2.2**	**2.2**	**2.7**	**1.8**
	Minimum	*1.0*		*2.0*	*1.0*	*1.6*	*2.1*	*1.0*
	Maximum	*3.5*		*3.2*	*2.9*	*2.5*	*3.5*	*3.3*
WATERMAN RESERVOIR	**Mean**							
	Minimum							
	Maximum							
SLACK RESERVOIR	**Mean**	**2.6**		**3.1**	**3.0**	**2.2**	**2.7**	**2.4**
	Minimum	*1.5*		*2.0*	*2.0*	*1.6*	*1.5*	*1.7*
	Maximum	*4.5*		*4.5*	*4.5*	*3.6*	*3.4*	*3.3*
STILLWATER RESERVOIR SOUTH END	**Mean**	**2.6**		**3.3**	**2.4**	**2.6**	**2.2**	**2.6**
	Minimum	*0.9*		*2.4*	*1.6*	*1.9*	*0.9*	*2.0*
	Maximum	*4.2*		*4.2*	*3.2*	*3.1*	*3.1*	*3.1*
STILLWATER RESERVOIR	**Mean**	**3.0**	**2.4**	**3.7**	**3.0**	**3.1**	**2.7**	**2.9**
	Minimum	*1.6*	*1.6*	*2.7*	*1.9*	*2.3*	*2.0*	*2.1*
	Maximum	*4.8*	*3.3*	*4.8*	*4.3*	*3.7*	*3.4*	*3.6*
STILLWATER POND	**Mean**	**2.4**			**2.6**	**2.4**	**2.7**	**2.2**
	Minimum	*1.0*			*2.5*	*1.0*	*1.5*	*1.5*
	Maximum	*4.0*			*2.7*	*3.1*	*4.0*	*3.1*
GEORGIAVILLE POND	**Mean**	**3.4**	**3.5**	**3.8**	**3.8**	**2.9**	**3.5**	**2.4**
	Minimum	*1.9*	*2.7*	*2.5*	*2.7*	*2.0*	*2.5*	*1.9*
	Maximum	*5.6*	*4.6*	*5.6*	*5.4*	*3.5*	*5.0*	*3.1*

Regulatory Standard: 6.5 to 9.0 or as naturally occurs.

Figure 4-18

Trophic Status Concentration - Reservoirs

Reservoir	All Years (1993-1998)	1993	1994	1995	1996	1997	1998
UPPER SPRAGUE RESERVOIR	M	M					
LOWER SPRAGUE RESERVOIR	E		E	E	M/E	M/E	E
WATERMAN RESERVOIR	M	M	M	M	M	M	M
SLACK RESERVOIR	M		M	M	M	M	M
STILLWATER RESERVOIR SOUTH END	M		M	M	M	M	M
STILLWATER RESERVOIR	M	M	M	M	M	M	M
STILLWATER POND	M				M	M	M
GEORGIAVILLE POND	M	M	M	M	M	M	M

Regulatory Standard: --

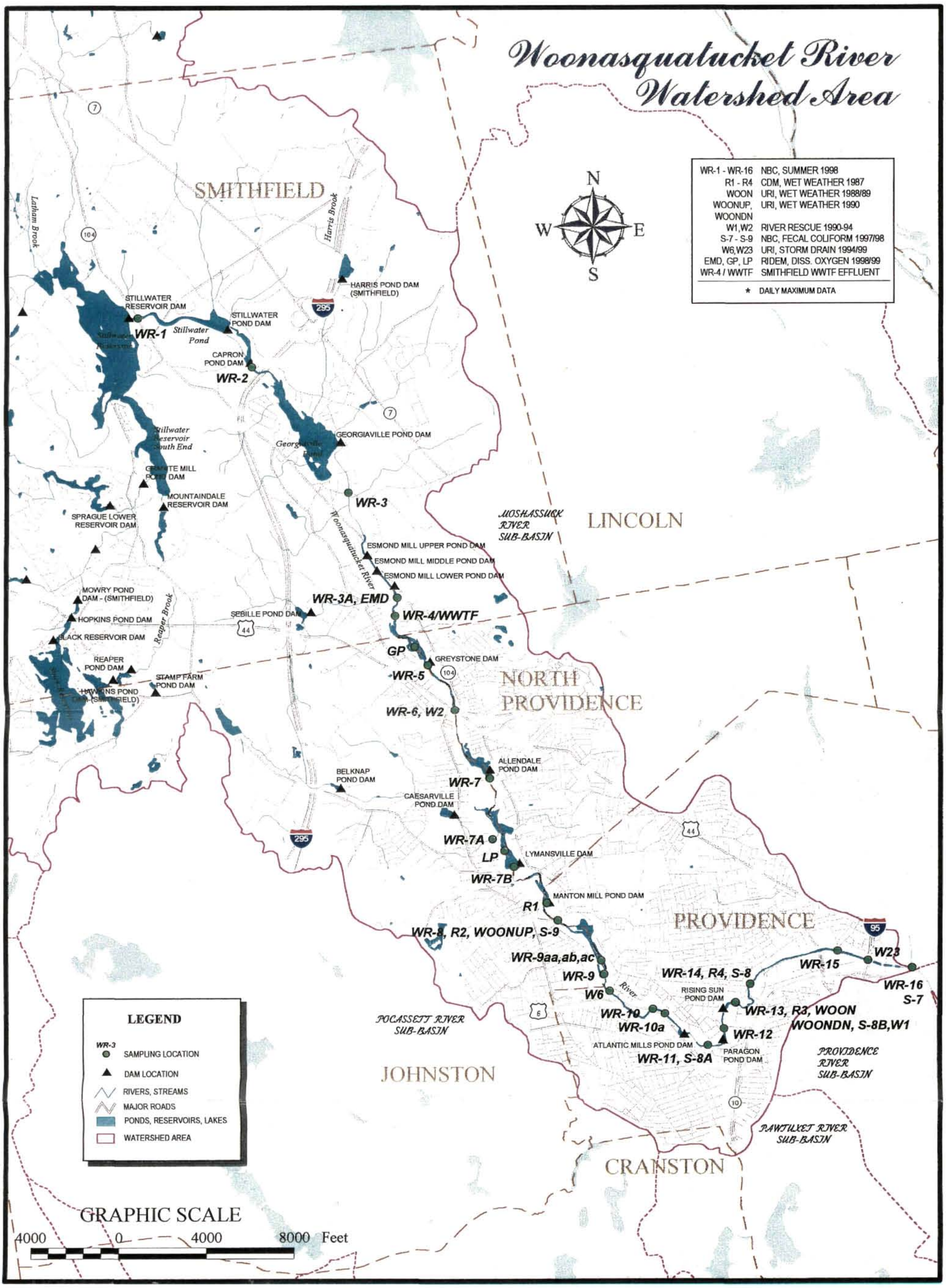

Figure 4-19

DRY WEATHER SAMPLING STATIONS

The Louis Berger Group, Inc. | Source: RIGIS, RIDEM | File: LAY20B.apr | May 2000 | Rhode Island DEM

Figure 4-20

Dry Weather Data - Number of Samples

Station No.	Location	Number of Samples	All Weather Conditions	Dry Weather Conditions
WR-1	Stillwater Reservoir Dam	8	A	
WR-2	Capron Road	8	A	
WR-3	Sri Chimroy Peace Bridge	8	A	
WR-3a	Esmond Mill Drive	8	A	
EMD	Esmond Mill Drive	2,320	A	
WR-4	Smithfield WWTF Effluent	5	A	
WWTF	Smithfield WWTF Effluent	>60	A	
GP	Greystone Pond	2,314	A	
WR-5	Greystone Street	8	A	
WR-6	Route 44, Centerdale	8	A	
W2	Route 44, Centerdale	16-52	A	
WR-7	Allendale Avenue	8	A	
WR-7a	Assapumpset Brook	3	A	
LP	Lymansville Pond	755	A	
WR-7b	Lymansville Dam	8	A	
R1	Manton Dam	5		D
WR-8	Manton Avenue	8	A	
R2	Manton Avenue	5		D
WOONUP	Manton Avenue	4		D
S-9	Manton Avenue	88		D
WR-9aa	Lincoln Lace & Braid	1-4	A	
WR-9ab	Lincoln Lace & Braid	1	A	
WR-9ac	Lincoln Lace & Braid	1-4	A	
WR-9	Dyerville Complex	8	A	
W6	Killingly Interchange Stormdrain			
WR-10	Merino Park	8	A	
WR-10a	Riverside Mills	1	A	
WR-11	Olneyville Square	8	A	
S-8a	Olneyville Square	60		D
WR-12	Delanie Street	8	A	
WR-13	Valley Street	8	A	
R3	Valley Street	5		D
WOON	Valley Street			
WOONDN	Valley Street	4		D
S-8b	Valley Street	43		D
W1	Valley Street	42-62	A	
WR-14	Atwells Avenue	8	A	
R4	Atwells Avenue	5		D
S-8	Atwells Avenue	89		D
WR-15	Bath Street	8	A	
W23	Civic Center Stormdrain			
WR-16	Exchange Street	8	A	
S-7	Exchange Street	88		D

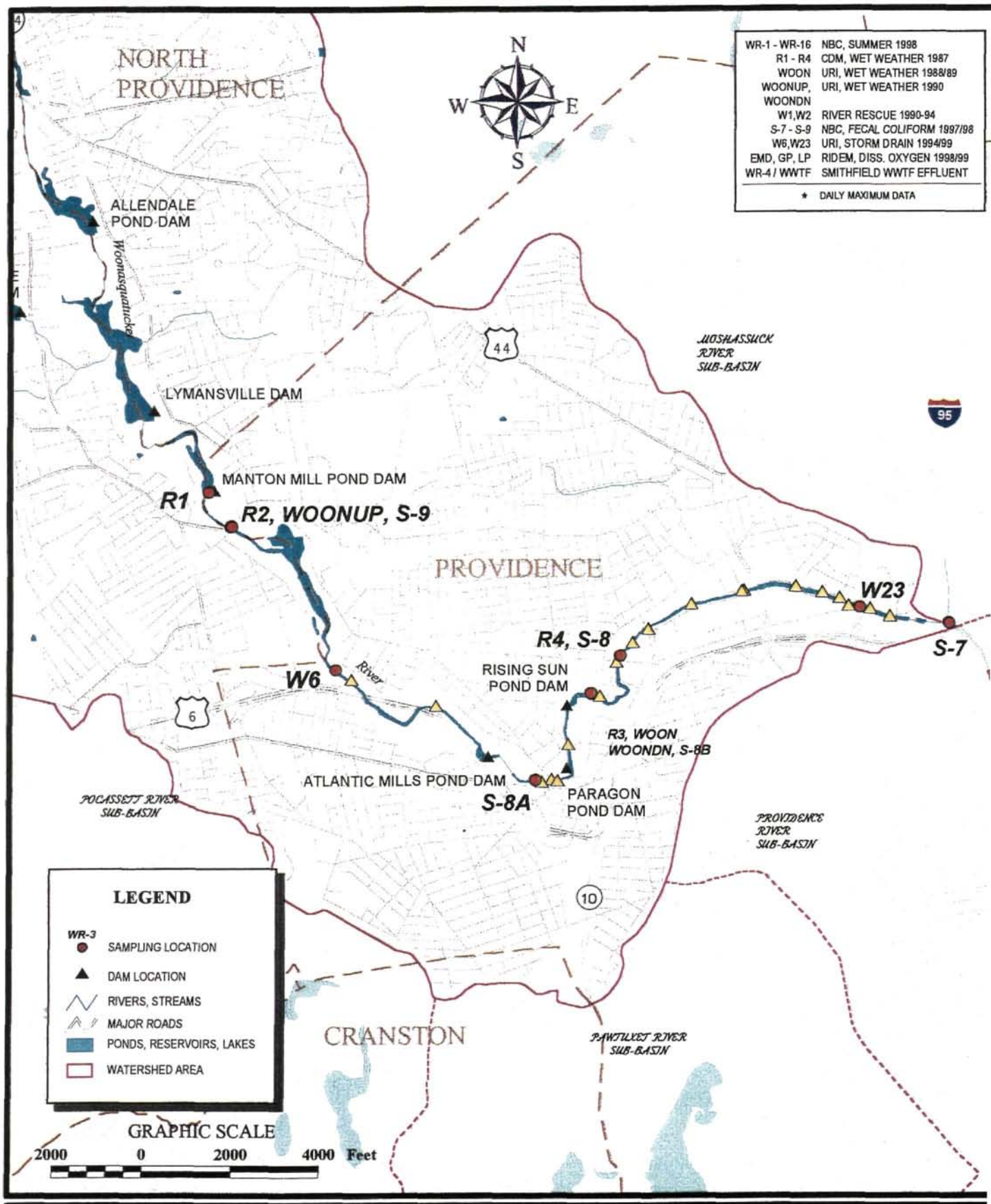

Figure 4-21

WET WEATHER SAMPLING STATIONS

The Louis Berger Group, Inc. | Source: RIGIS, RIDEM | File: LAY20C.apr | May 2000 | Rhode Island DEM

Figure 4-22

Wet Weather Data - Number of Samples

Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam	5	15			
S-9	Manton Avenue	88	34			
R2	Manton Avenue	5	15			
WOONUP	Manton Avenue	4	16	18	5	2
S-8a	Olneyville Square	60	14			
W6	Killingly Interchange Drain		130 (*)			
S-8b	Valley Street	43	10			
R3	Valley Street	5	15			
WOON	Valley Street	3	16	13	8	6
WOONDN	Valley Street	4	16	18	6	2
S-8	Atwells Avenue	89	34			
R4	Atwells Avenue	5	15			
S-7	Exchange Street	88	34			
W23	Civic Center Drain		130 (*)			

(*) Approximate number of samples collected at a total of 4 storms.

Figure 4-23

Flow Rates in the Woonasquatucket River during Storm Monitoring

Flow Rates (cfs)		Mean Flow Rate					Minimum Flow Rate					Maximum Flow Rate				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam															
S-9	Manton Avenue															
R2	Manton Avenue															
WOONUP	Manton Avenue	**74**	**122**	**129**	**132**	**109**	48	58	65	80	58	118	238	248	196	159
S-8a	Olneyville Square															
W6	Killingly Interch. Drain															
S-8b	Valley Street															
R3	Valley Street															
WOON	Valley Street	**103**	**171**	**193**	**172**	**184**	21	35	36	37	41	193	475	473	400	329
WOONDN	Valley Street	**82**	**131**	**142**	**145**	**119**	53	64	71	88	64	129	261	271	215	174
S-8	Atwells Avenue															
R4	Atwells Avenue															
S-7	Exchange Street															
W23	Civic Center Drain															

Figure 4-24

Water Temperature - Station W2 (Route 44)

(Kerr and Lee, 1996)

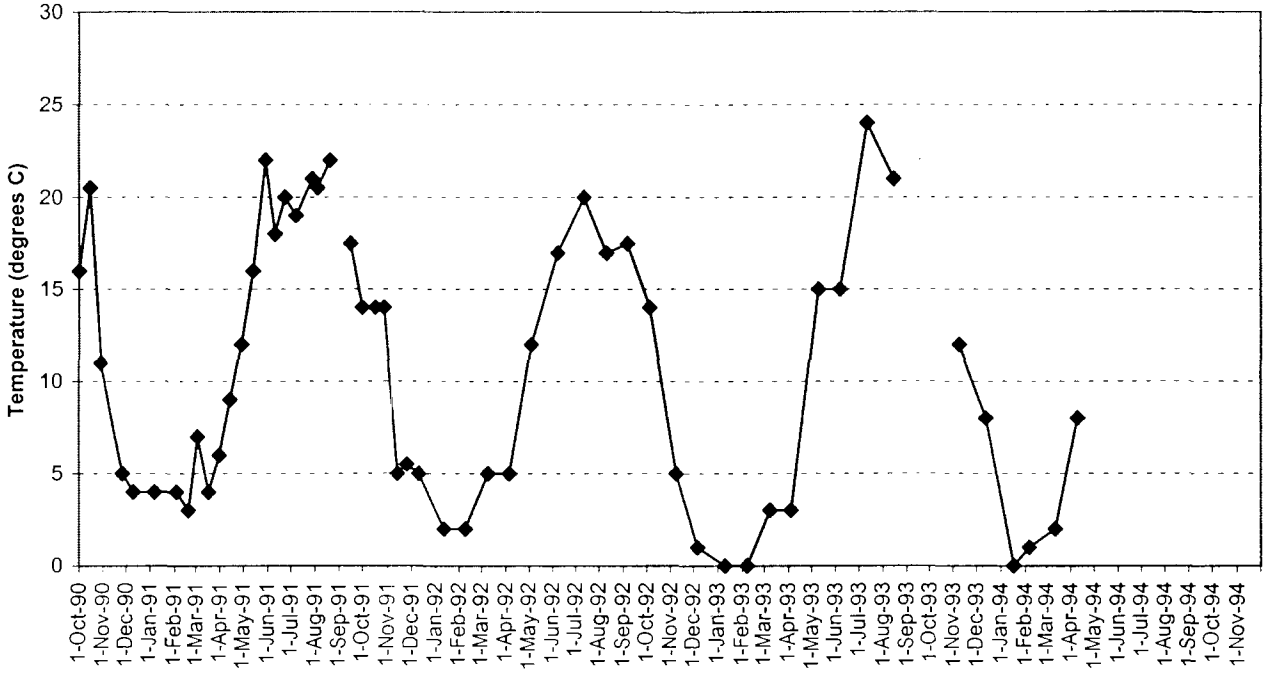

Figure 4-25

Water Temperature -Station W1 (Valley Street)

(Kerr and Lee, 1996)

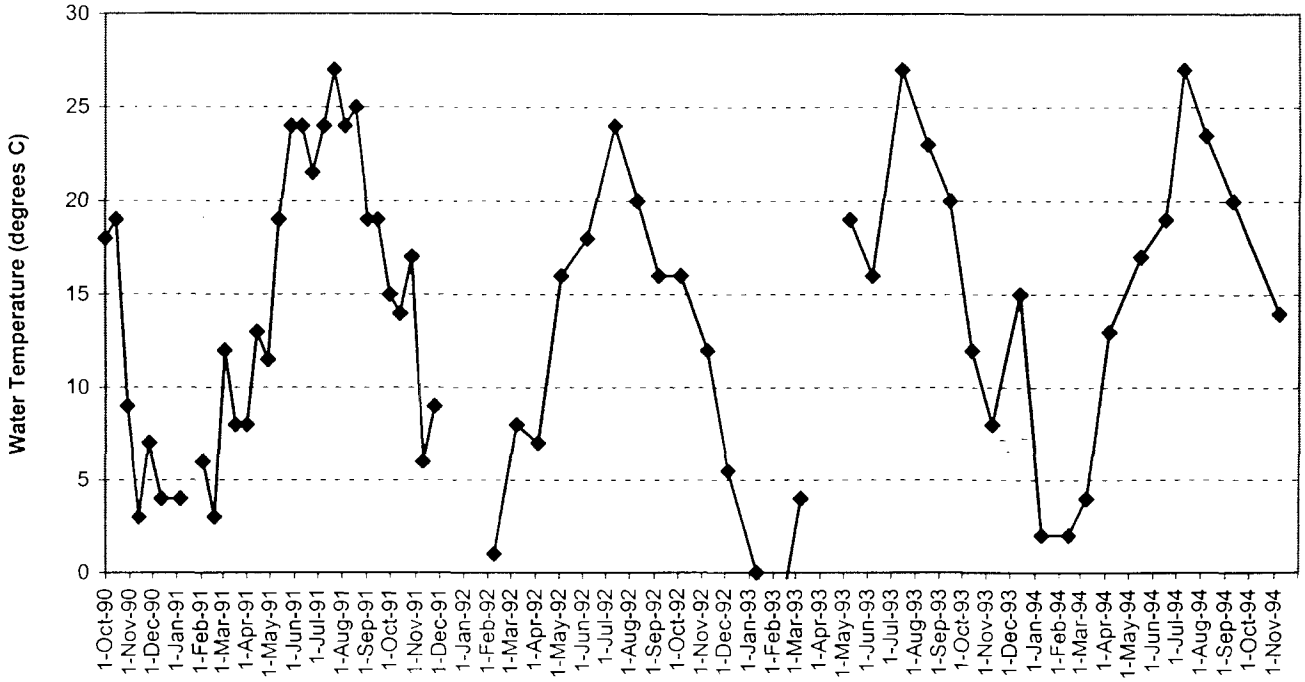

Figure 25a

Water Temperature (NBC, 1998)

(Data from July 15 to August 24 only)

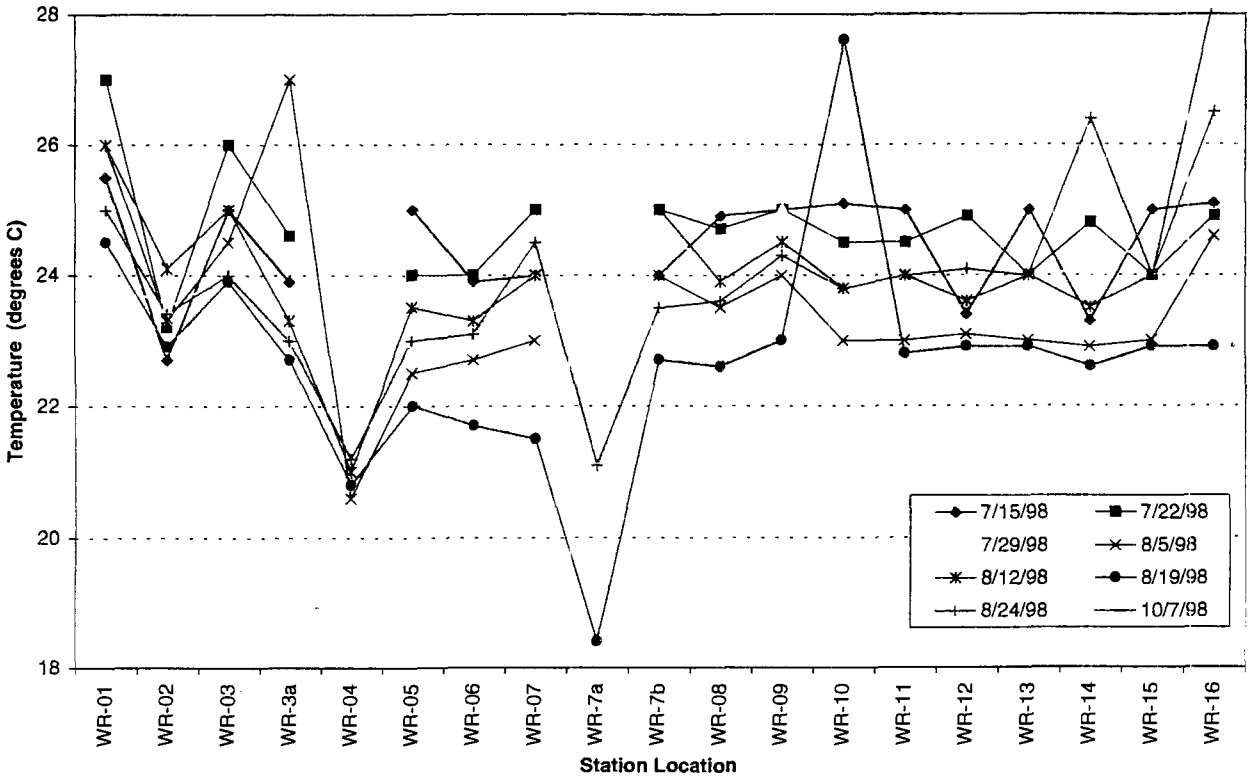

Figure 25b

Temperature - Statistics (NBC, 1998)

(Data from July 15 to August 24 only)

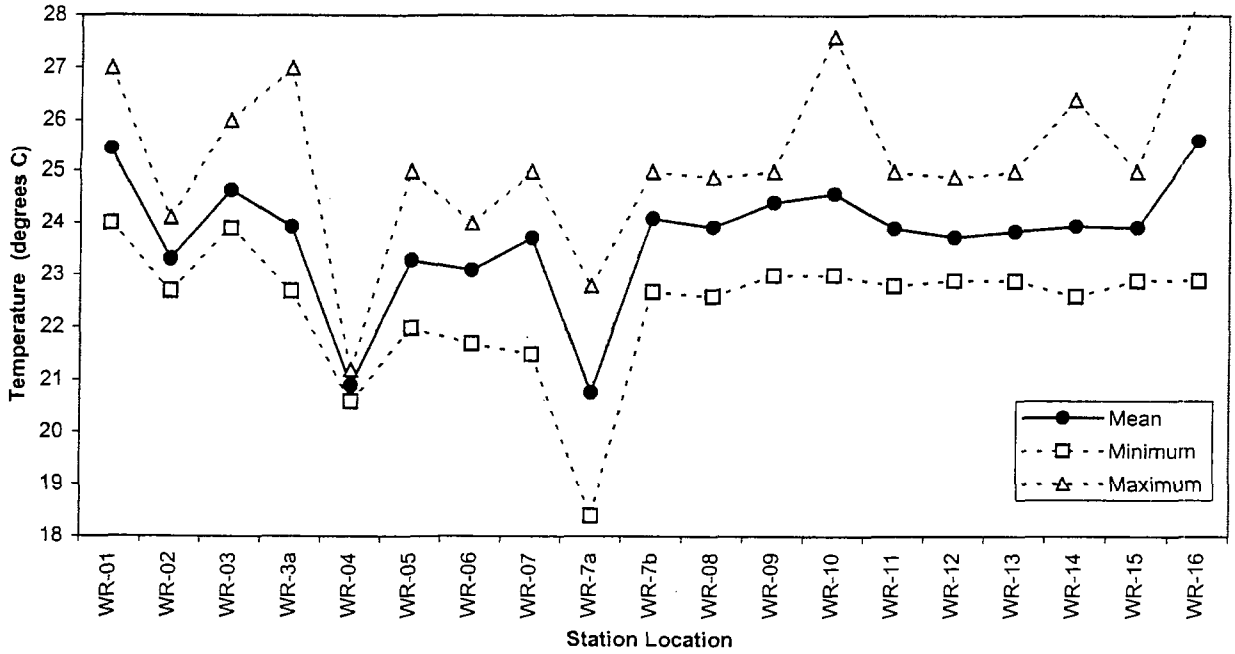

Figure 25c

pH (NBC, 1998)

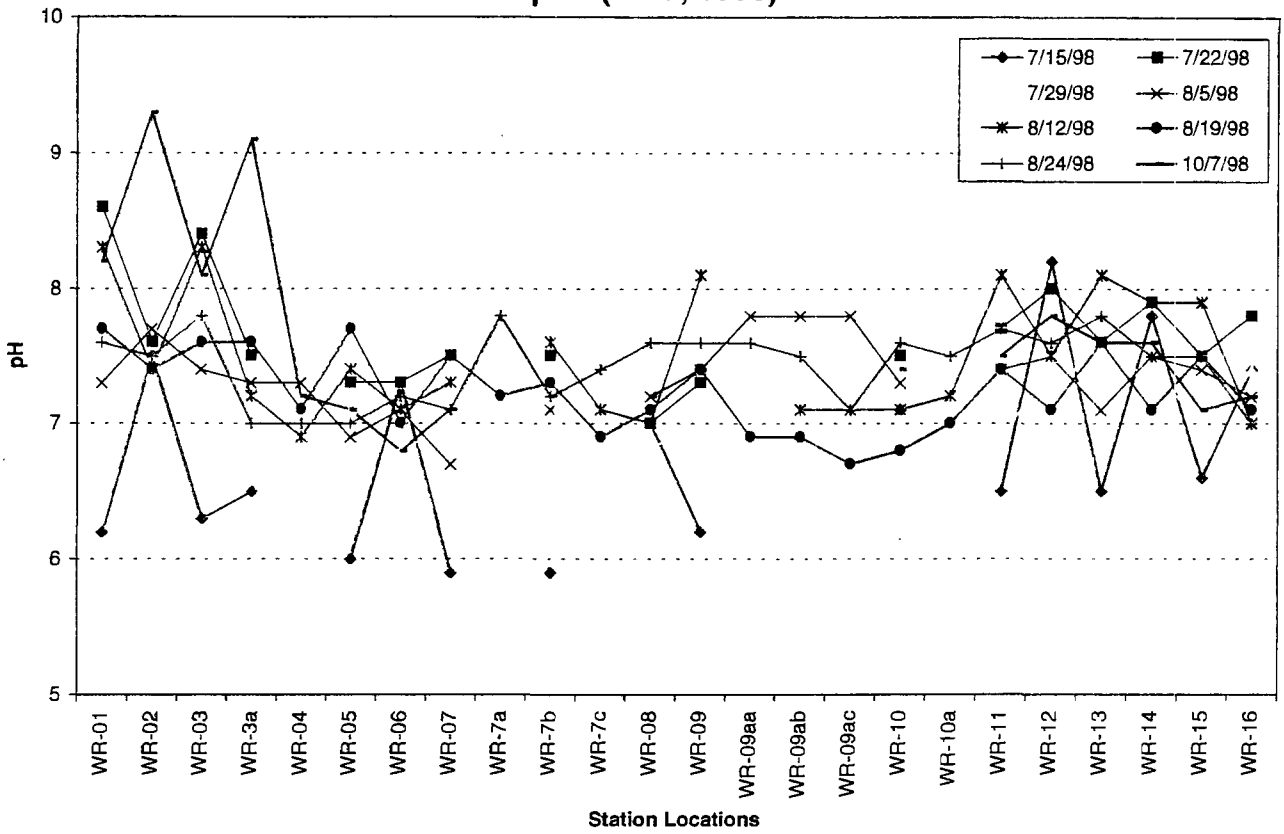

Figure 25d

pH - Statistics (NBC, 1998)

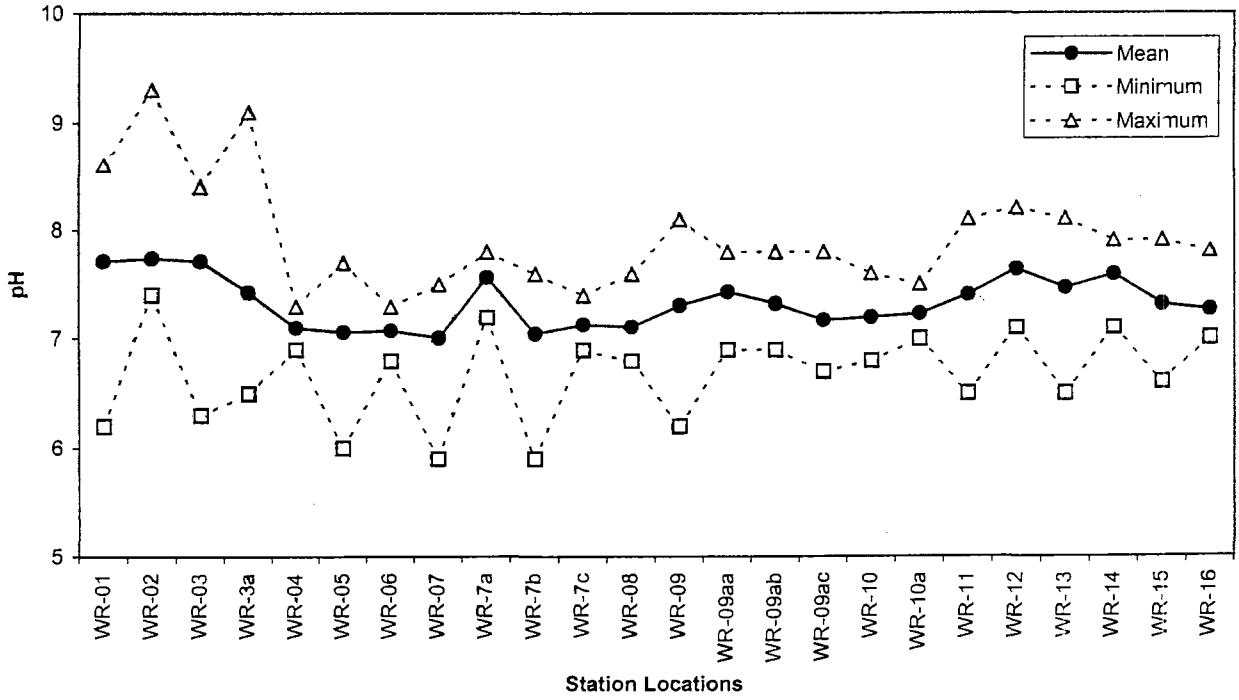

Figure 4-26

Total Suspended Sediment Concentrations - Dry Weather Data

Station No.	Location	Total Susp. Solids (mg/l)		
		Mean	Minimum	Maximum
WR-1	Stillwater Reservoir Dam	**5.1**	5.0	6.0
WR-2	Capron Road	**<5.0**	<5.0	8.5
WR-3	Sri Chimroy Peace Bridge	**<5.0**	<5.0	5.5
WR-3a	Esmond Mill Drive	**<5.0**	<5.0	6.5
EMD	Esmond Mill Drive			
WR-4	Smithfield WWTF Effluent	**<10.0**	<5.0	14.0
WWTF	Smithfield WWTF Effluent	**10.4**	4.0	34.0
GP	Greystone Pond			
WR-5	Greystone Street	**<5.0**	<5.0	5.8
WR-6	Route 44, Centerdale	**<6.1**	<5.0	12.3
W2	Route 44, Centerdale	**1.5**	0.1	3.4
WR-7	Allendale Avenue	**6.4**	5.0	12.0
WR-7a	Assapumpset Brook	**<5.0**	<5.0	<5.0
LP	Lymansville Pond			
WR-7b	Lymansville Dam	**<5.0**	<5.0	6.3
R1	Manton Dam	**1.6**	<0.50	3.6
WR-8	Manton Avenue	**<5.0**	<5.0	<5.0
R2	Manton Avenue	**0.9**	<0.50	2.0
WOONUP	Manton Avenue	**2.8**	0.5	5.2
S-9	Manton Avenue			
WR-9aa	Lincoln Lace & Braid			
WR-9ab	Lincoln Lace & Braid			
WR-9ac	Lincoln Lace & Braid			
WR-9	Dyerville Complex	**<5.0**	<5.0	6.0
W6	Killingly Interch. Outfall			
WR-10	Merino Park	**<5.0**	<5.0	7.0
WR-10a	Riverside Mills			
WR-11	Olneyville Square	**<5.0**	<5.0	9.0
S-8a	Olneyville Square			
WR-12	Delanie Street	**<5.0**	<5.0	5.0
WR-13	Valley Street	**<6.0**	<5.0	7.0
R3	Valley Street	**5.5**	<0.5	23.5
WOON	Valley Street	**4.7**	1.7	8.5
WOONDN	Valley Street	**2.4**	1.8	3.8
S-8b	Valley Street			
W1	Valley Street	**2.6**	0.2	32.9
WR-14	Atwells Avenue	**<5.0**	<5.0	5.0
R4	Atwells Avenue	**3.8**	<0.5	15.7
S-8	Atwells Avenue			
WR-15	Bath Street	**<5.0**	<5.0	7.0
W23	Civic Center Outfall			
WR-16	Exchange Street	**<8.4**	<5.0	13.0
S-7	Exchange Street			

Figure 4-27

Total Suspended Sediment Concentration - Wet Weather Data

Total Suspended Sediment (mg/l)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam	**1.6**	**13.0**				<0.5	1.2				3.6	59.7			
S-9	Manton Avenue															
R2	Manton Avenue	**0.9**	**13.2**				<0.5	<0.5				2.0	44.0			
WOONUP	Manton Avenue	**2.8**	**5.3**	**2.4**	**1.9**	**2.5**	0.5	1.2	0.6	0.8	1.8	5.2	9.6	6.2	3.0	3.2
S-8a	Olneyville Square															
W6	Killingly Interch. Drain							4.8					198.0			
S-8b	Valley Street															
R3	Valley Street	**5.5**	**11.8**				<0.5	<0.5				23.5	53.3			
WOON	Valley Street	**4.7**	**12.7**	**7.6**	**6.3**	**9.6**	1.7	2.8	2.8	1.7	3.7	8.5	64.4	17.9	12.7	18.9
WOONDN	Valley Street	**2.4**	**13.8**	**4.6**	**4.1**	**2.9**	1.8	0.4	0.6	0.6	2.4	3.8	31.8	9.8	7.4	3.4
S-8	Atwells Avenue															
R4	Atwells Avenue	**3.8**	**19.1**				<0.5	<0.5				15.7	102.0			
S-7	Exchange Street															
W23	Civic Center Drain							7.0					366.0			

Figure 4-28

Total Suspended Sediment Concentration - Station W2 (Route 44)

(Kerr and Lee, 1996)

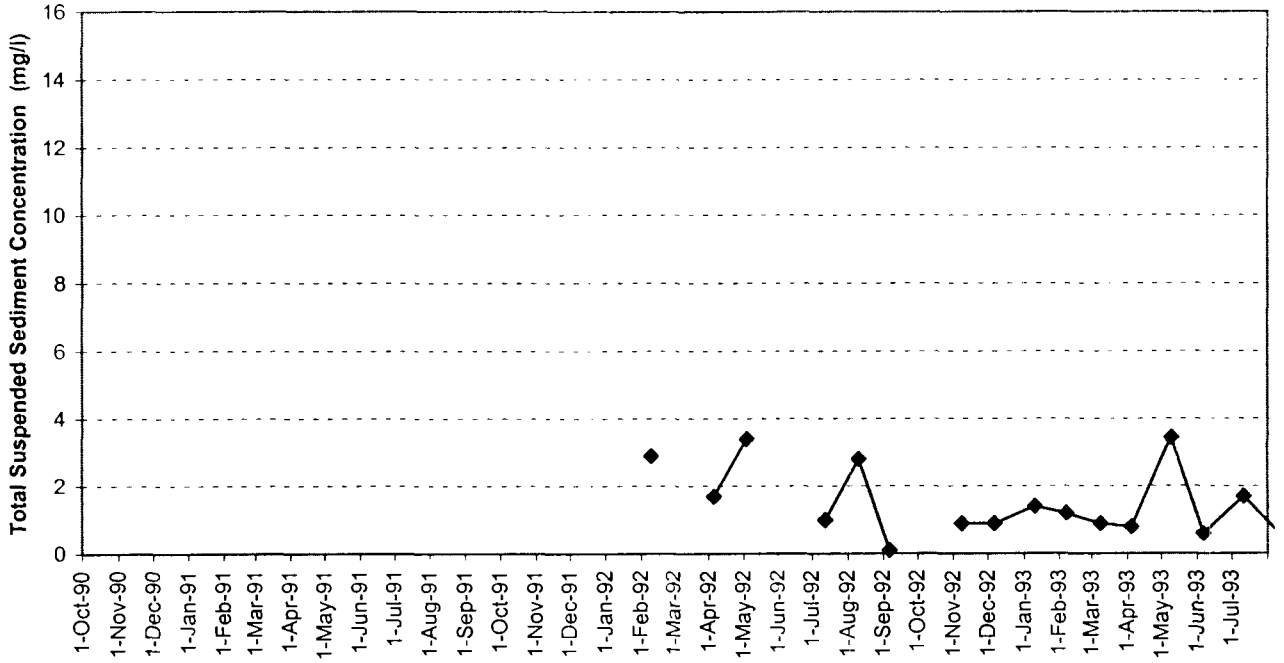

Figure 4-29

Total Suspended Sediment Concentration -Station W1 (Valley Street)

(Kerr and Lee, 1996)

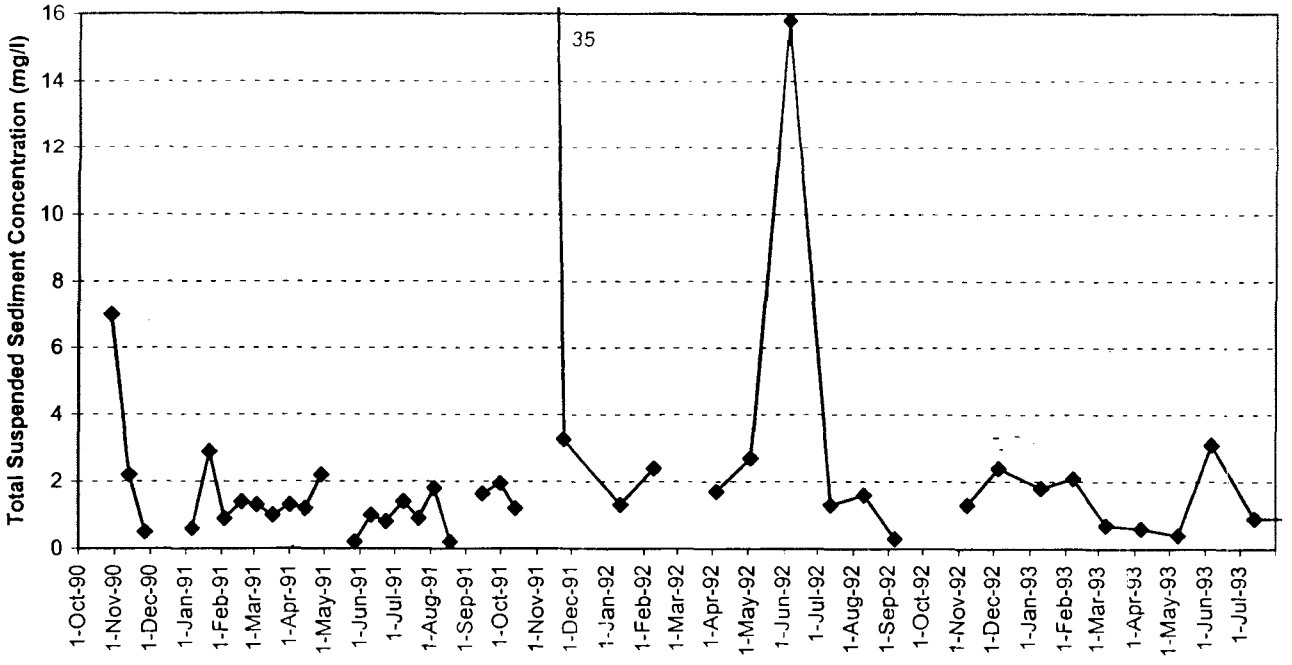

Figure 4-30

Fecal Coliform Concentrations - Dry Weather Data

Station No.	Location	Fecal Coliform (MPN/100 ml) Mean	Minimum	Maximum
WR-1	Stillwater Reservoir Dam	**2**	1	20
WR-2	Capron Road	**41**	11	500
WR-3	Sri Chimroy Peace Bridge	**449**	120	7,500
WR-3a	Esmond Mill Drive	**501**	73	1,000
EMD	Esmond Mill Drive			
WR-4	Smithfield WWTF Effluent	**9**	1	40
WWTF	Smithfield WWTF Effluent	**27**	2	914
GP	Greystone Pond			
WR-5	Greystone Street	**140**	65	403
WR-6	Route 44, Centerdale	**393**	210	670
W2	Route 44, Centerdale			
WR-7	Allendale Avenue	**597**	110	4,200
WR-7a	Assapumpset Brook	**1,423**	1,200	2,000
LP	Lymansville Pond			
WR-7b	Lymansville Dam	**206**	28	3,200
R1	Manton Dam	**211**	23	1,100
WR-8	Manton Avenue	**183**	34	1,260
R2	Manton Avenue	**1,655**	93	11,000
WOONUP	Manton Avenue	**243**	100	620
S-9	Manton Avenue	**112**	3	15,000
WR-9aa	Lincoln Lace & Braid			
WR-9ab	Lincoln Lace & Braid			
WR-9ac	Lincoln Lace & Braid			
WR-9	Dyerville Complex	**229**	79	1,650
W6	Killingly Interch. Outfall			
WR-10	Merino Park	**491**	150	1,700
WR-10a	Riverside Mills			
WR-11	Olneyville Square	**610**	350	2,200
S-8a	Olneyville Square	**307**	23	93,000
WR-12	Delanie Street	**661**	350	1,000
WR-13	Valley Street	**675**	320	3,000
R3	Valley Street	**4,893**	460	24,000
WOON	Valley Street	**465**	6	7,900
WOONDN	Valley Street	**182**	140	260
S-8b	Valley Street	**930**	43	93,000
W1	Valley Street			
WR-14	Atwells Avenue	**705**	130	3,500
R4	Atwells Avenue	**1,852**	210	24,000
S-8	Atwells Avenue	**882**	23	2,300,000
WR-15	Bath Street	**2,361**	485	110,000
W23	Civic Center Outfall			
WR-16	Exchange Street	**1,584**	240	95,000
S-7	Exchange Street	**1,469**	23	110,000

Regulatory Standard for Fecal Coliform:

Not to exceed a geometric mean of 200 MPN/100 ml.

Not more than 20% of the samples shall exceed a value of 500 MPN/100 ml.

Figure 4-31

Fecal Coliform Concentration - Wet Weather Data

Fecal Coliform (MPN/100 ml)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam	**211**	**1,990**				23	150				1,100	46,000			
S-9	Manton Avenue	**112**	**363**				3	23				15,000	15,000			
R2	Manton Avenue	**1,650**	**26,200**				93	4,600				11,000	460,000			
WOONUP	Manton Avenue	**243**	**1,130**	**658**	**344**		100	160	140	160		620	5,700	2,700	1,000	
S-8a	Olneyville Square	**307**	**1,480**				23	93				93,000	46,000			
W6	Killingly Interch. Outfall							5					25,000			
S-8b	Valley Street	**930**	**10,700**				43	1,500				93,000	93,000			
R3	Valley Street	**4,890**	**28,700**				460	150				24,000	460,000			
WOON	Valley Street	**465**	**3,200**	**2,060**	**730**	**800**	6	127	430	50	120	7,900	130,000	25,000	4,400	3,800
WOONDN	Valley Street	**182**	**5,880**	**1,170**	**527**		140	370	440	270		260	200,000	6,000	2,500	
S-8	Atwells Avenue	**882**	**5,200**				23	23				2,300,000	110,000			
R4	Atwells Avenue	**1,850**	**47,600**				210	93				24,000	2,400,000			
S-7	Exchange Street	**1,470**	**8,100**				23	93				110,000	2,300,000			
W23	Civic Center Outfall							10					73,000			

Regulatory Standard: Not to exceed a geometric mean of 200 MPN/10 ml.
Not more than 20% of the samples shall exceed a value of 500 MPN/100 ml.

Figure 4-32

Fecal Coliform Concentration (NBC, 1998)

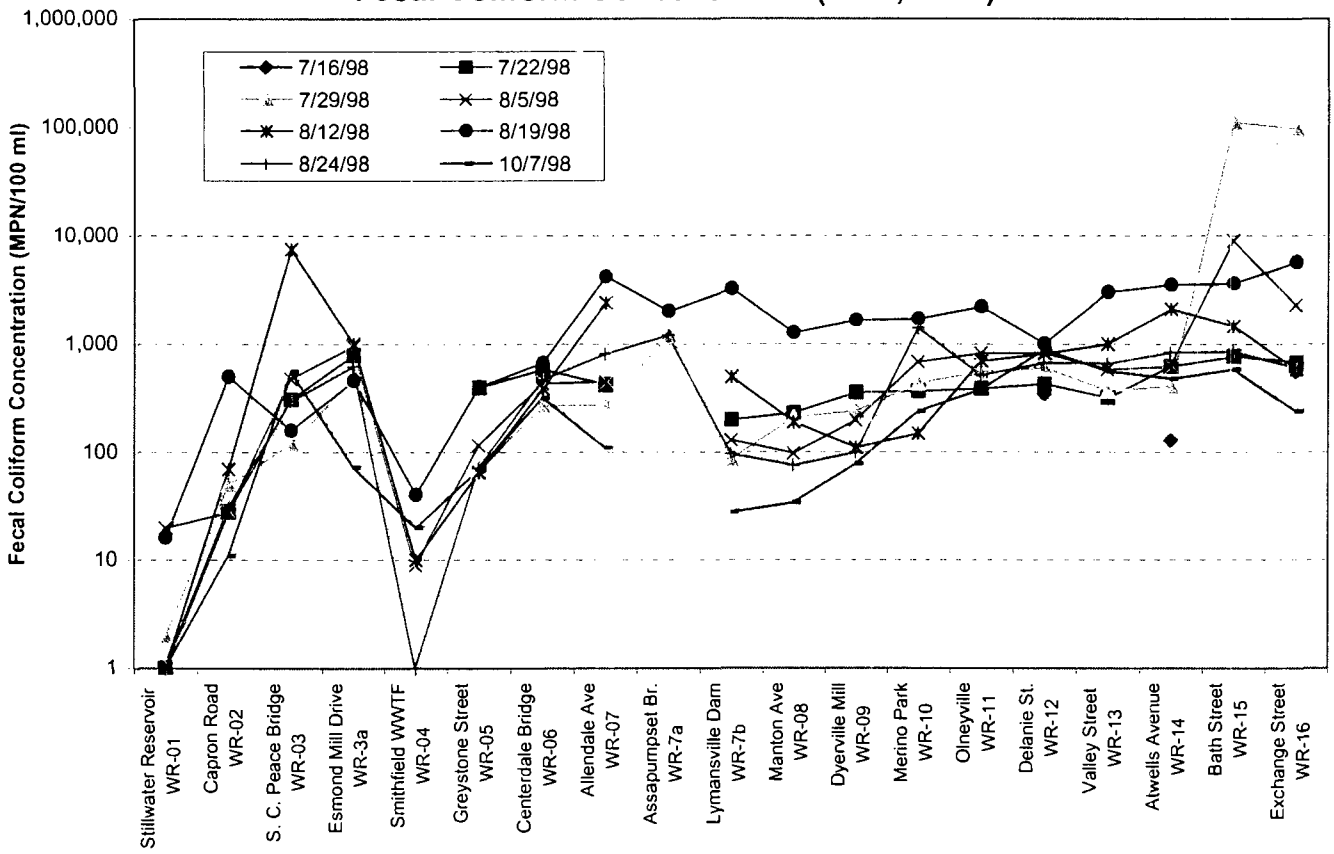

Figure 4-33

Fecal Coliform - Statistics (NBC, 1998)

(without August 19, 1998 Event [wet weather])

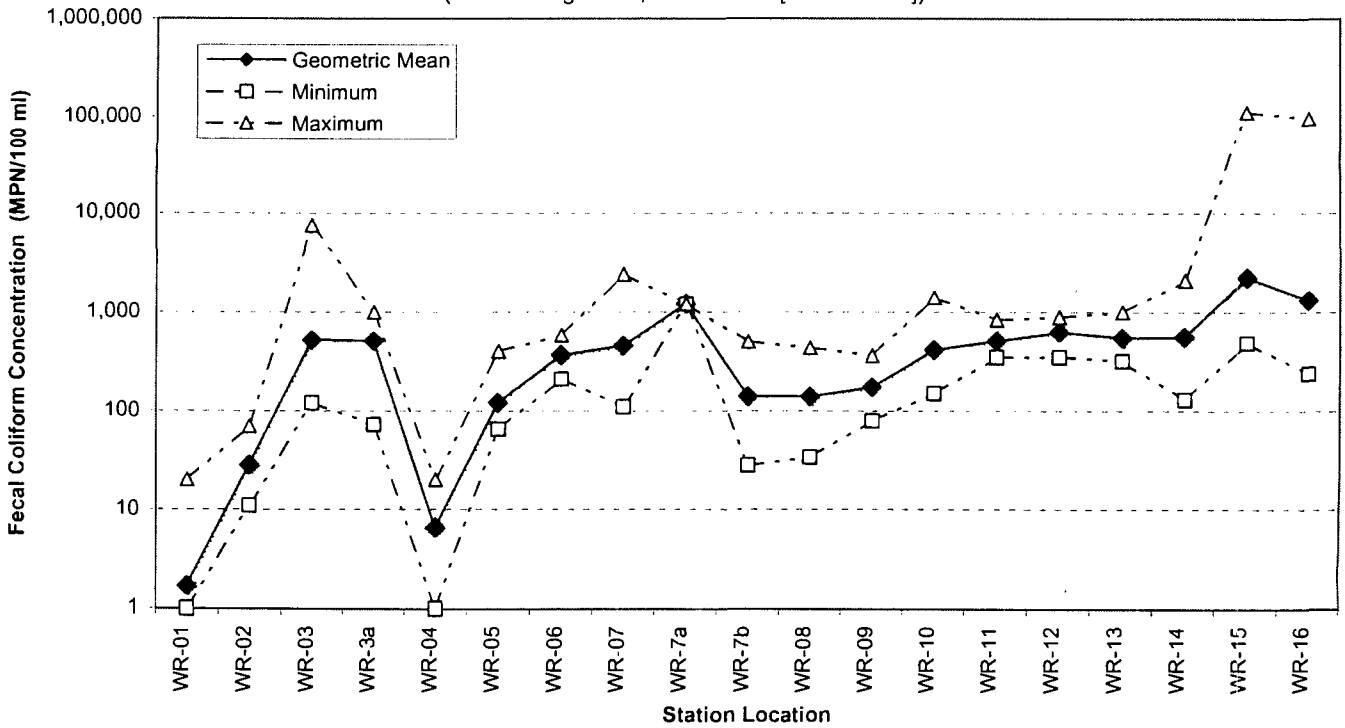

Figure 4-34

Fecal Coliform Concentration - Station S-9: Manton Avenue

(NBC, 1997-1999)

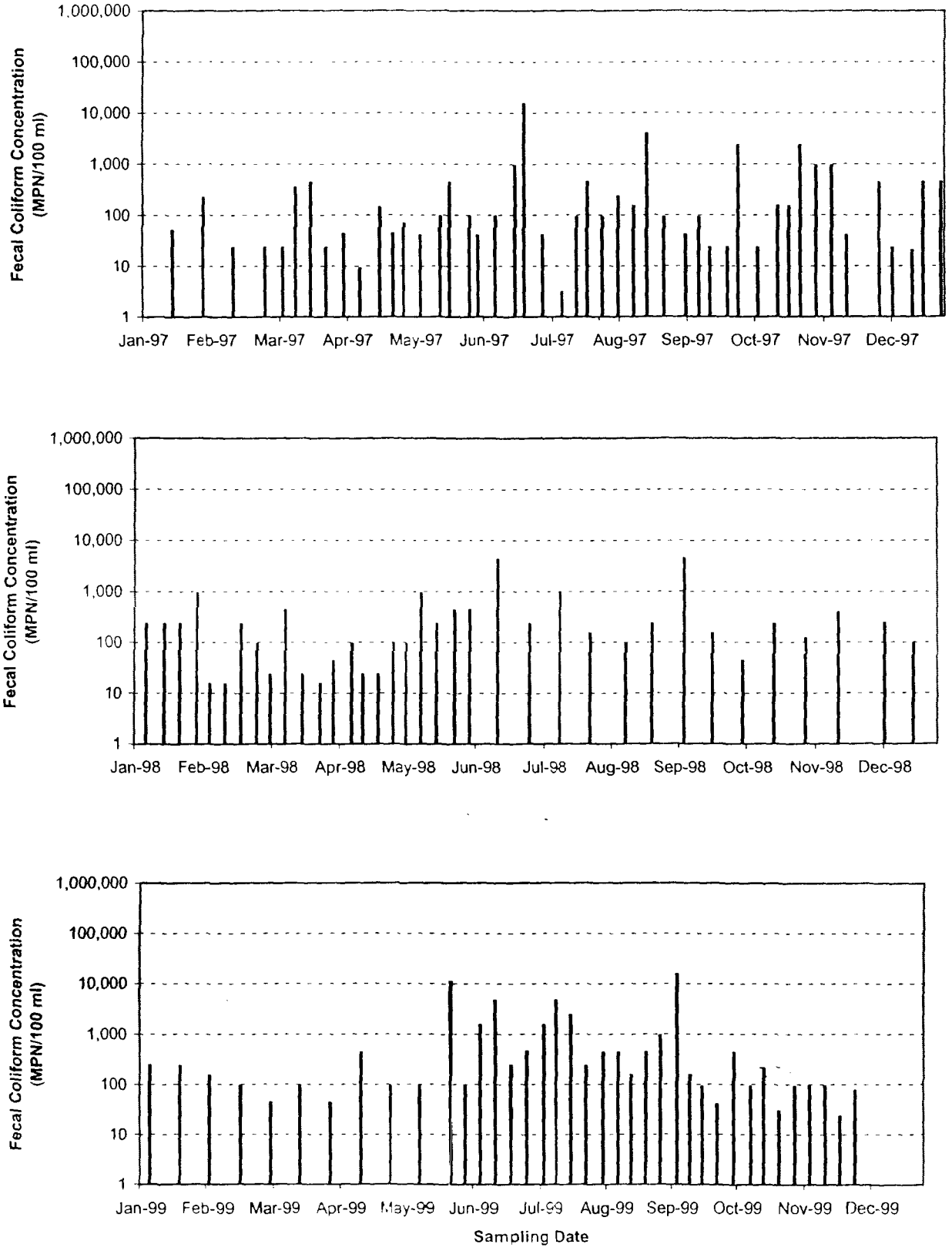

Figure 4-35

Fecal Coliform Concentration - Station S-8: Atwells Avenue

(NBC, 1997-1999)

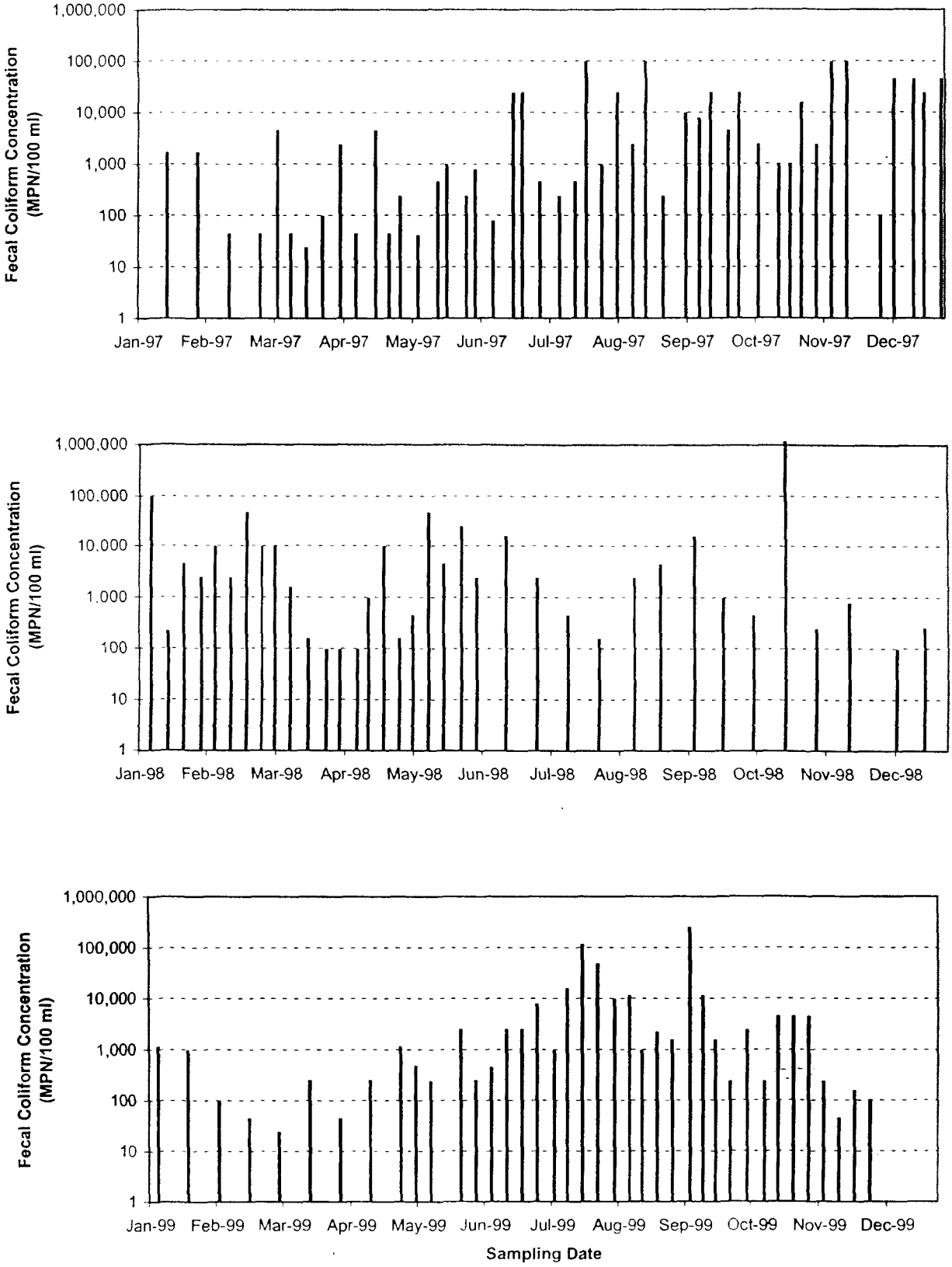

Figure 4-36

Fecal Coliform Concentration - Station S-7: Exchange Street

(NBC, 1997-1999)

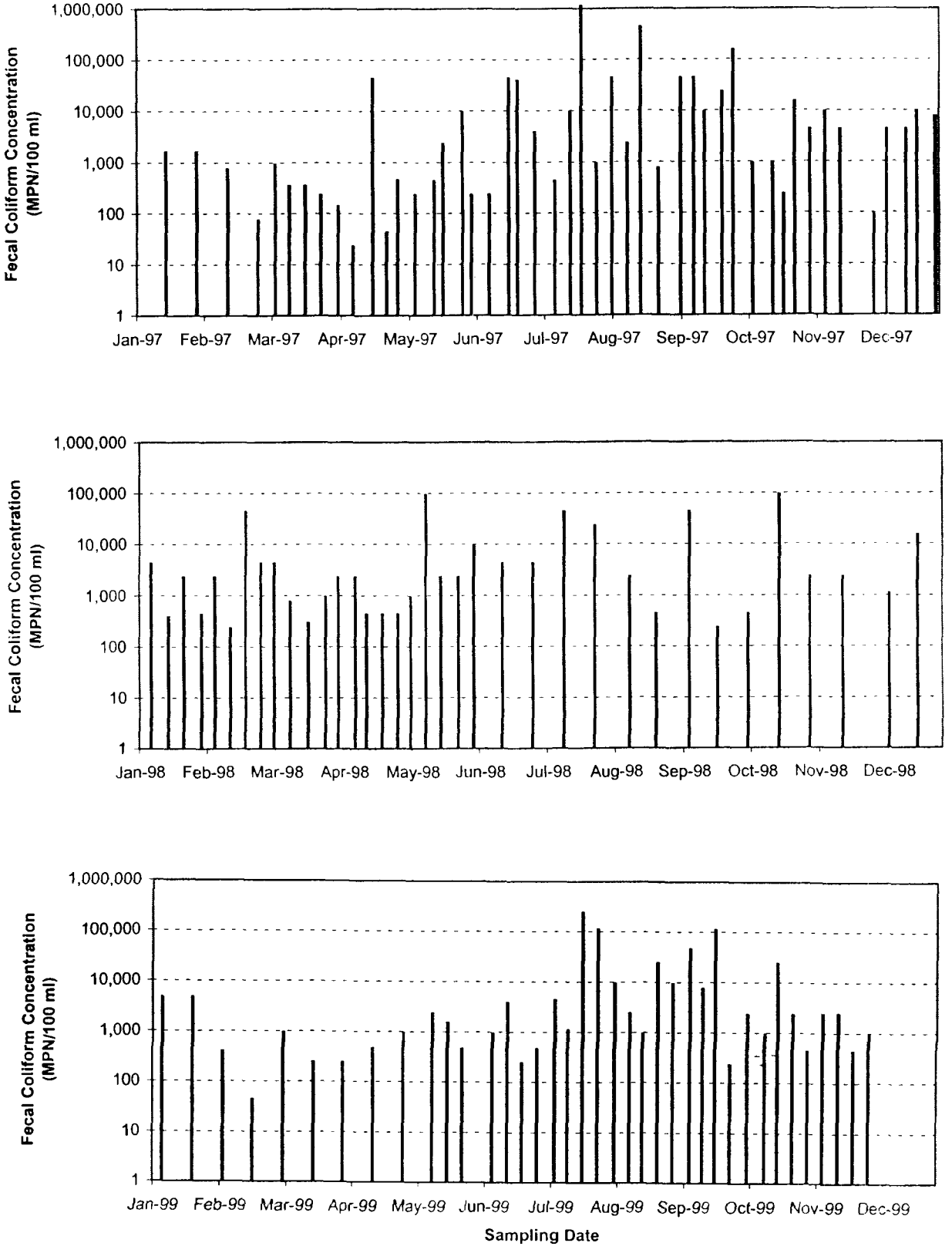

Figure 4-37

Woonasquatucket River Discharge Rate

USGS Centerdale Station 1997 to 1999)

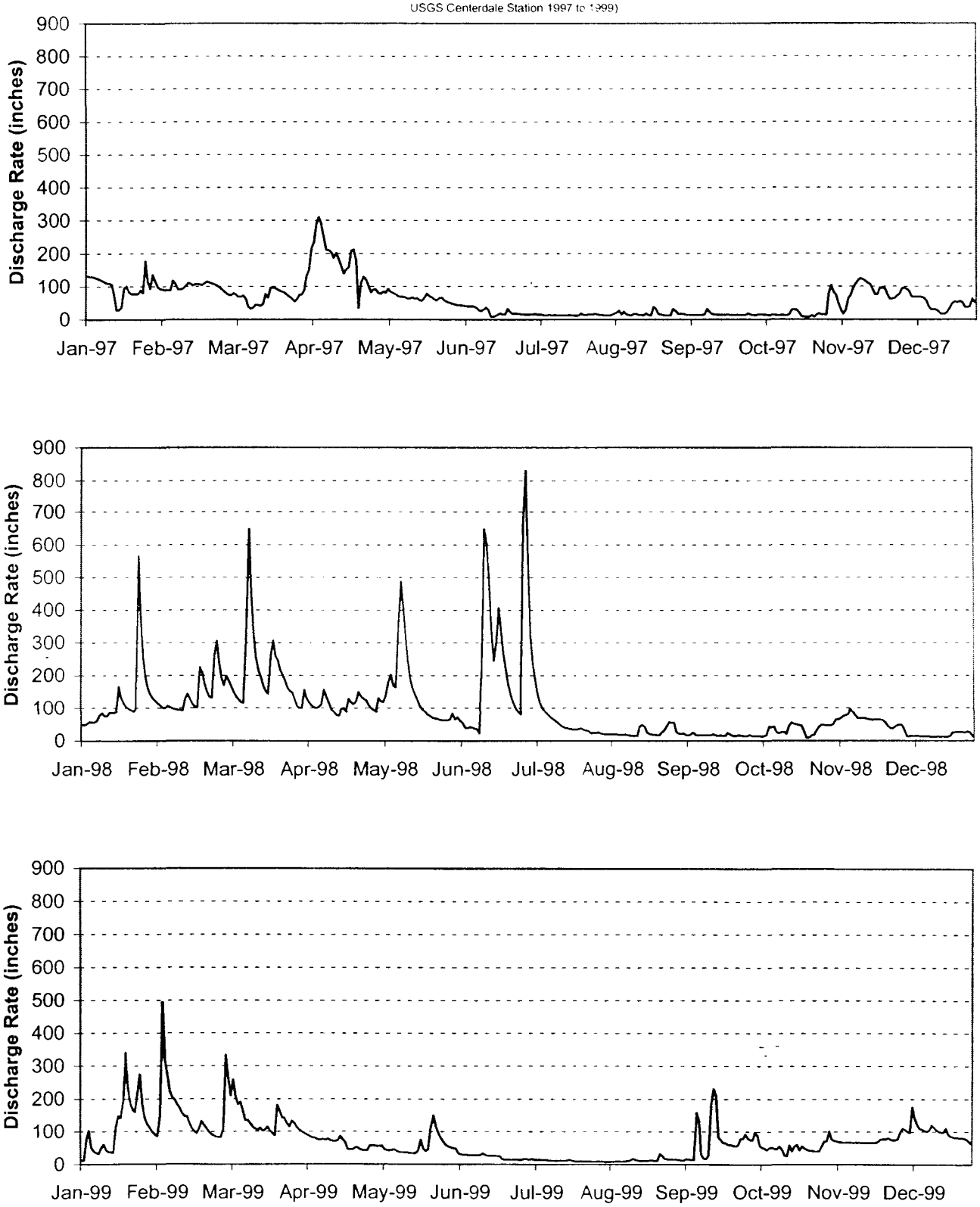

Figure 4-38

Dissolved Oxygen Concentrations - Dry Weather Data

Station No.	Location	Dissolved Oxygen (mg/l) Mean	Minimum	Maximum
WR-1	Stillwater Reservoir Dam	**7.2**	5.4	8.4
WR-2	Capron Road	**7.6**	6.0	9.4
WR-3	Sri Chimroy Peace Bridge	**7.7**	6.6	9.1
WR-3a	Esmond Mill Drive	**7.7**	6.2	8.4
EMD	Esmond Mill Drive	**7.5**	5.5	9.9
WR-4	Smithfield WWTF Effluent	**5.7**	5.1	6.2
WWTF	Smithfield WWTF Effluent			
GP	Greystone Pond	**2.7**	0.1	9.8
WR-5	Greystone Street	**6.6**	5.5	8.0
WR-6	Route 44, Centerdale	**6.1**	4.5	7.8
W2	Route 44, Centerdale	**9.4**	4.6	13.2
WR-7	Allendale Avenue	**7.8**	6.9	9.4
WR-7a	Assapumpset Brook	**8.3**	8.0	8.6
LP	Lymansville Pond	**7.4**	2.9	11.0
WR-7b	Lymansville Dam	**6.3**	5.1	8.3
R1	Manton Dam			
WR-8	Manton Avenue	**7.8**	6.2	9.9
R2	Manton Avenue	**7.7**	7.3	8.0
WOONUP	Manton Avenue	**8.0**	6.6	9.0
S-9	Manton Avenue			
WR-9aa	Lincoln Lace & Braid			
WR-9ab	Lincoln Lace & Braid			
WR-9ac	Lincoln Lace & Braid			
WR-9	Dyerville Complex	**8.2**	7.2	9.5
W6	Killingly Interchange Stormdrain			
WR-10	Merino Park	**7.6**	5.8	9.0
WR-10a	Riverside Mills	**8.7**	8.7	8.7
WR-11	Olneyville Square	**8.6**	7.9	10.6
S-8a	Olneyville Square			
WR-12	Delanie Street	**8.6**	7.0	10.3
WR-13	Valley Street	**8.3**	7.4	10.2
R3	Valley Street	**8.3**	5.4	11.2
WOON	Valley Street			
WOONDN	Valley Street	**8.8**	7.7	10.0
S-8b	Valley Street			
W1	Valley Street	**10.3**	5.2	15.1
WR-14	Atwells Avenue	**8.0**	6.5	9.8
R4	Atwells Avenue	**9.5**	5.5	11.9
S-8	Atwells Avenue			
WR-15	Bath Street	**7.6**	5.2	8.8
W23	Civic Center Stormdrain			
WR-16	Exchange Street	**5.8**	3.0	7.9
S-7	Exchange Street			

Regulatory Standard: Instantaneous minimum dissolved oxygen concentration of at least 5 mg/l.

Figure 4-39

Dissolved Oxygen Concentration - Wet Weather Data

Dissolved Oxygen (mg/l)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam		**7.7**					7.2					8.2			
S-9	Manton Avenue															
R2	Manton Avenue	**7.7**	**7.7**				7.3	6.5				8.0	9.0			
WOONUP	Manton Avenue	**8.0**	**8.3**	**8.4**	**8.5**		6.6	6.7	7.1	7.5	7.1	9.0	9.0	9.2	9.4	
S-8a	Olneyville Square															
W6	Killingly Interch. Drain															
S-8b	Valley Street															
R3	Valley Street	**8.3**	**8.7**				5.4	5.3				11.2	12.2			
WOON	Valley Street															
WOONDN	Valley Street	**8.8**	**9.1**	**9.0**	**9.2**		7.7	7.8	7.9	8.5	8.0	10.0	9.8	9.8	10.0	
S-8	Atwells Avenue															
R4	Atwells Avenue	**9.5**	**9.9**				5.5	5.0				11.9	13.0			
S-7	Exchange Street															
W23	Civic Center Drain															

Regulatory Standard: Instantaneous minimum dissolved oxygen concentration of at least 5 mg/l.

Figure 4-40

BOD5 Concentration - Wet Weather Data

BOD5 (mg/l)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam	**<2.0**	**<3.1**				<2.0	<2.0				<2.0	9.0			
S-9	Manton Avenue															
R2	Manton Avenue	**<2.0**	**5.3**				<2.0	<2.0				<2.0	15.0			
WOONUP	Manton Avenue	**<2.0**	**<1.0**	**<1.0**			<1.0	<1.0	<1.0			3.0	5.0	3.0		
S-8a	Olneyville Square															
W6	Killingly Interch. Drain							4.5					20.0			
S-8b	Valley Street															
R3	Valley Street	**<2.0**	**5.5**				<2.0	<2.0				<2.0	14.0			
WOON	Valley Street	**<2.0**	**5.3**	**<2.0**	**<2.0**	**<2.0**	<2.0	2.0	<2.0			<2.0	9.0	<2.0		
WOONDN	Valley Street	**4.0**	**<2.0**	**<1.0**			<2.0	<1.0	<1.0			<1.0	7.0	4.0		
S-8	Atwells Avenue															
R4	Atwells Avenue	**<2.0**	**13.7**				<2.0	<2.0				<2.0	63.0			
S-7	Exchange Street															
W23	Civic Center Drain							1.8					15.8			

Figure 40a

Dissolved Oxygen Concentration (NBC, 1998)

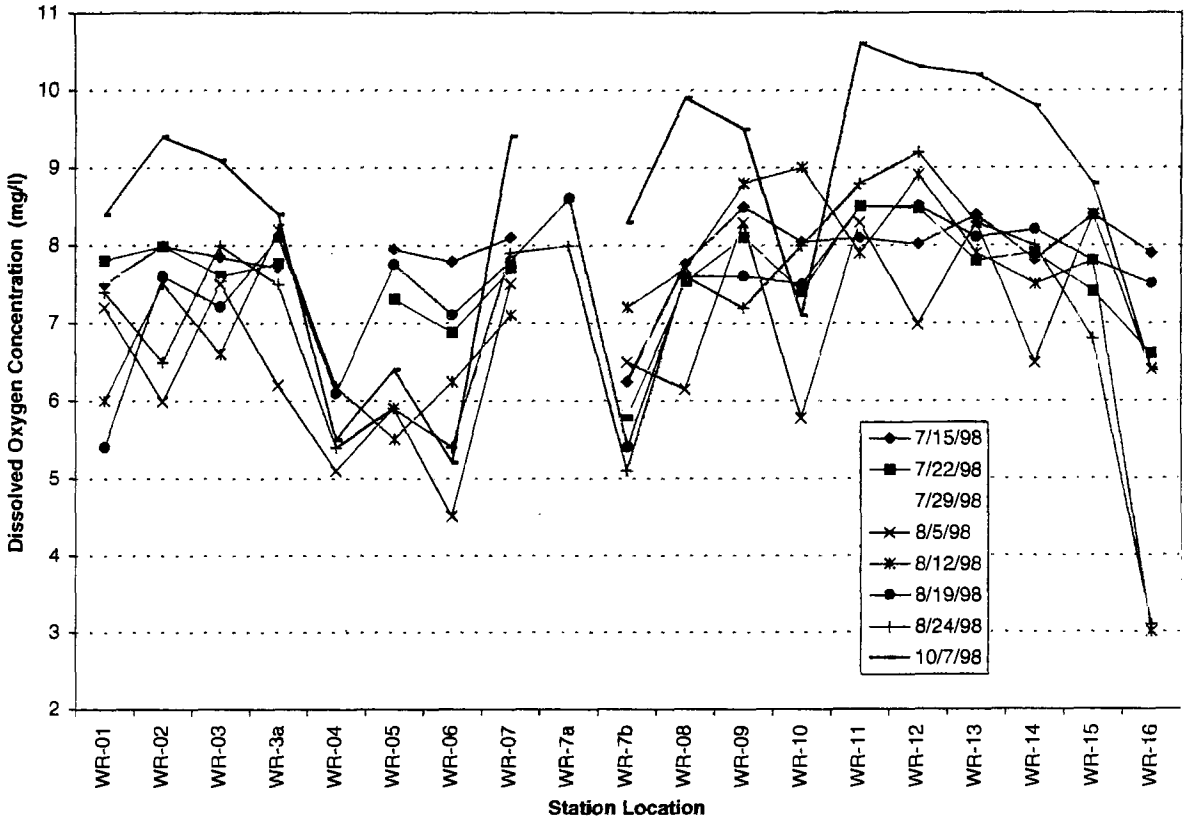

Figure 40b

Dissolved Oxygen - Statistics (NBC, 1998)

(Data from July 15 to August 24 only)

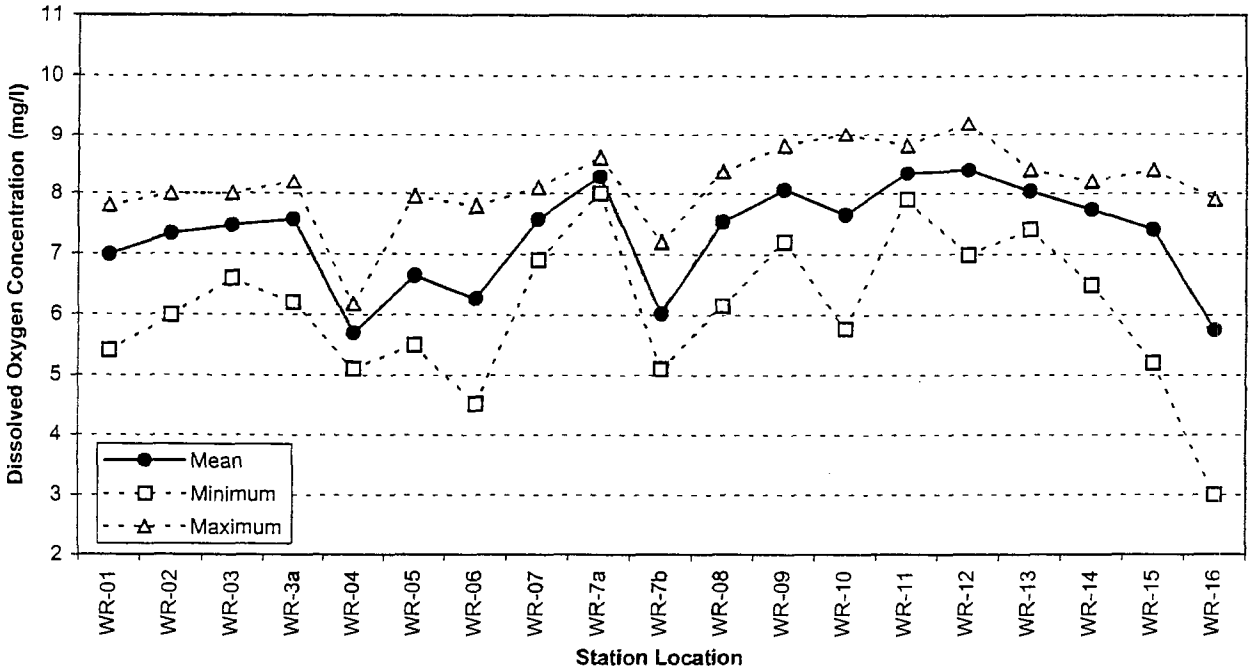

Figure 4-41

Dissolved Oxygen Concentration - Station W2 (Route 44)

(Kerr and Lee, 1996)

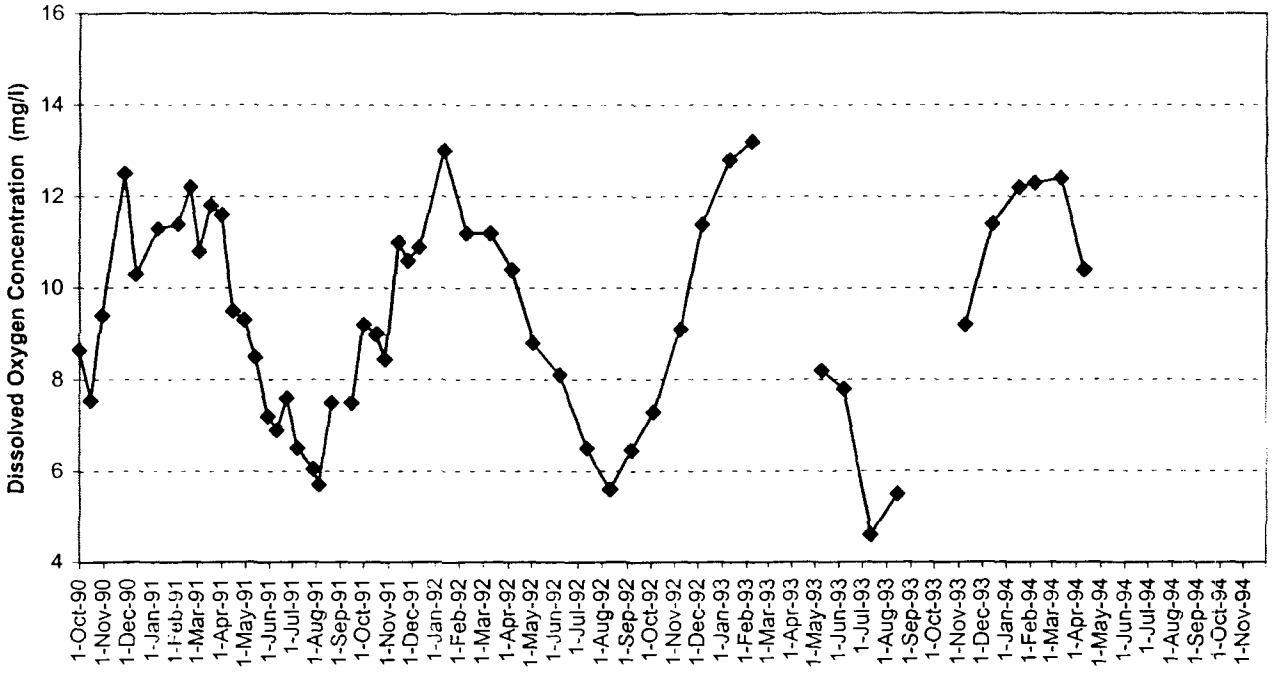

Figure 4-42

Dissolved Oxygen Concentration -Station W1 (Valley Street)

(Kerr and Lee, 1996)

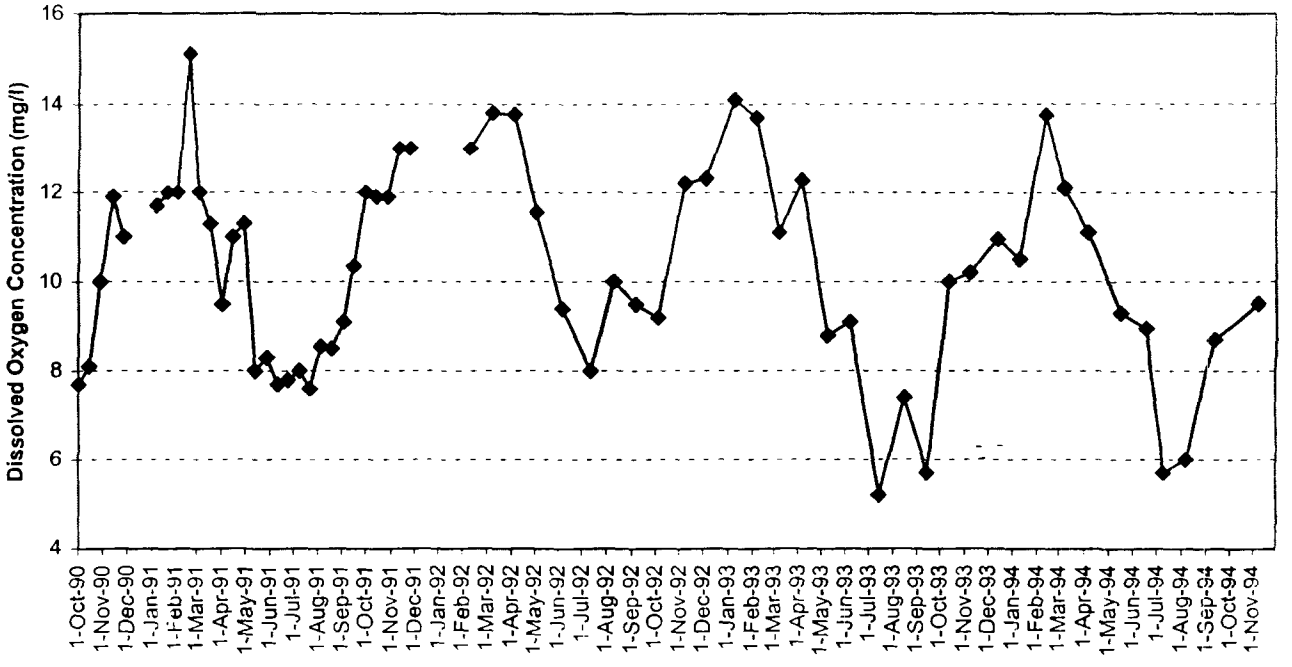

Figure 4-43

Ammonia and Nitrate/Nitrite Concentrations - Dry Weather Data

Station No.	Location	Ammonia (mg/l N)			Nitrate+Nitrite (mg/l N)		
		Mean	Minimum	Maximum	Mean	Minimum	Maximum
WR-1	Stillwater Reservoir Dam	**<0.21**	<0.10	0.40	**<0.04**	<0.02	0.04
WR-2	Capron Road	**<0.26**	<0.10	0.50	**0.15**	0.06	0.67
WR-3	Sri Chimroy Peace Bridge	**0.17**	0.10	0.30	**0.12**	0.06	0.36
WR-3a	Esmond Mill Drive	**0.16**	0.10	0.20	**0.17**	0.10	0.52
EMD	Esmond Mill Drive						
WR-4	Smithfield WWTF Effluent	**12.00**	6.20	18.75	**0.49**	0.16	0.79
WWTF	Smithfield WWTF Effluent	**13.36**	2.30	30.00	**2.05**	<0.02	20.90
GP	Greystone Pond						
WR-5	Greystone Street	**0.89**	0.20	1.68	**0.56**	0.17	1.04
WR-6	Route 44, Centerdale	**0.62**	0.20	1.10	**0.75**	0.30	1.66
W2	Route 44, Centerdale	**0.26**	0.01	1.19	**0.56**	0.00	4.46
WR-7	Allendale Avenue	**<0.84**	<0.10	3.63	**0.81**	0.30	1.74
WR-7a	Assapumpset Brook	**<0.14**	<0.10	0.20	**0.38**	0.21	0.70
LP	Lymansville Pond						
WR-7b	Lymansville Dam	**0.28**	0.10	0.50	**0.68**	0.26	1.43
R1	Manton Dam	**0.41**	0.17	0.51	**0.33**	0.16	0.57
WR-8	Manton Avenue	**0.23**	0.10	0.40	**1.35**	0.40	5.60
R2	Manton Avenue	**0.46**	0.23	0.70	**0.36**	0.19	0.58
WOONUP	Manton Avenue				**0.41**	0.18	0.55
S-9	Manton Avenue						
WR-9aa	Lincoln Lace & Braid						
WR-9ab	Lincoln Lace & Braid						
WR-9ac	Lincoln Lace & Braid						
WR-9	Dyerville Complex	**<0.21**	<0.10	0.40	**2.11**	0.40	6.90
W6	Killingly Interchange Outfall						
WR-10	Merino Park	**<0.18**	<0.10	0.40	**1.33**	0.50	5.30
WR-10a	Riverside Mills						
WR-11	Olneyville Square	**<0.19**	<0.10	0.30	**0.71**	0.30	1.40
S-8a	Olneyville Square						
WR-12	Delanie Street	**<0.18**	<0.10	0.30	**0.74**	0.50	1.40
WR-13	Valley Street	**<0.20**	<0.10	0.40	**0.75**	0.50	1.40
R3	Valley Street	**0.46**	0.22	0.63	**0.38**	0.19	0.60
WOON	Valley Street	**0.12**	0.01	0.24	**0.80**	0.50	1.31
WOONDN	Valley Street				**0.60**	0.36	0.95
S-8b	Valley Street						
W1	Valley Street	**0.22**	0.00	0.95	**0.57**	0.00	1.87
WR-14	Atwells Avenue	**<0.16**	<0.10	0.40	**0.76**	0.50	1.40
R4	Atwells Avenue	**0.30**	0.18	0.40	**0.42**	0.21	0.62
S-8	Atwells Avenue						
WR-15	Bath Street	**<0.16**	<0.10	0.30	**0.65**	0.40	0.90
W23	Civic Center Outfall						
WR-16	Exchange Street	**<0.25**	<0.10	0.50	**0.59**	0.40	0.90
S-7	Exchange Street						

pH	Acute Criteria (mg/l as N)[1]	Chronic Criteria (mg/l as N)[2] Temperature (C)		
		10.0	15.0	20.0
6.5	48.8	8.9	6.5	4.7
7	36.1	7.9	5.7	4.2
7.5	19.9	5.8	4.2	3.1

[1]Ammonia criteria for acute and chronic is based upon criteria with early life stage absent.

[2]Chronic ammonia criteria is temperature and pH dependant.

Figure 4-44

Ammonia and Nitrate/Nitrite Concentrations - Wet Weather Data

Ammonia (mg/l N)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam	0.41	0.59				0.17	0.36				0.51	0.84			
S-9	Manton Avenue															
R2	Manton Avenue	0.46	0.70				0.23	0.47				0.70	1.00			
WOONUP	Manton Avenue															
S-8a	Olneyville Square															
W6	Killingly Interch. Drain															
S-8b	Valley Street															
R3	Valley Street	0.46	0.52				0.22	0.23				0.63	1.00			
WOON	Valley Street	0.12	0.08	0.08	0.06	0.12	0.01	0.01	0.01	0.01	0.01	0.24	0.20	0.16	0.17	0.26
WOONDN	Valley Street															
S-8	Atwells Avenue															
R4	Atwells Avenue	0.30	0.96				0.18	0.22				0.40	4.30			
S-7	Exchange Street															
W23	Civic Center Drain															

	Acute Criteria (mg/l as N)[1]	Chronic Criteria (mg/l as N)[2]		
		Temperature (C)		
pH		10.0	15.0	20.0
6.5	48.8	8.9	6.5	4.7
7	36.1	7.9	5.7	4.2
7.5	19.9	5.8	4.2	3.1

[1]Ammonia criteria for acute and chronic is based upon criteria with early life stage absent.

[2]Chronic ammonia criteria is temperature and pH dependant

Nitrate + Nitrite (mg/l N)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam	0.31	0.44				0.16	0.32				0.57	0.86			
S-9	Manton Avenue															
R2	Manton Avenue	0.36	0.44				0.19	0.29				0.58	0.61			
WOONUP	Manton Avenue	0.41	0.46	0.56	0.56	0.38	0.18	0.35	0.25	0.33	0.26	0.55	0.58	1.18	0.71	0.50
S-8a	Olneyville Square															
W6	Killingly Interch. Drain							0.01				- -	5.64			
S-8b	Valley Street															
R3	Valley Street	0.38	0.43				0.19	0.33				0.60	0.55			
WOON	Valley Street	0.80	0.79	0.65	0.73	0.95	0.50	0.30	0.33	0.28	0.34	1.31	1.86	1.17	1.37	1.61
WOONDN	Valley Street	0.60	0.58	0.59	0.54	0.58	0.36	0.41	0.31	0.34	0.47	0.95	0.74	0.94	0.64	0.68
S-8	Atwells Avenue															
R4	Atwells Avenue	0.42	0.47				0.21	0.28				0.62	1.26			
S-7	Exchange Street															
W23	Civic Center Drain							0.02					1.86			

Figure 4-45

Ammonia Concentration (NBC, 1998)

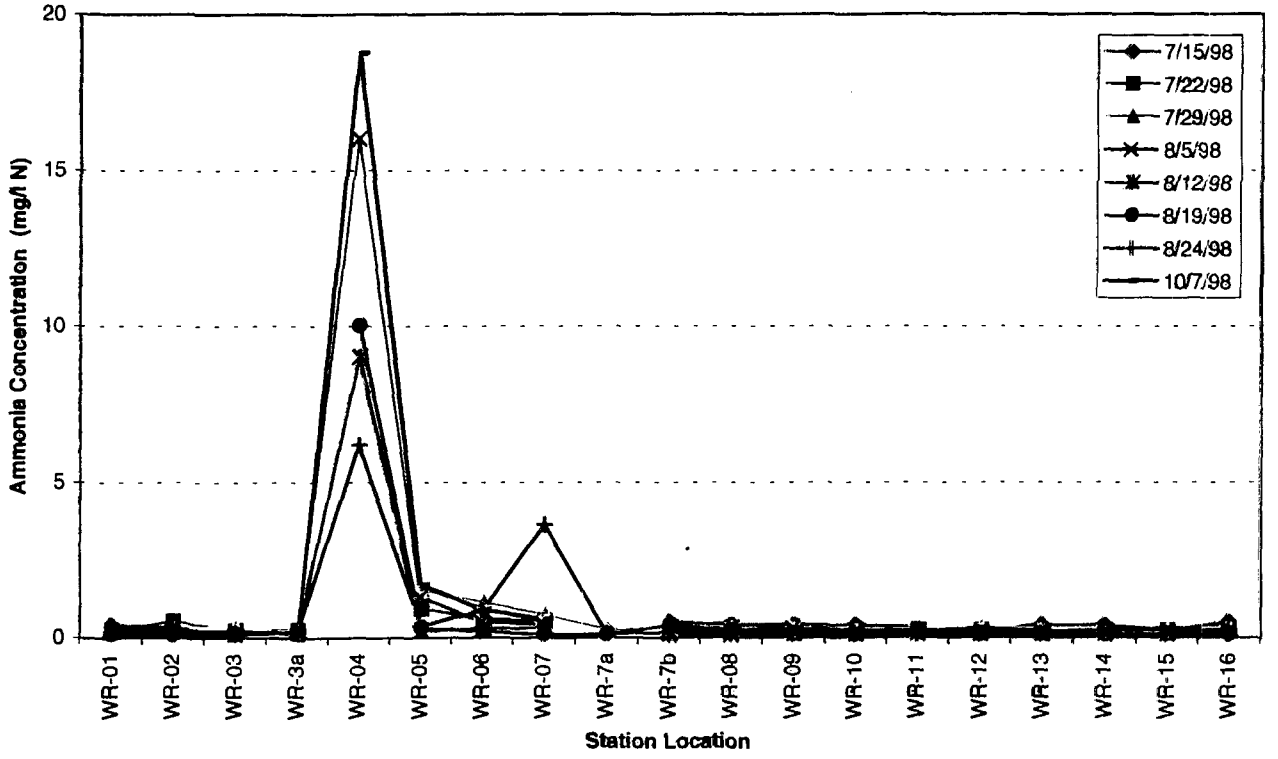

Figure 4-46

Ammonia Concentration (NBC, 1998) *(at higher resolution)*

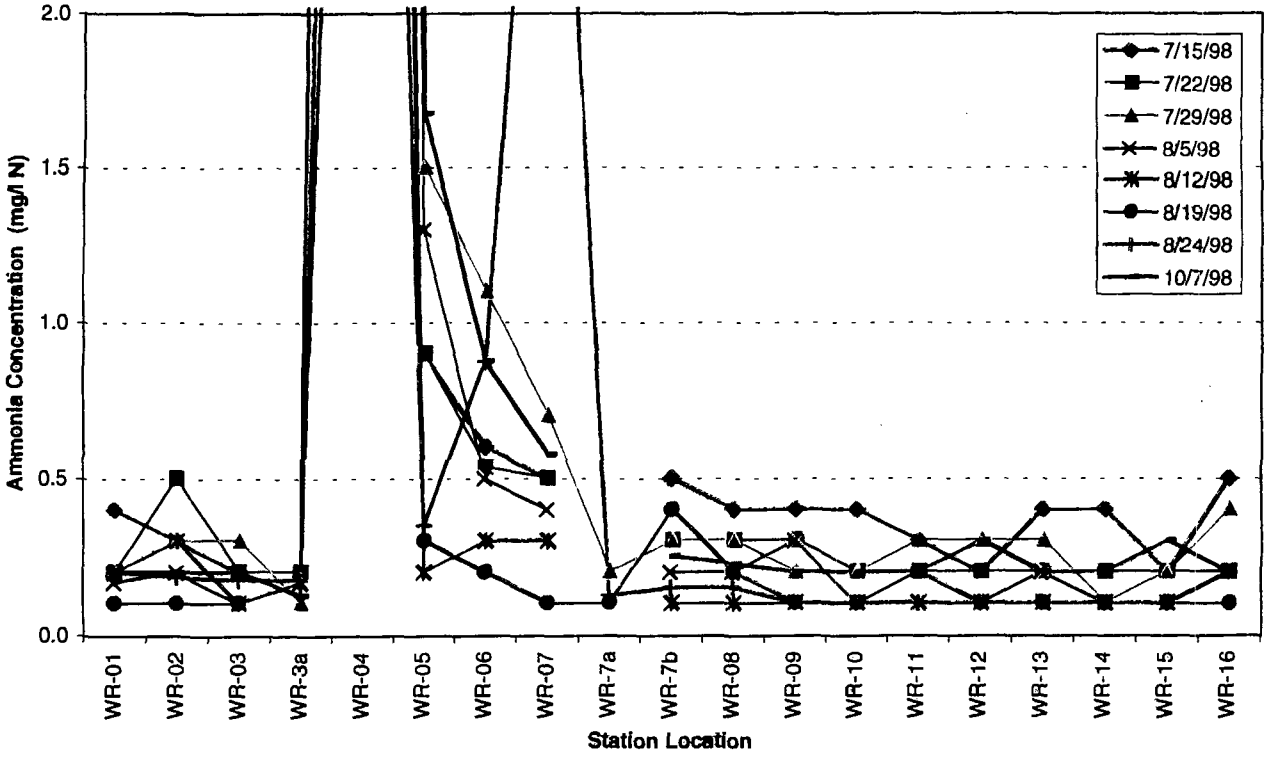

Figure 4-47

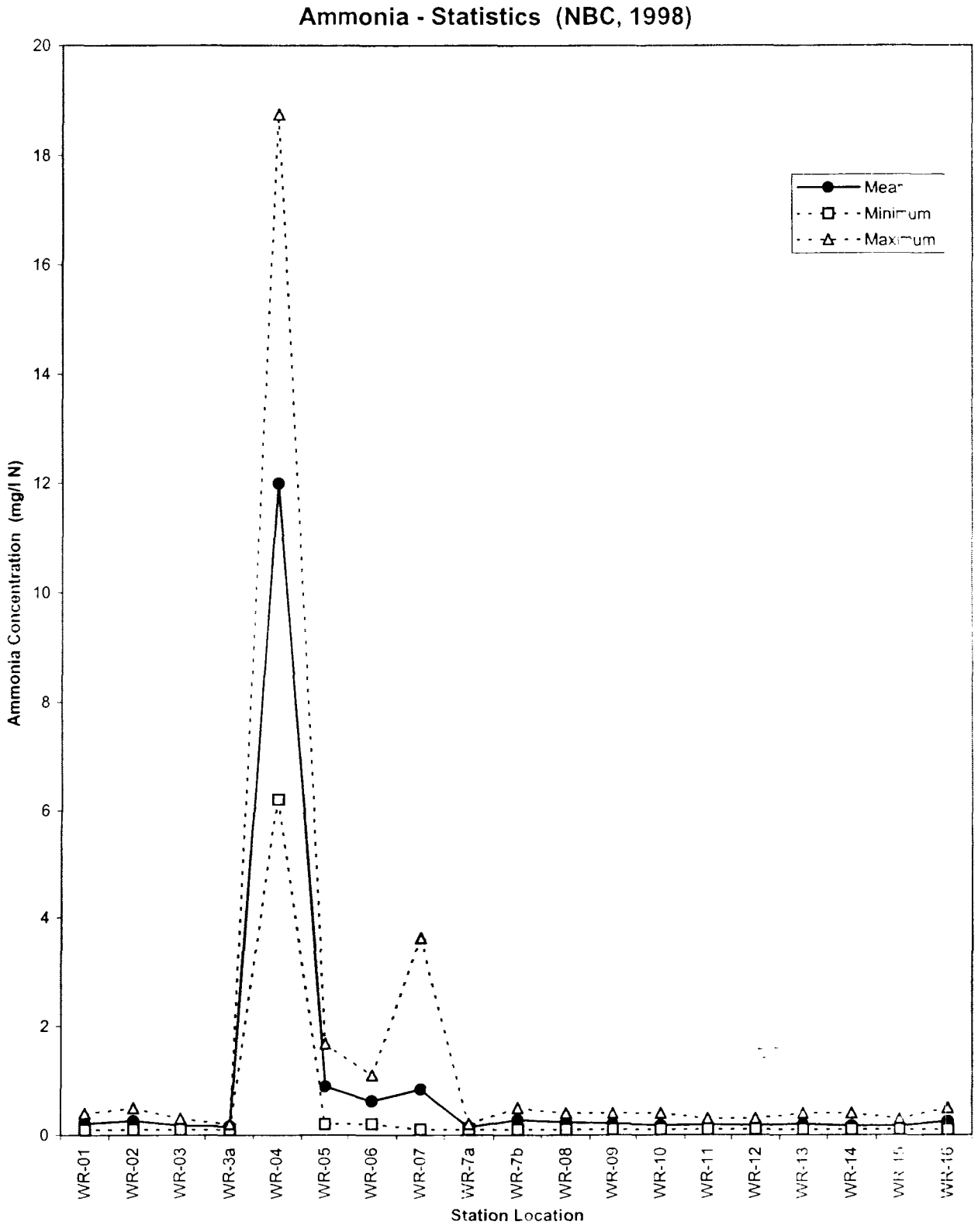
Ammonia - Statistics (NBC, 1998)
Ammonia Concentration (mg/l N)
20
18
16
14
12
10
8
6
4
2
0
Mean
Minimum
Maximum
WR-01
WR-02
WR-03
WR-3a
WR-04
WR-05
WR-06
WR-07
WR-7a
WR-7b
WR-08
WR-09
WR-10
WR-11
WR-12
WR-13
WR-14
WR-16
Station Location

Figure 4-48

Ammonia - Statistics (NBC, 1998)

(at higher resolution)

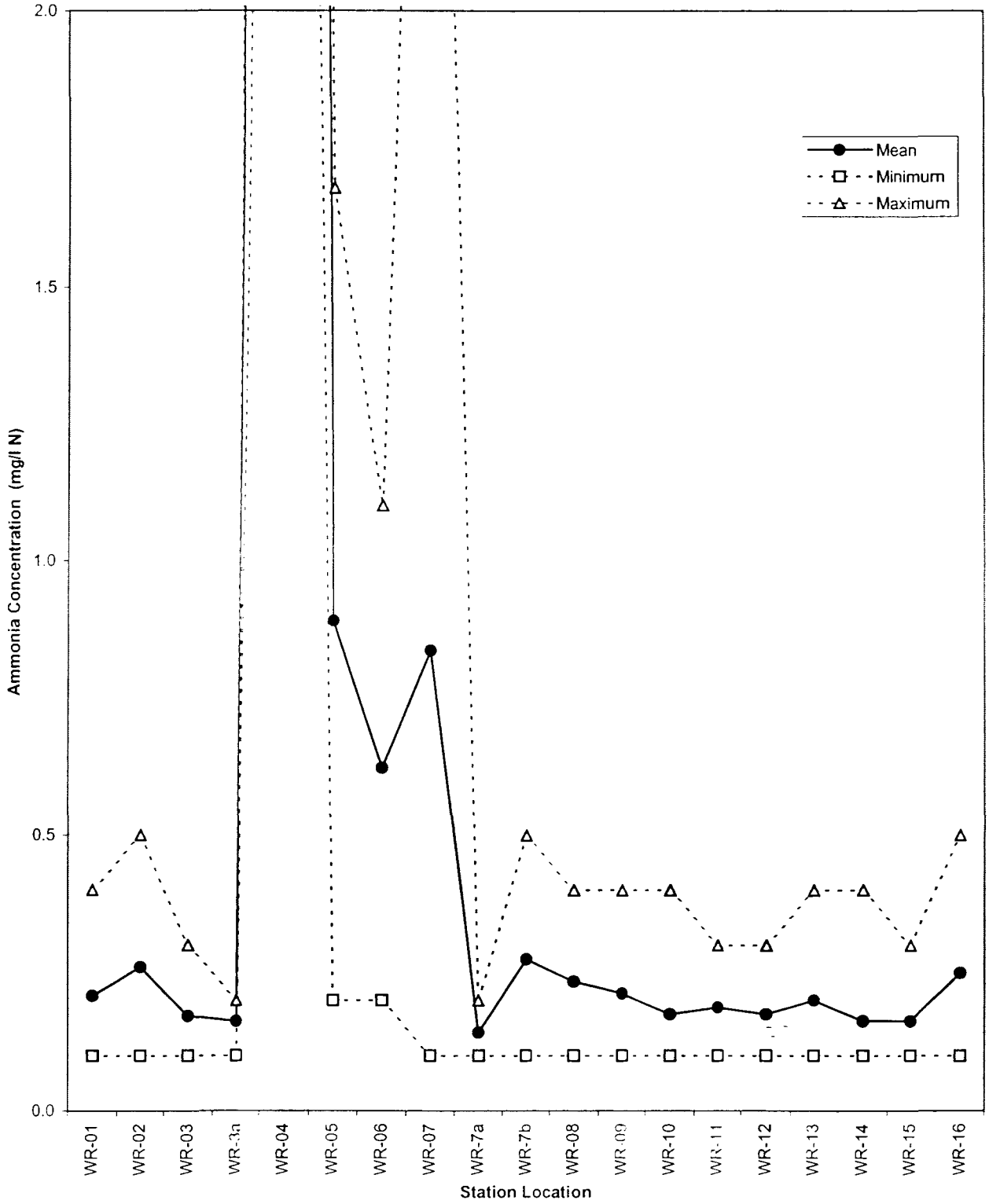

Figure 4-49

Dissolved Ammonia Concentration - Station W2 (Route 44)

(Kerr and Lee, 1996)

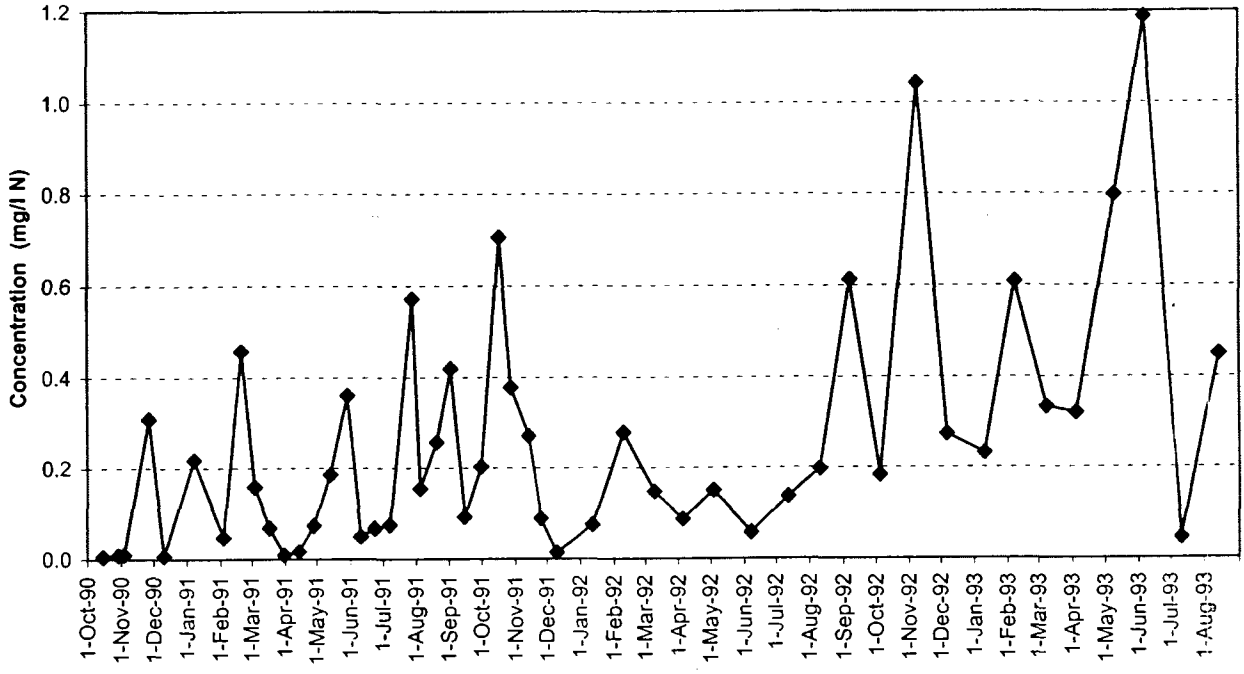

Figure 4-50

Dissolved Ammonia Concentration - Station W1 (Valley Street)

(Kerr and Lee, 1996)

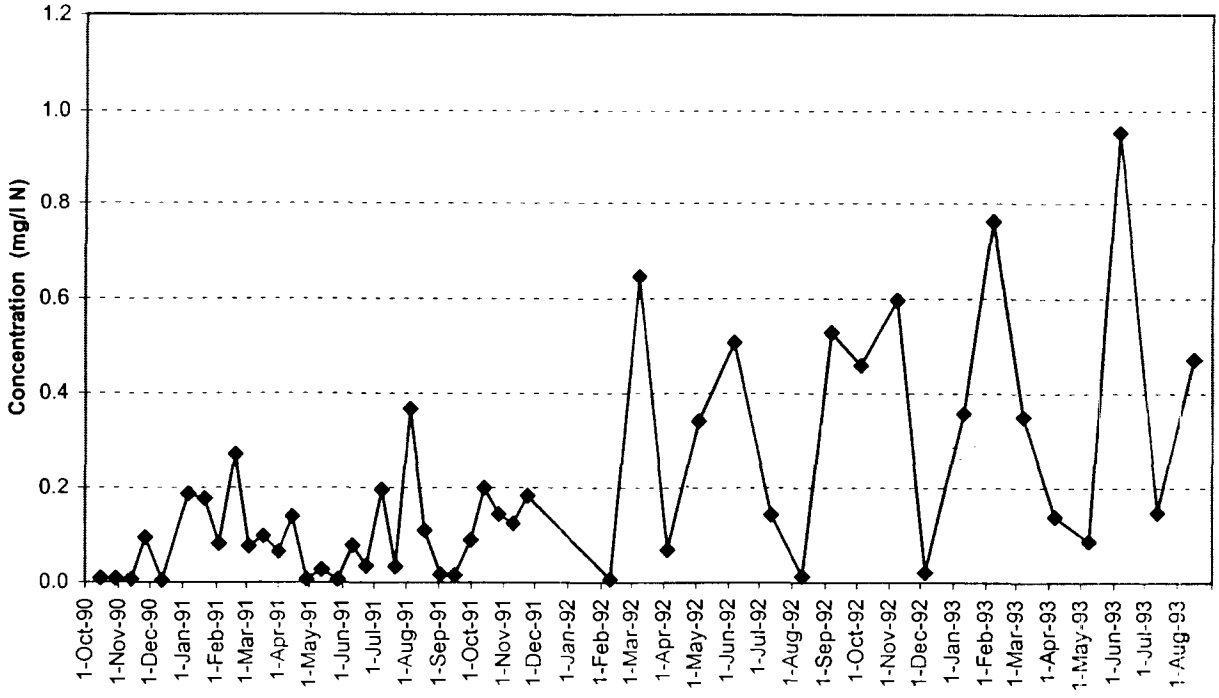

Figure 4-51

Nitrate + Nitrite Concentration (NBC, 1998)

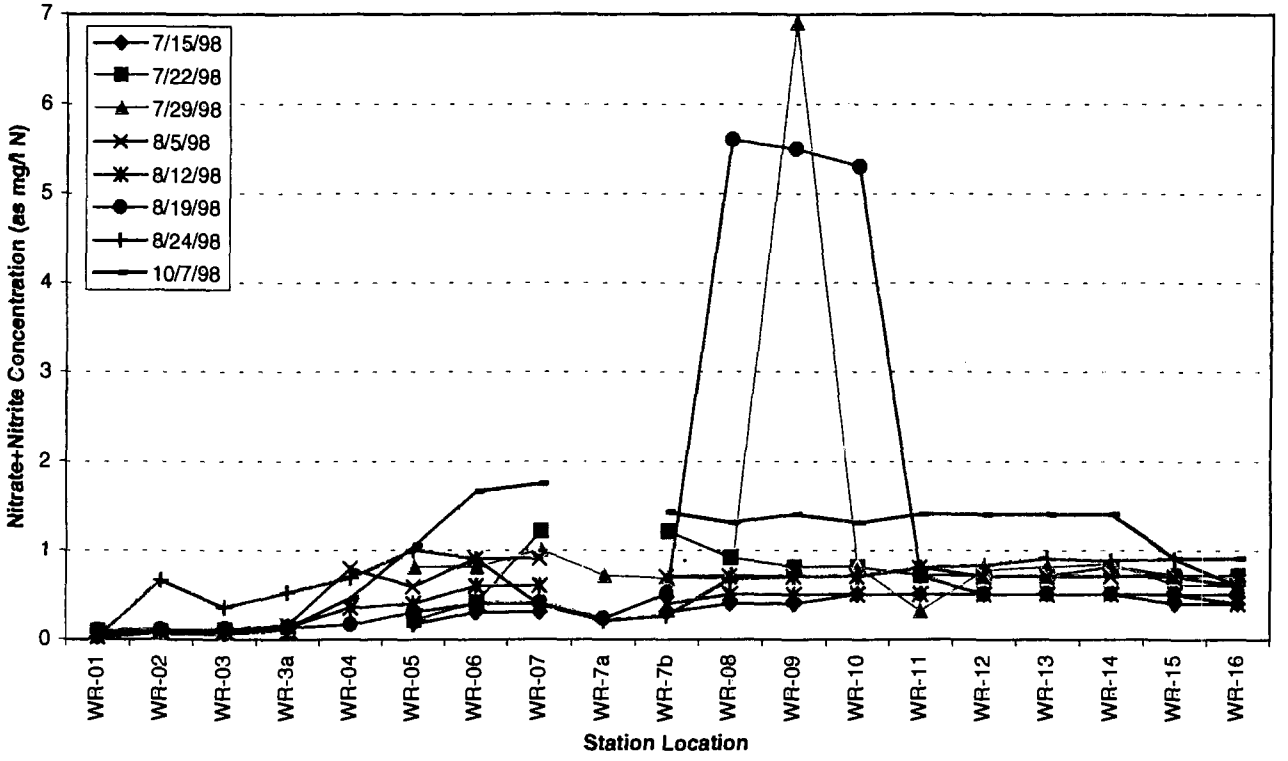

Figure 4-52

Nitrate + Nitrite Concentration (NBC, 1998) *(at higher resolution)*

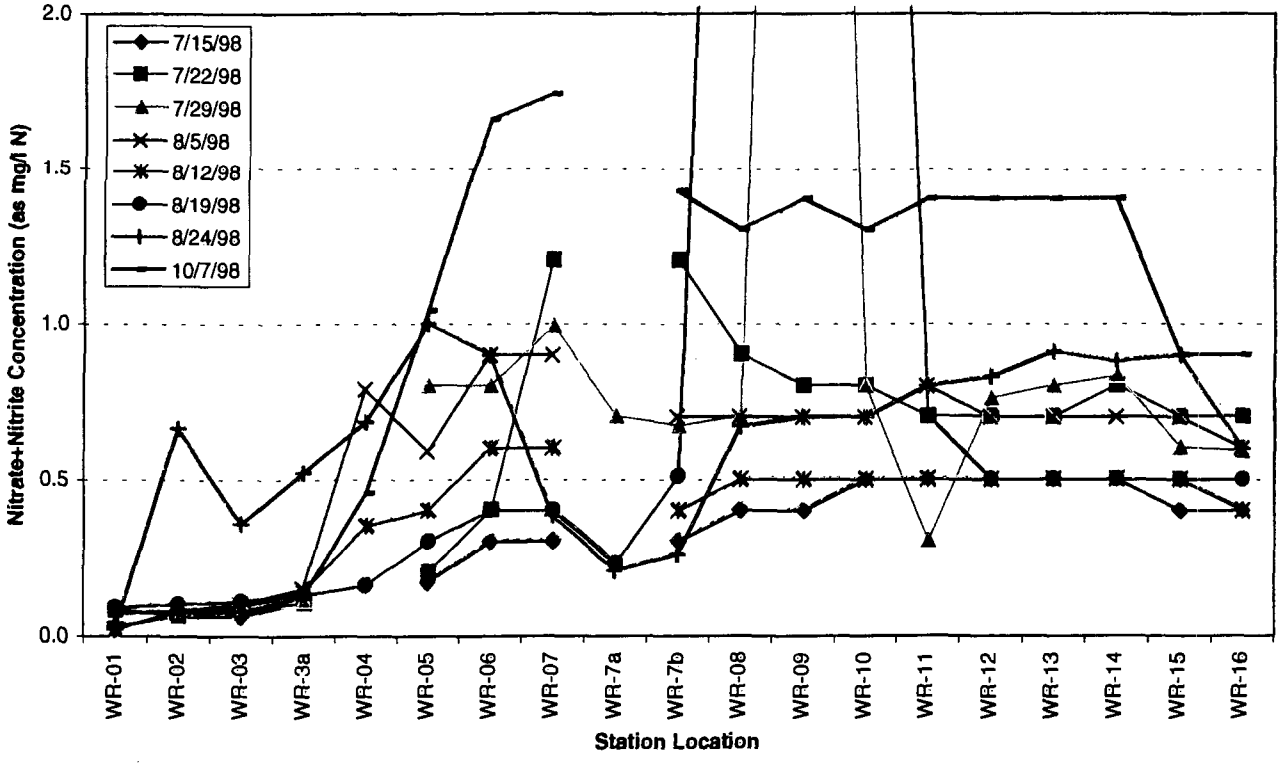

Figure 4-53

Nitrate + Nitrite Concentration - Statistics (NBC, 1998)

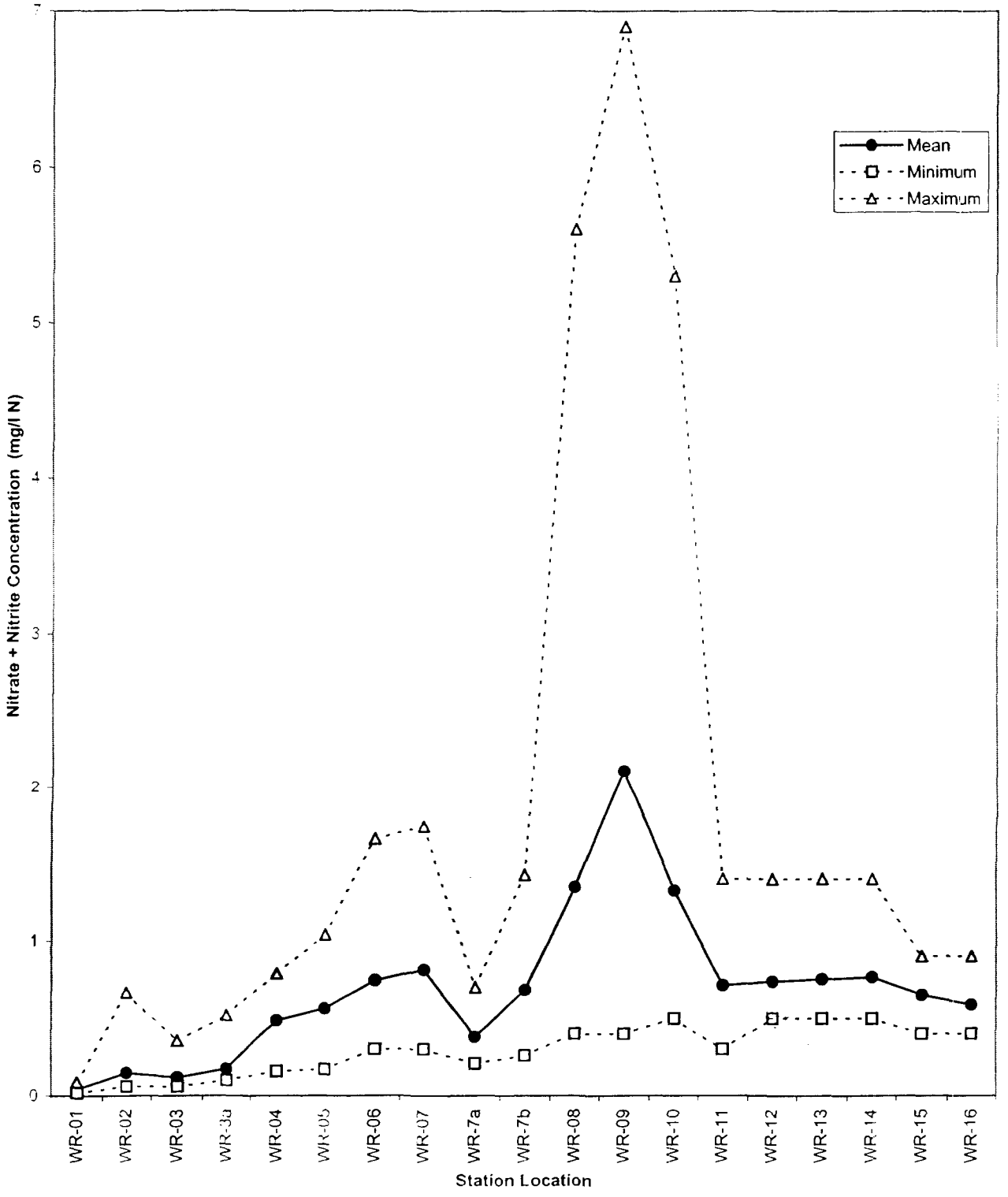

Figure 4-54

Nitrate + Nitrite Concentration - Statistics (NBC, 1998)

(at higher resolution)

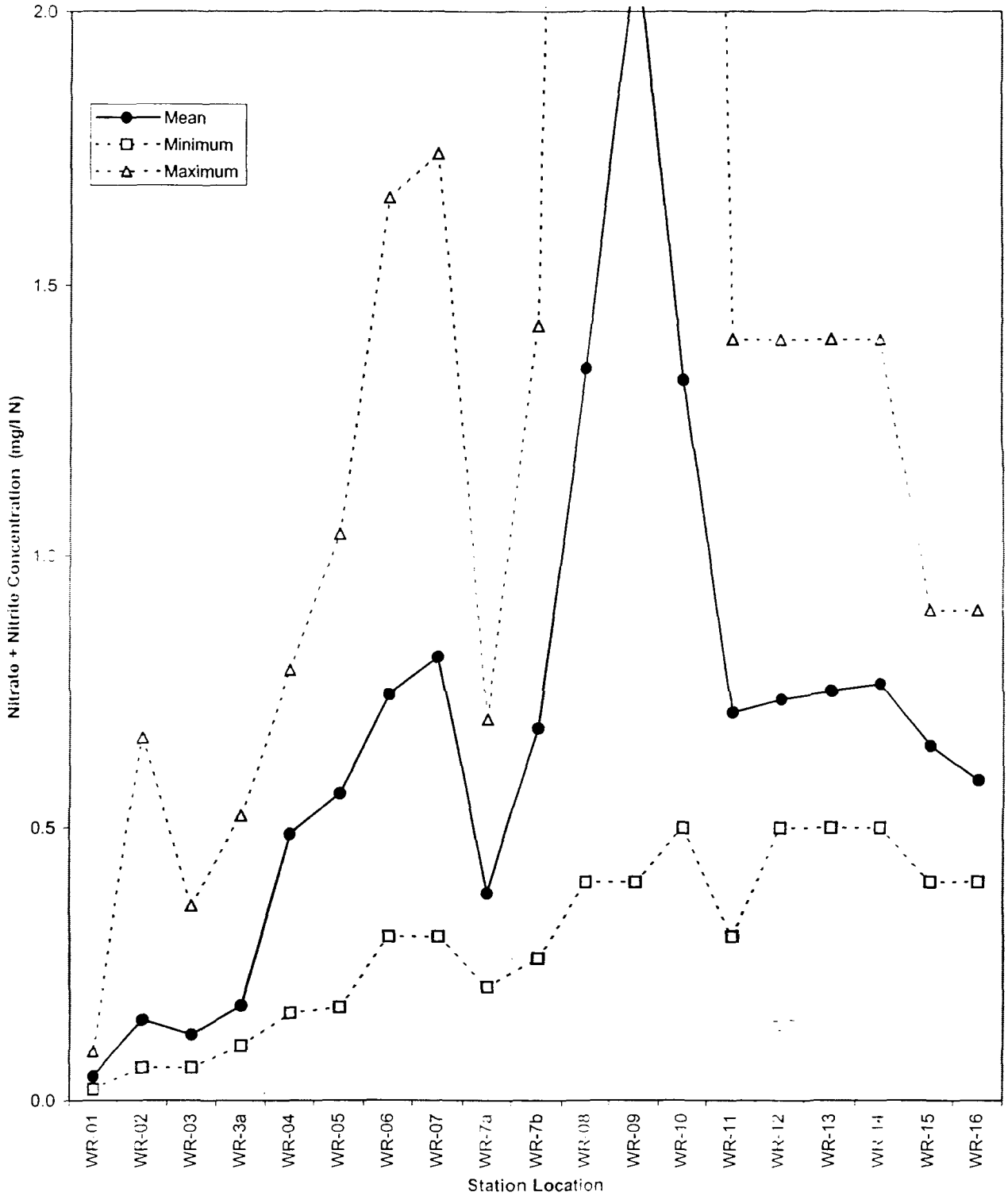

Figure 4-55

Nitrate+Nitrite Concentration - Station W2 (Route 44)

(Kerr and Lee, 1996)

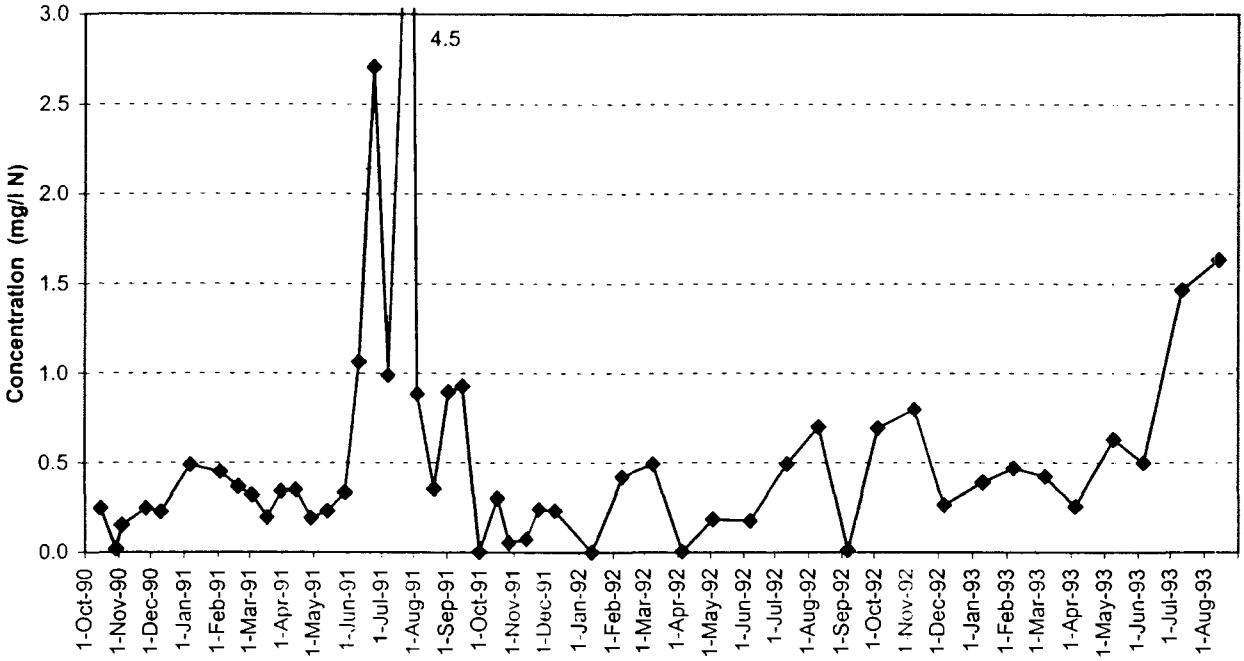

Figure 4-56

Nitrate+Nitrite Concentration - Station W1 (Valley Street)

(Kerr and Lee, 1996)

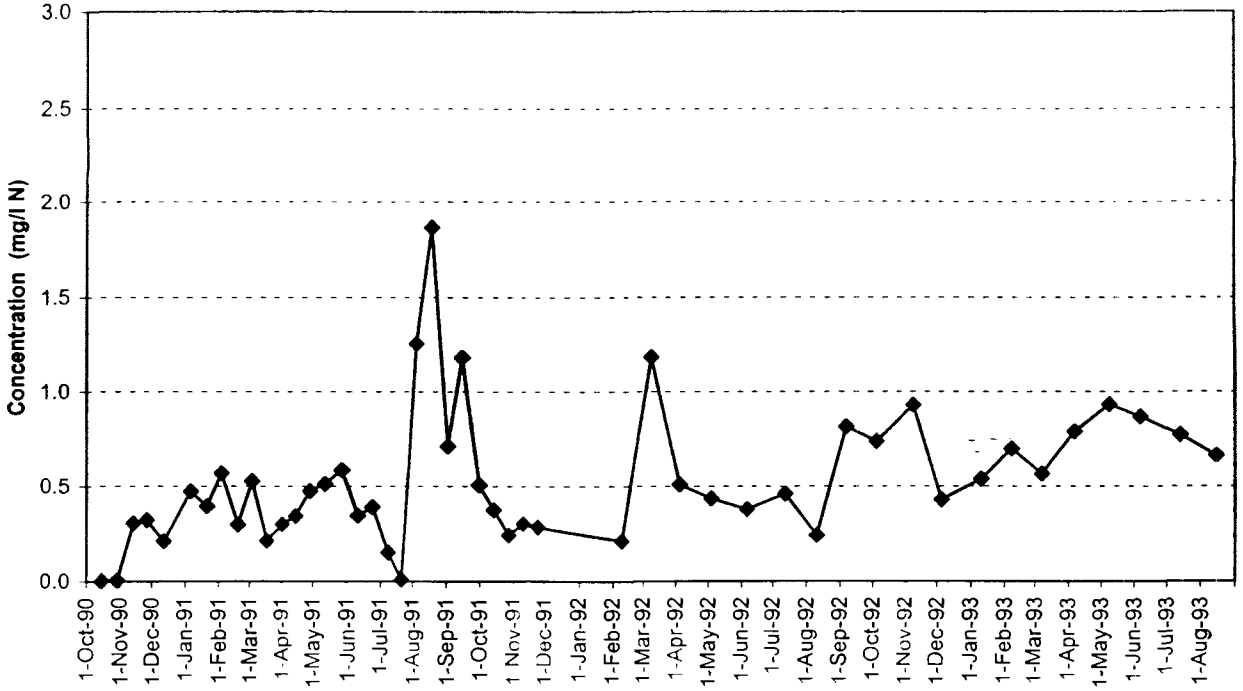

Figure 4-57

Total Kjehldahl Nitrogen and Total Nitrogen - Dry Weather Data

Station No.	Location	Total Kjehldahl Nitrogen (mg/l N)			Total Nitrogen (mg/l N)		
		Mean	Minimum	Maximum	Mean	Minimum	Maximum
WR-1	Stillwater Reservoir Dam	**0.45**	0.33	0.60	**<0.49**	<0.39	0.68
WR-2	Capron Road	**0.55**	0.37	1.00	**0.70**	0.47	1.17
WR-3	Sri Chimroy Peace Bridge	**0.37**	0.20	0.53	**0.49**	0.26	0.88
WR-3a	Esmond Mill Drive	**0.36**	0.20	0.60	**0.53**	0.31	1.07
EMD	Esmond Mill Drive						
WR-4	Smithfield WWTF Effluent	**13.48**	8.40	22.00	**13.97**	9.09	22.46
WWTF	Smithfield WWTF Effluent						
GP	Greystone Pond						
WR-5	Greystone Street	**1.24**	0.60	2.40	**1.80**	0.90	3.44
WR-6	Route 44, Centerdale	**0.96**	0.50	1.48	**1.70**	0.90	3.14
W2	Route 44, Centerdale				**1.68**	0.39	9.52
WR-7	Allendale Avenue	**1.24**	0.60	4.35	**2.05**	1.00	4.73
WR-7a	Assapumpset Brook	**0.37**	0.20	0.50	**0.75**	0.43	1.20
LP	Lymansville Pond						
WR-7b	Lymansville Dam	**0.71**	0.45	1.00	**1.39**	0.71	2.15
R1	Manton Dam						
WR-8	Manton Avenue	**0.56**	0.48	0.73	**1.91**	0.90	6.20
R2	Manton Avenue						
WOONUP	Manton Avenue						
S-9	Manton Avenue						
WR-9aa	Lincoln Lace & Braid						
WR-9ab	Lincoln Lace & Braid						
WR-9ac	Lincoln Lace & Braid						
WR-9	Dyerville Complex	**0.48**	0.37	0.60	**2.60**	0.90	7.40
W6	Killingly Interchange Stormdrain						
WR-10	Merino Park	**0.51**	0.40	0.60	**1.84**	1.00	5.80
WR-10a	Riverside Mills						
WR-11	Olneyville Square	**0.53**	0.40	0.80	**1.24**	0.90	2.20
S-8a	Olneyville Square						
WR-12	Delanie Street	**0.51**	0.40	0.70	**1.25**	0.90	2.00
WR-13	Valley Street	**0.49**	0.30	0.60	**1.24**	0.90	2.00
R3	Valley Street						
WOON	Valley Street						
WOONDN	Valley Street						
S-8b	Valley Street						
W1	Valley Street				**1.49**	0.08	3.31
WR-14	Atwells Avenue	**0.48**	0.40	0.60	**1.24**	0.90	1.90
R4	Atwells Avenue						
S-8	Atwells Avenue						
WR-15	Bath Street	**0.51**	0.40	0.70	**1.16**	0.90	1.60
W23	Civic Center Stormdrain						
WR-16	Exchange Street	**0.54**	0.40	0.70	**1.12**	0.90	1.50
S-7	Exchange Street						

Figure 4-58

Total Kjeldahl Nitrogen Concentration (NBC, 1998)

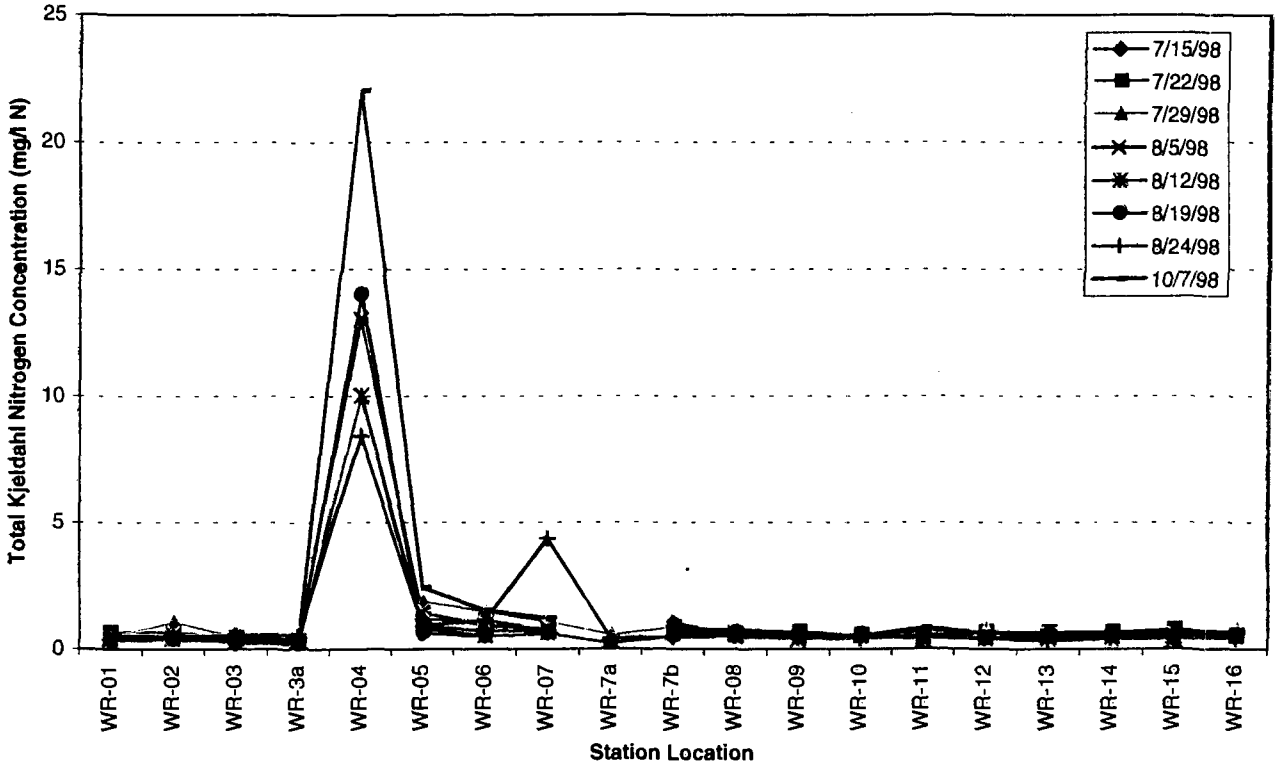

Figure 4-59

Total Kjeldahl Nitrogen Concentration (NBC, 1998) *(higher resolution)*

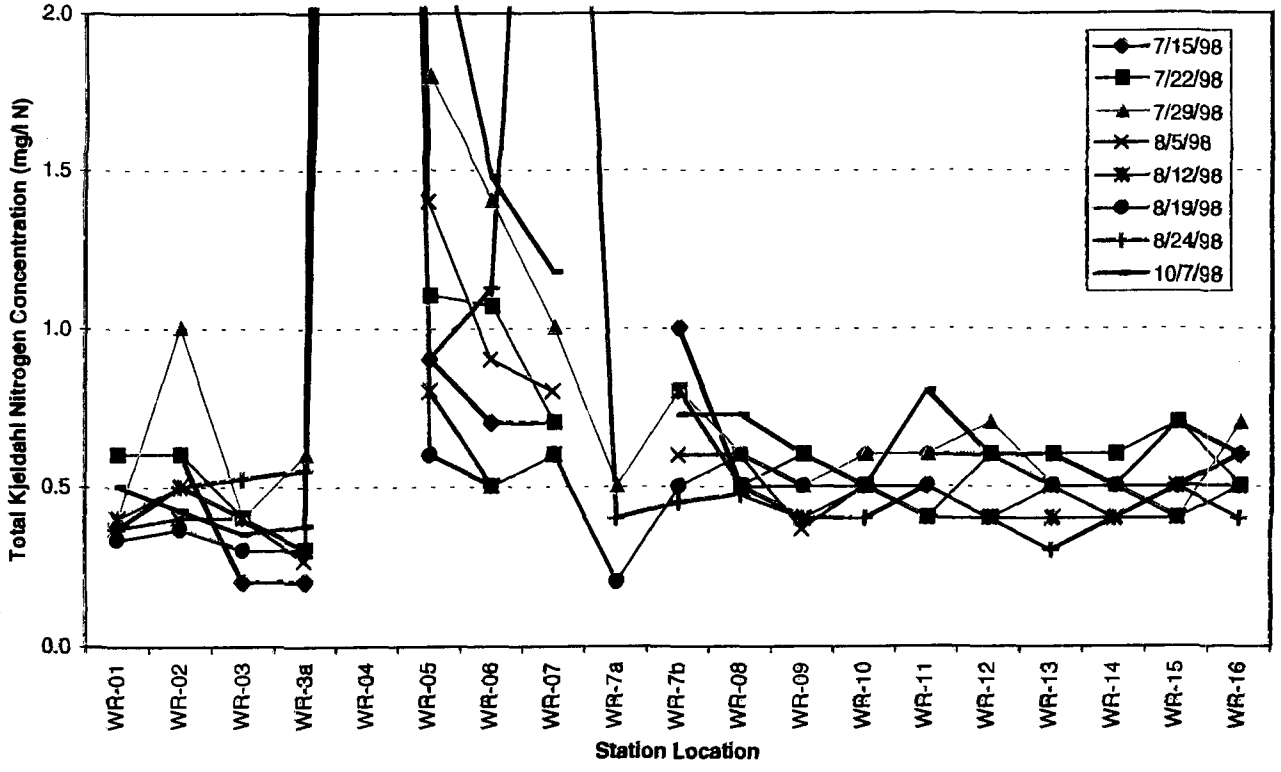

Figure 4-60

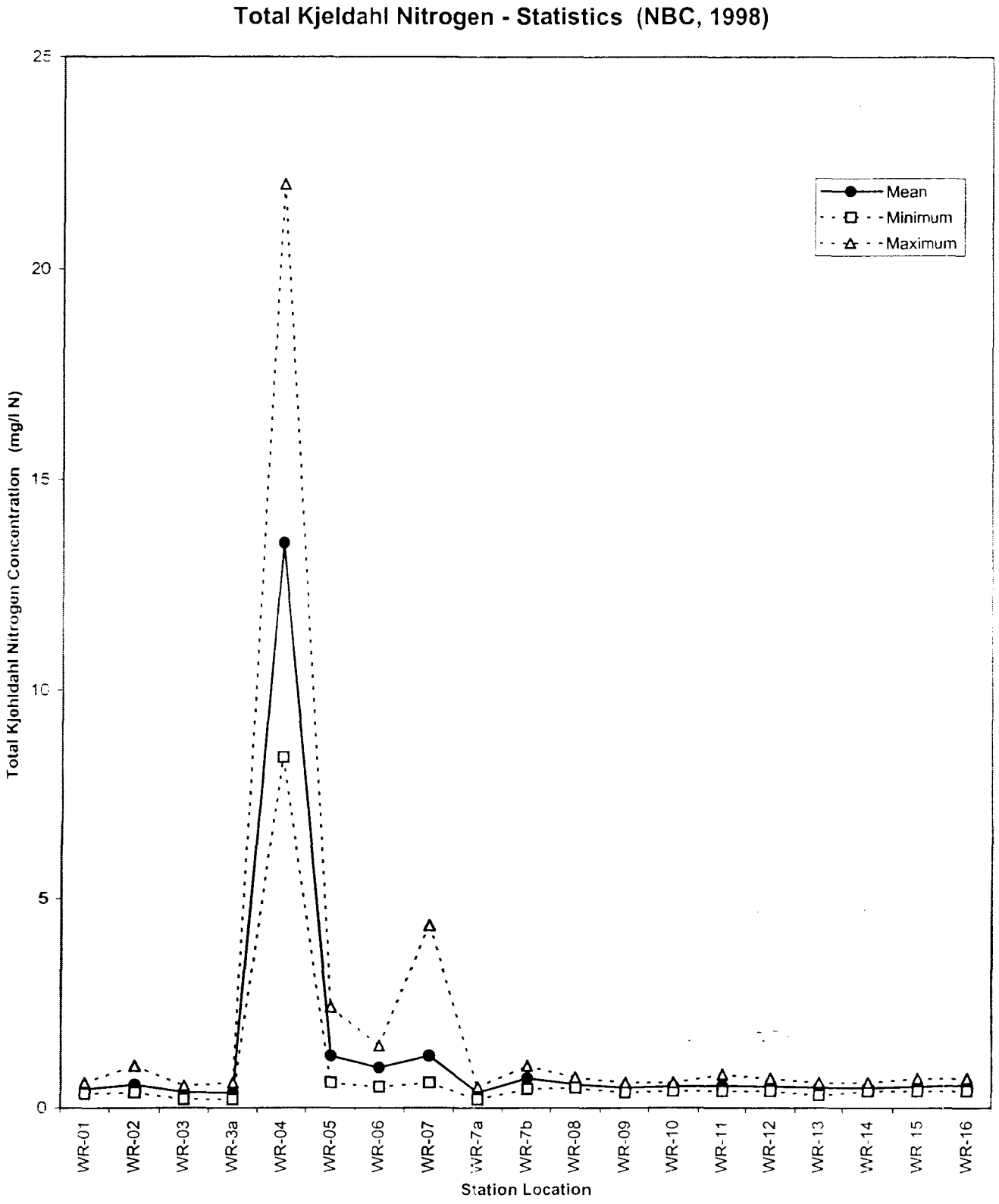
Total Kjeldahl Nitrogen - Statistics (NBC, 1998)
Mean
Minimum
Maximum
Total Kjeldahl Nitrogen Concentration (mg/l N)
25
20
15
10
5
0
WR-01
WR-02
WR-03
WR-3a
WR-04
WR-05
WR-06
WR-07
WR-7a
WR-7b
WR-08
WR-09
WR-10
WR-11
WR-12
WR-13
WR-14
WR 15
WR-16
Station Location

Figure 4-61

Total Kjeldahl Nitrogen - Statistics (NBC, 1998)

(at higher resolution)

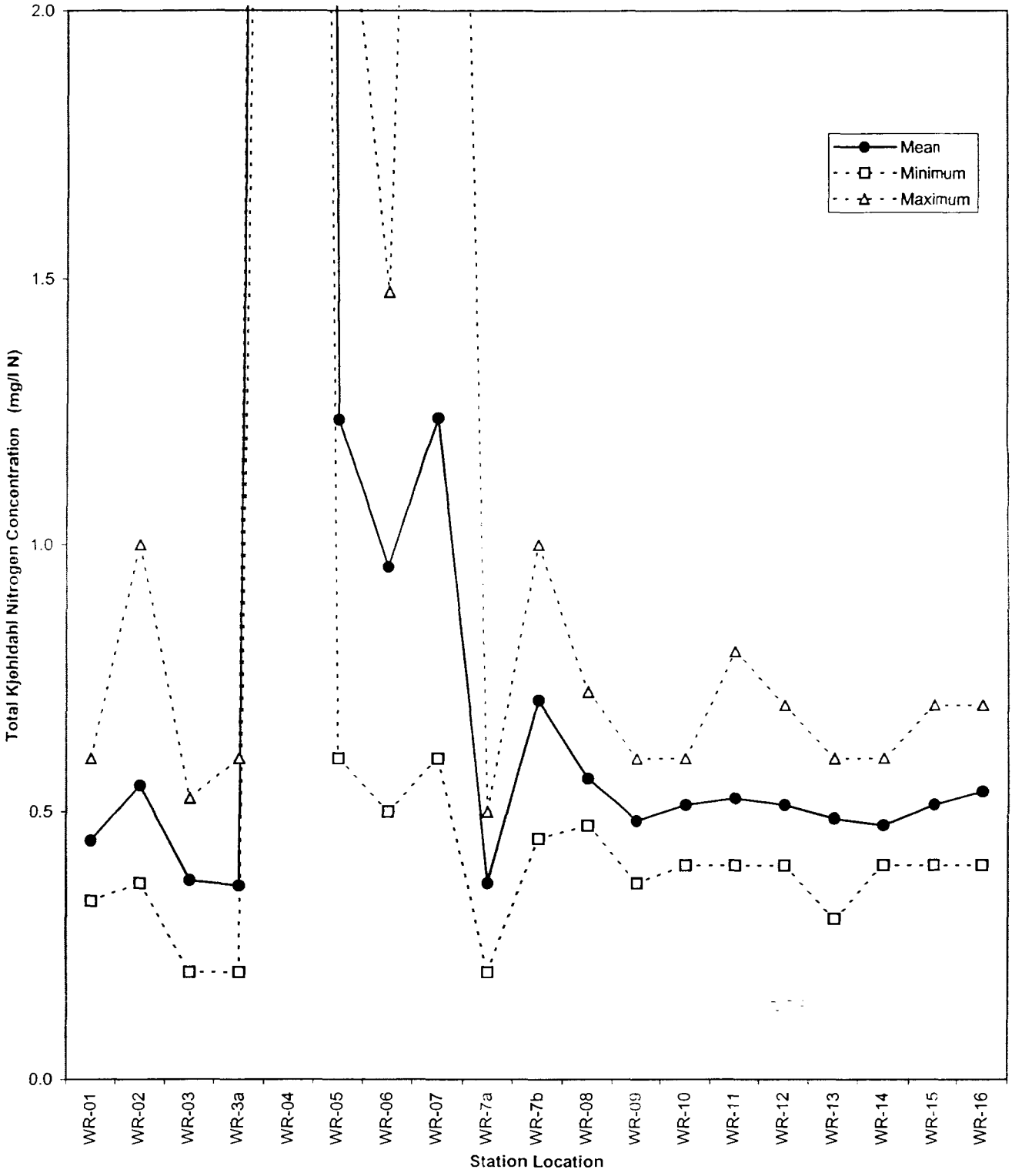

Figure 4-62

Total Nitrogen Concentration (NBC, 1998)

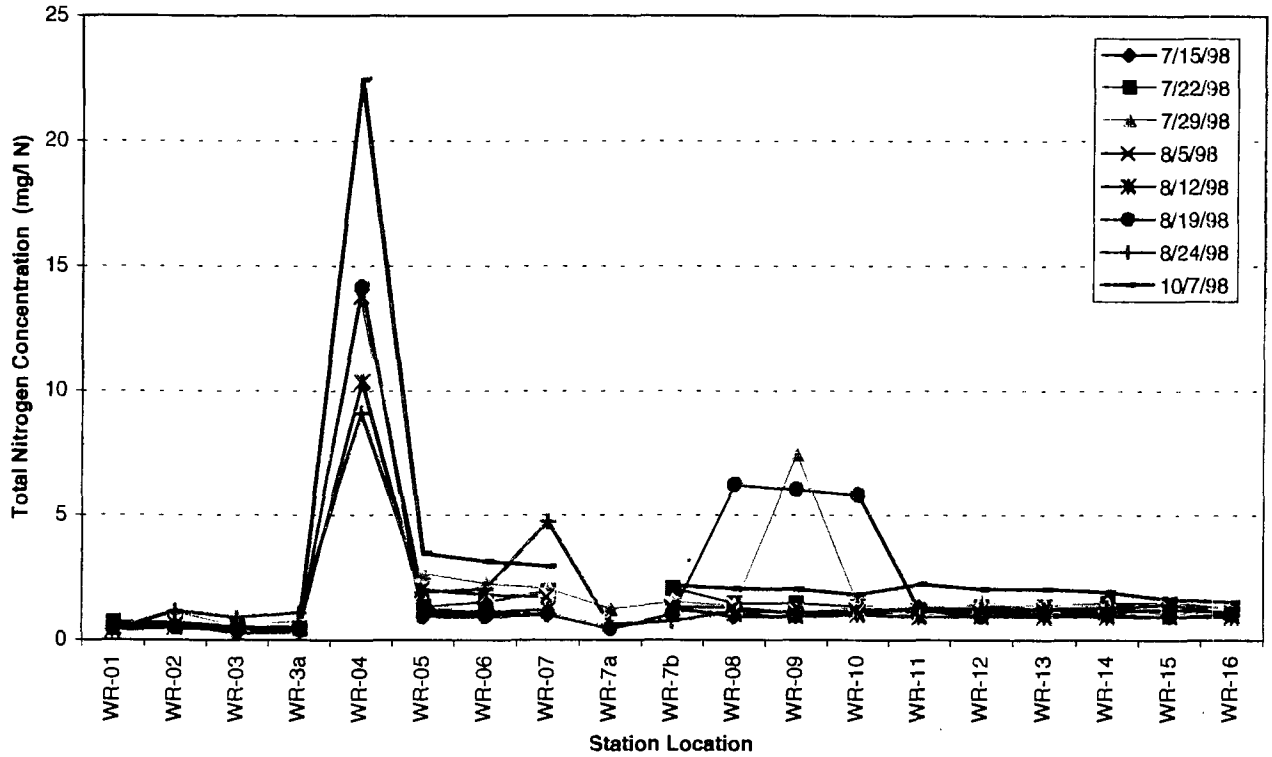

Figure 4-63

Total Nitrogen Concentration (NBC, 1998) *(at higher resolution)*

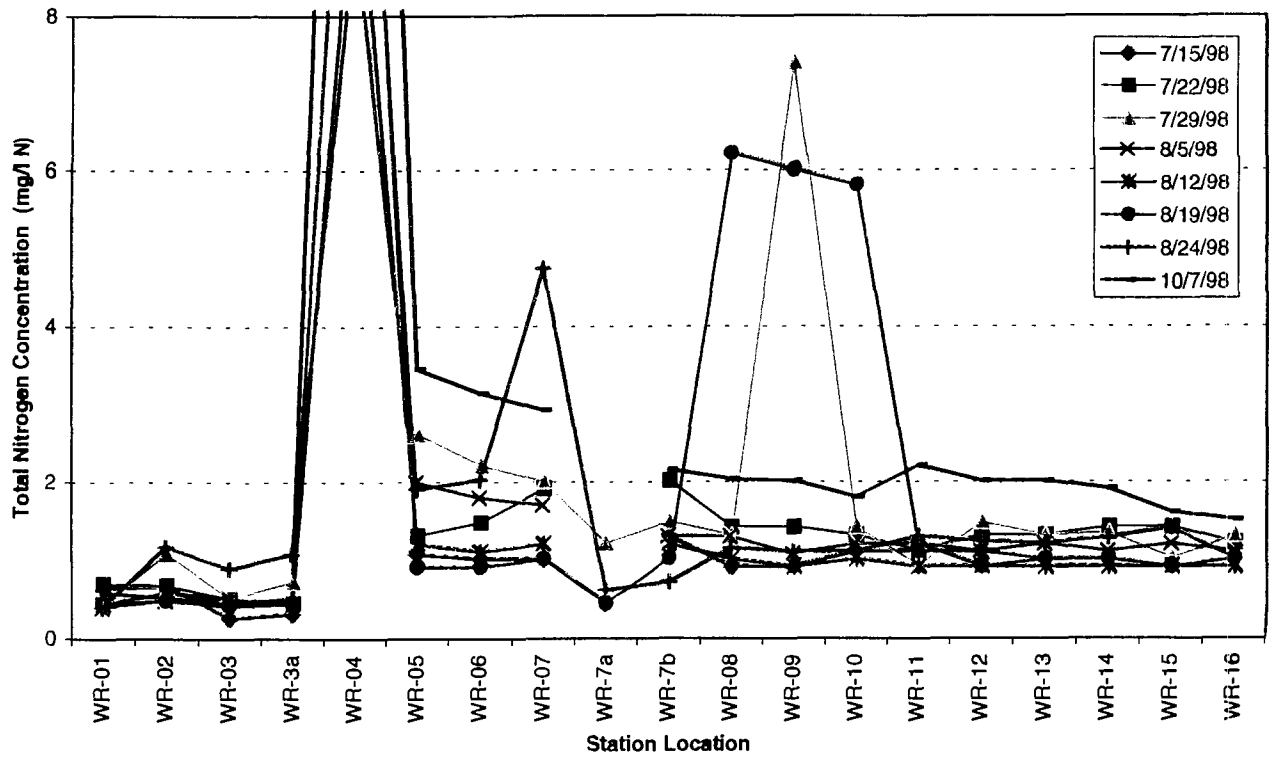

Figure 4-64

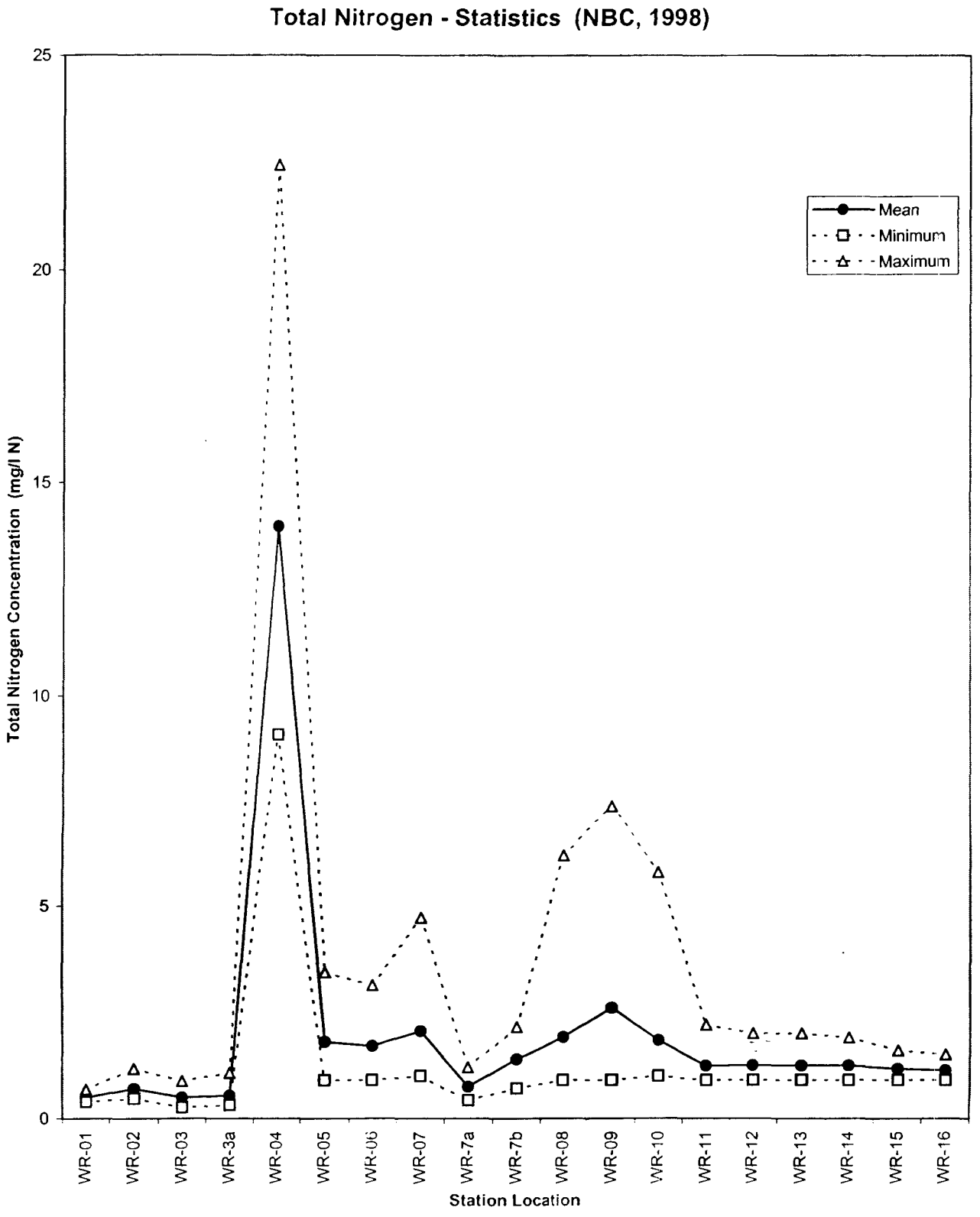
Total Nitrogen - Statistics (NBC, 1998)
Total Nitrogen Concentration (mg/l N)
25
20
15
10
5
0
Mean
Minimum
Maximum
WR-01
WR-02
WR-03
WR-3a
WR-04
WR-05
WR-06
WR-07
WR-7a
WR-7b
WR-08
WR-09
WR-10
WR-11
WR-12
WR-13
WR-14
WR-15
WR-16
Station Location

Figure 4-65

Total Nitrogen - Statistics (NBC, 1998)

(at higher resolution)

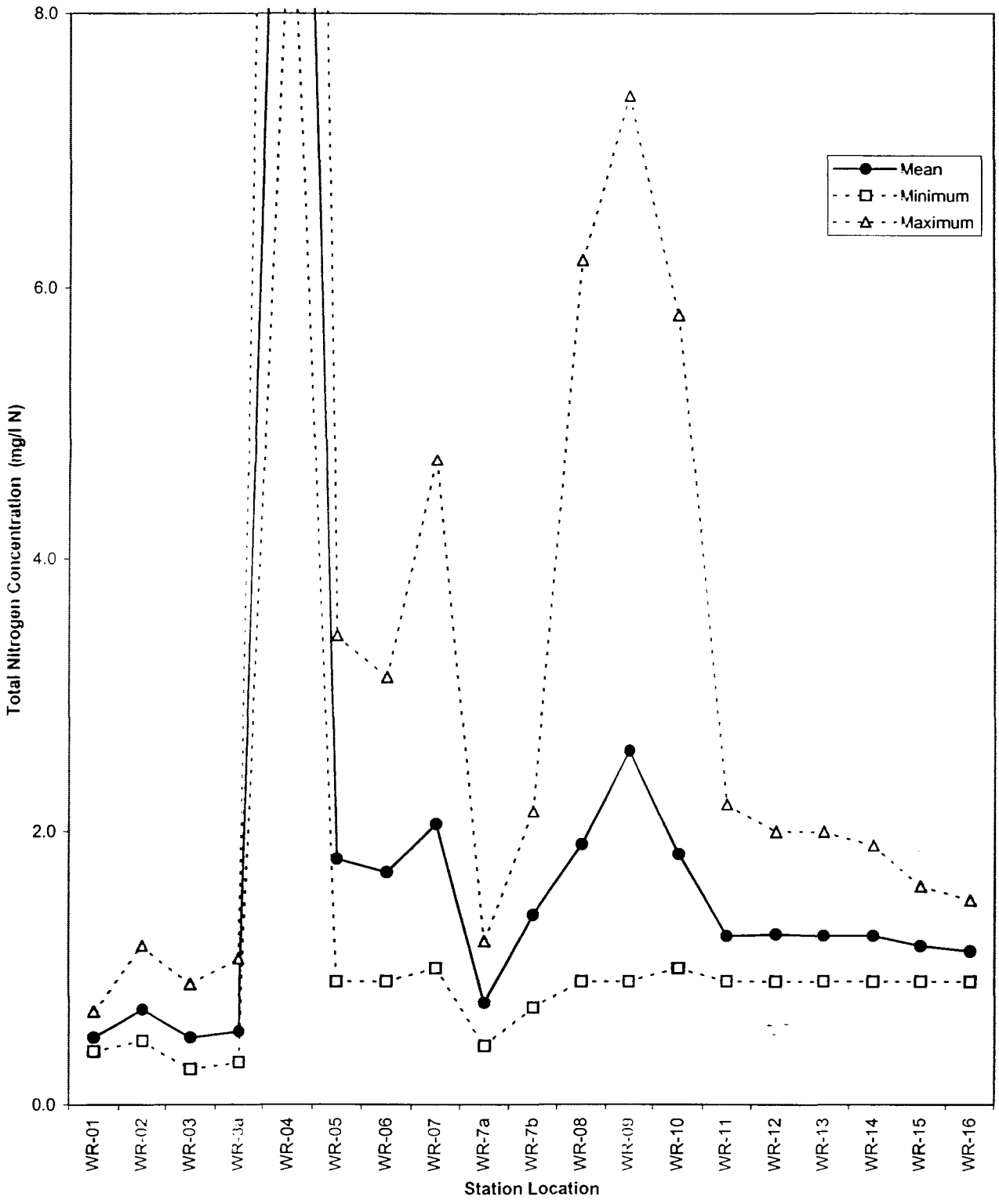

Figure 4-66

Total Dissolved Nitrogen Concentration - Station W2 (Route 44)

(Kerr and Lee, 1996)

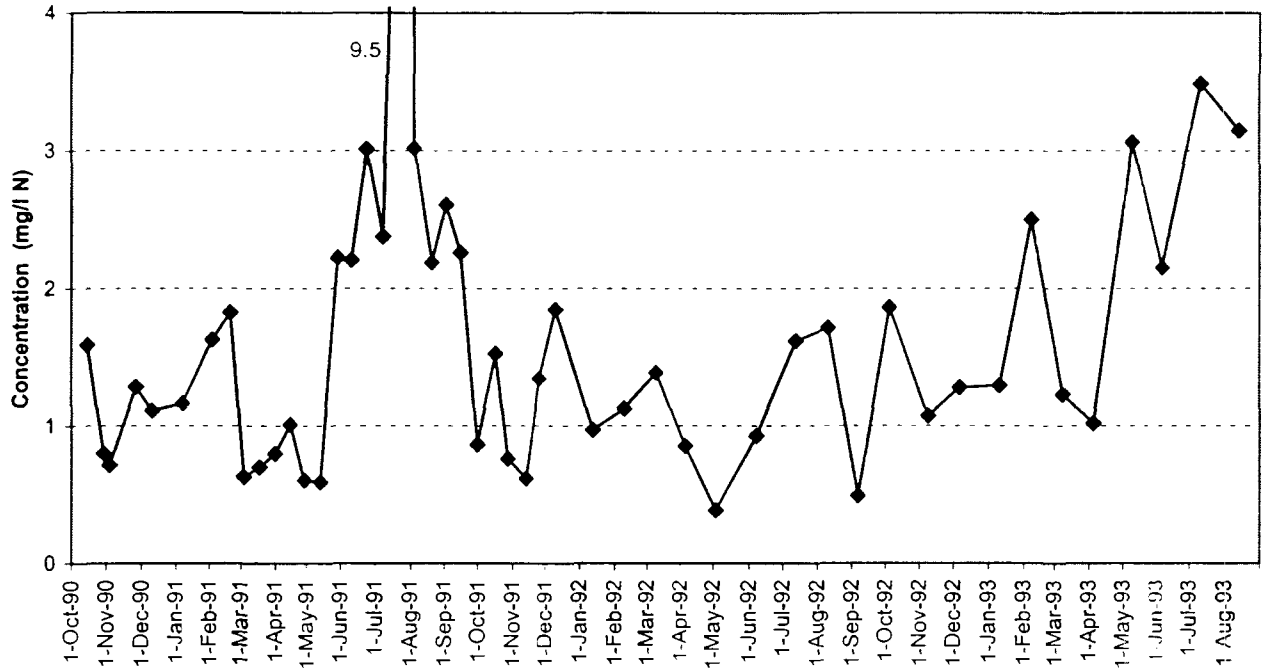

Figure 4-67

Total Dissolved Nitrogen Concentration - Station W1 (Valley Street)

(Kerr and Lee, 1996)

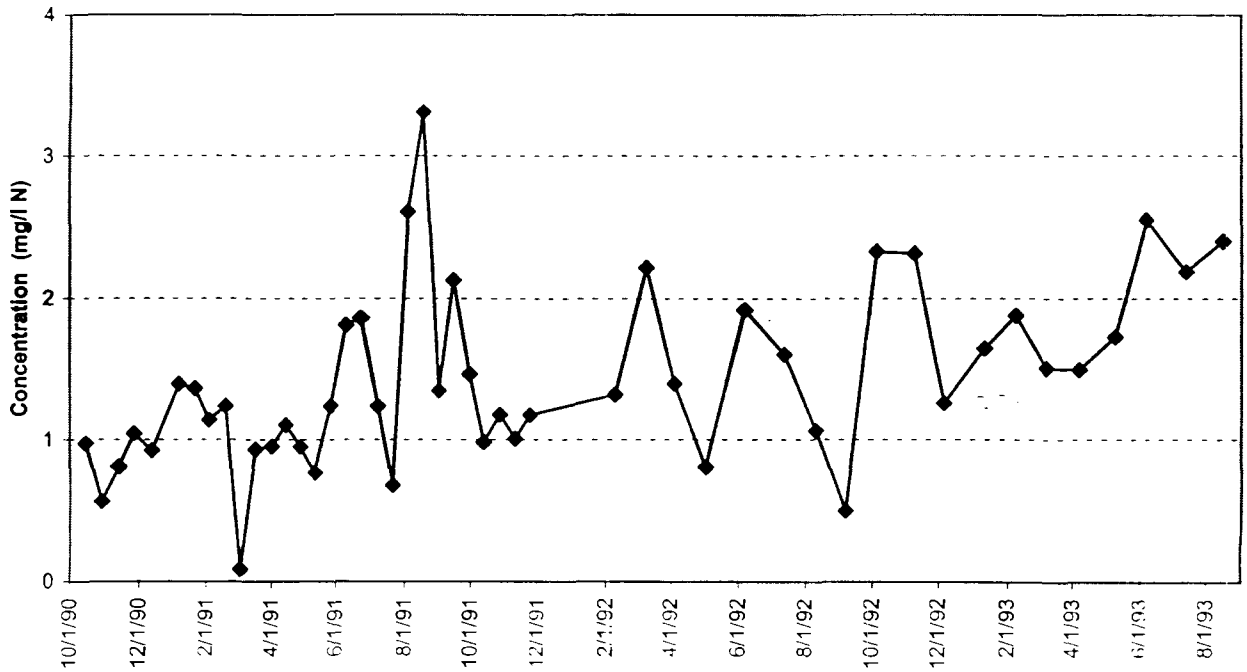

Figure 4-68

Phosphate and Total Phosphorus Concentrations - Dry Weather Data

Station No.	Location	Phosphate (mg/l P)			Total Phosphorus (mg/l P)		
		Mean	Minimum	Maximum	Mean	Minimum	Maximum
WR-1	Stillwater Reservoir Dam				0.11	0.10	0.20
WR-2	Capron Road				<0.10	<0.10	0.13
WR-3	Sri Chimroy Peace Bridge				<0.12	<0.10	0.20
WR-3a	Esmond Mill Drive				0.11	0.10	0.15
EMD	Esmond Mill Drive						
WR-4	Smithfield WWTF Effluent				4.85	1.65	9.58
WWTF	Smithfield WWTF Effluent				3.72	0.90	10.30
GP	Greystone Pond						
WR-5	Greystone Street				0.40	0.20	1.06
WR-6	Route 44, Centerdale				0.34	0.10	0.83
W2	Route 44, Centerdale	**0.076**	0.000	0.350	0.22	0.04	1.14
WR-7	Allendale Avenue				<0.34	<0.10	0.85
WR-7a	Assapumpset Brook				<0.27	<0.10	0.60
LP	Lymansville Pond						
WR-7b	Lymansville Dam				0.21	0.10	0.40
R1	Manton Dam				<0.10	<0.05	0.25
WR-8	Manton Avenue				0.16	0.10	0.33
R2	Manton Avenue				0.28	0.05	0.70
WOONUP	Manton Avenue	**0.092**	0.013	0.188			
S-9	Manton Avenue						
WR-9aa	Lincoln Lace & Braid						
WR-9ab	Lincoln Lace & Braid						
WR-9ac	Lincoln Lace & Braid						
WR-9	Dyerville Complex				0.15	0.10	0.20
W6	Killingly Interchange Stormdrain						
WR-10	Merino Park				<0.25	<0.10	0.90
WR-10a	Riverside Mills						
WR-11	Olneyville Square				0.18	0.10	0.20
S-8a	Olneyville Square						
WR-12	Delanie Street				<0.15	<0.10	0.20
WR-13	Valley Street				0.13	0.10	0.20
R3	Valley Street				0.13	<0.05	0.30
WOON	Valley Street	**0.101**	0.060	0.173			
WOONDN	Valley Street	**0.068**	0.014	0.142			
S-8b	Valley Street						
W1	Valley Street	**0.034**	0.003	0.131	**0.14**	0.06	**0.32**
WR-14	Atwells Avenue				**<0.11**	**<0.10**	**0.20**
R4	Atwells Avenue				**0.15**	<0.05	**0.35**
S-8	Atwells Avenue						
WR-15	Bath Street				**<0.13**	<0.10	**0.20**
W23	Civic Center Stormdrain						
WR-16	Exchange Street				<0.14	<0.10	0.30
S-7	Exchange Street						

Figure 4-69

Phosphate and Total Phosphorus Concentrations - Wet Weather Data

Phosphate (mg/l P)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam															
S-9	Manton Avenue															
R2	Manton Avenue															
WOONUP	Manton Avenue	0.09	0.12	0.13	0.10	0.09	0.01	0.02	0.01	0.01	0.04	0.19	0.19	0.22	0.18	0.14
S-8a	Olneyville Square															
W6	Killingly Interch. Drain							0.01					0.16			
S-8b	Valley Street															
R3	Valley Street															
WOON	Valley Street	0.10	0.08	0.09	0.07	0.11	0.06	0.01	0.01	0.01	0.01	0.17	0.17	0.15	0.14	0.24
WOONDN	Valley Street	0.07	0.10	0.10	0.08	0.07	0.01	0.01	0.01	0.01	0.01	0.14	0.19	0.18	0.16	0.12
S-8	Atwells Avenue															
R4	Atwells Avenue															
S-7	Exchange Street															
W23	Civic Center Drain							0.01					0.16			

Total Phosphorus (mg/l P)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam	<0.10	0.22				<0.05	<0.05				0.25	0.35			
S-9	Manton Avenue															
R2	Manton Avenue	0.28	0.26				0.05	0.09				0.70	0.41			
WOONUP	Manton Avenue															
S-8a	Olneyville Square															
W6	Killingly Interch. Drain															
S-8b	Valley Street															
R3	Valley Street	0.13	0.21				<0.05	0.08				0.30	0.35			
WOON	Valley Street															
WOONDN	Valley Street															
S-8	Atwells Avenue															
R4	Atwells Avenue	0.15	0.26				<0.05	<0.05				0.35	0.52			
S-7	Exchange Street															
W23	Civic Center Drain															

Figure 4-70

Phosphate (Dissolved Inorganic Phosphorus) Concentration - Station W2 (Route 44)

(Kerr and Lee, 1996)

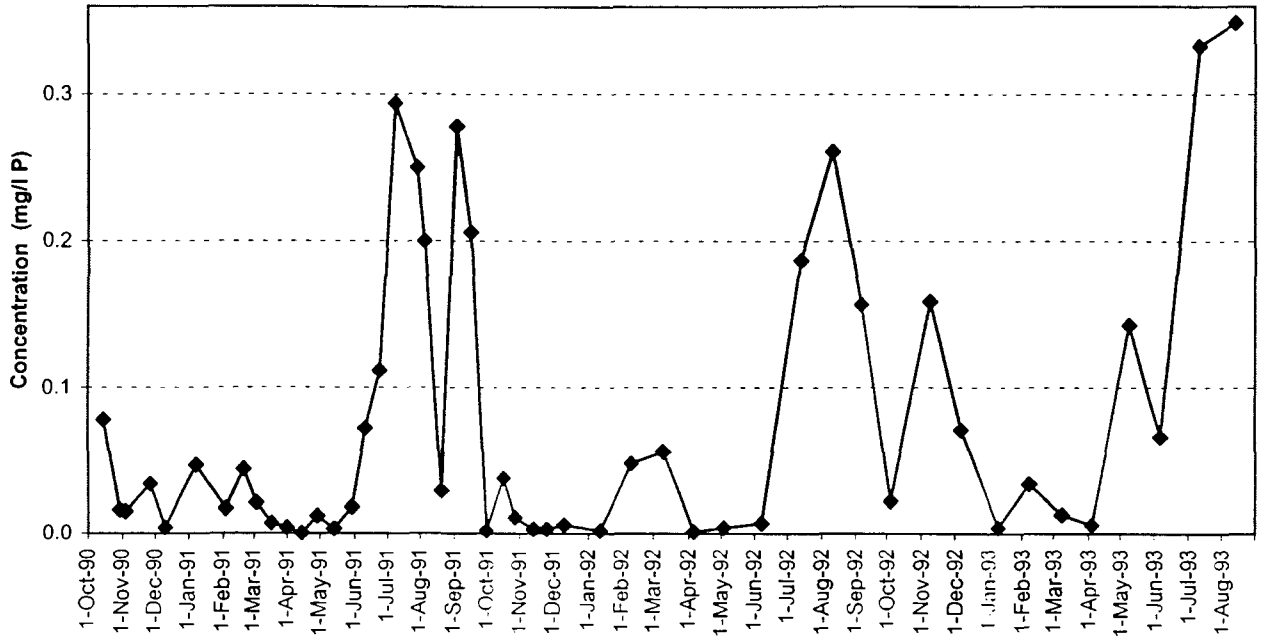

Figure 4-71

Phosphate (Dissolved Inorganic Phosphorus) Concentration - Station W1 (Valley Street)

(Kerr and Lee, 1996)

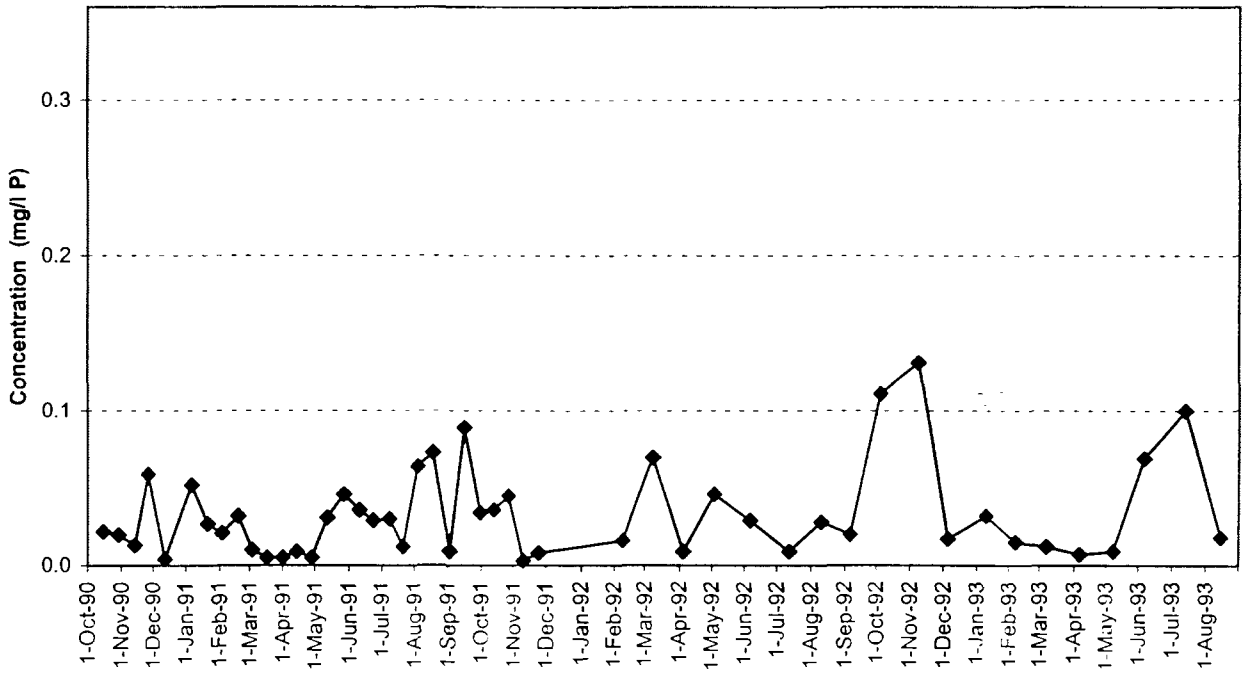

Figure 4-72

Total Phosphorus Concentration (NBC, 1998)

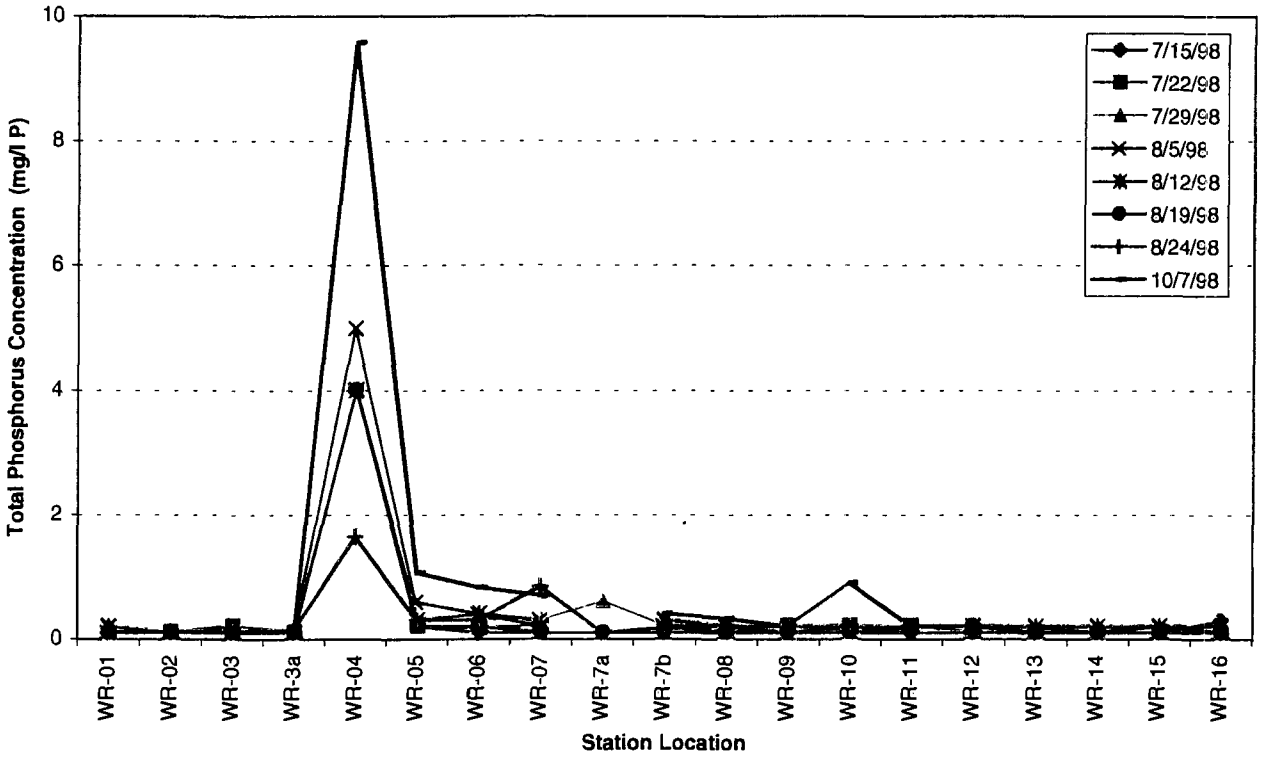

Figure 4-73

Total Phosphorus Concentration (NBC, 1998) *(at higher resolution)*

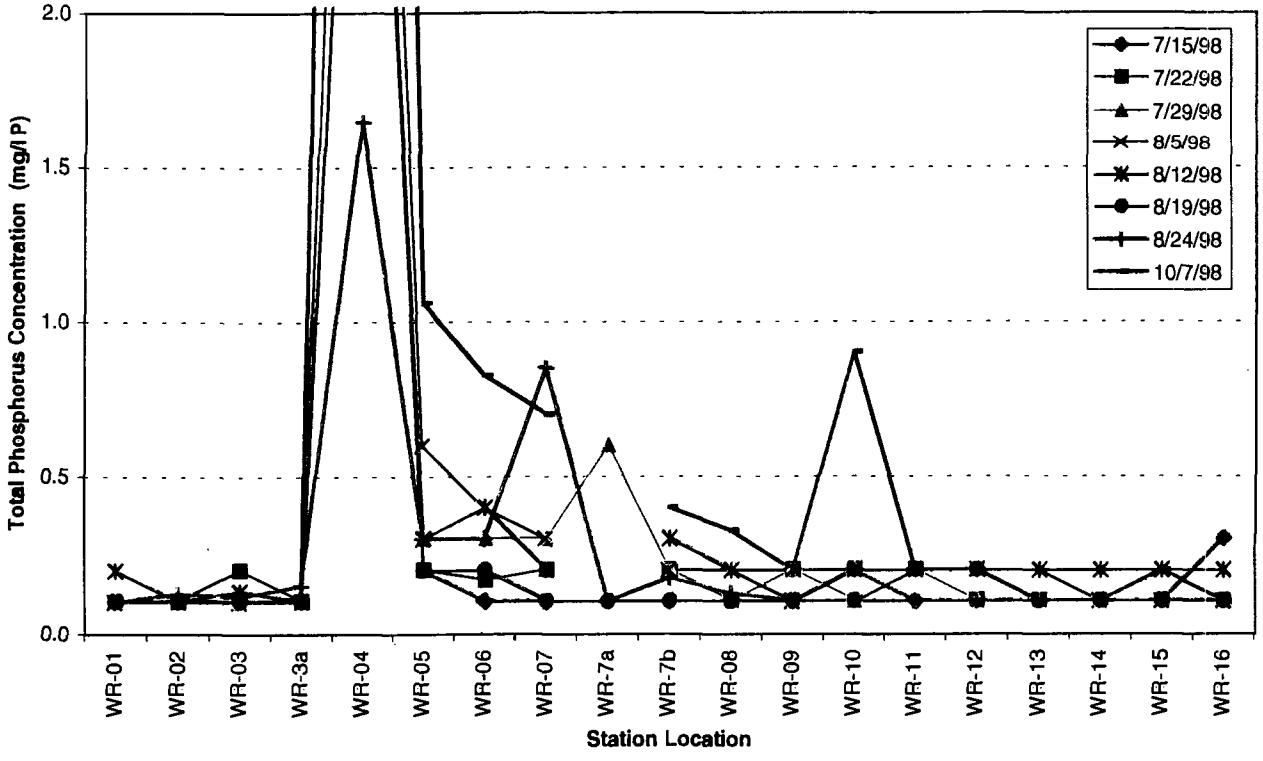

Figure 4-74

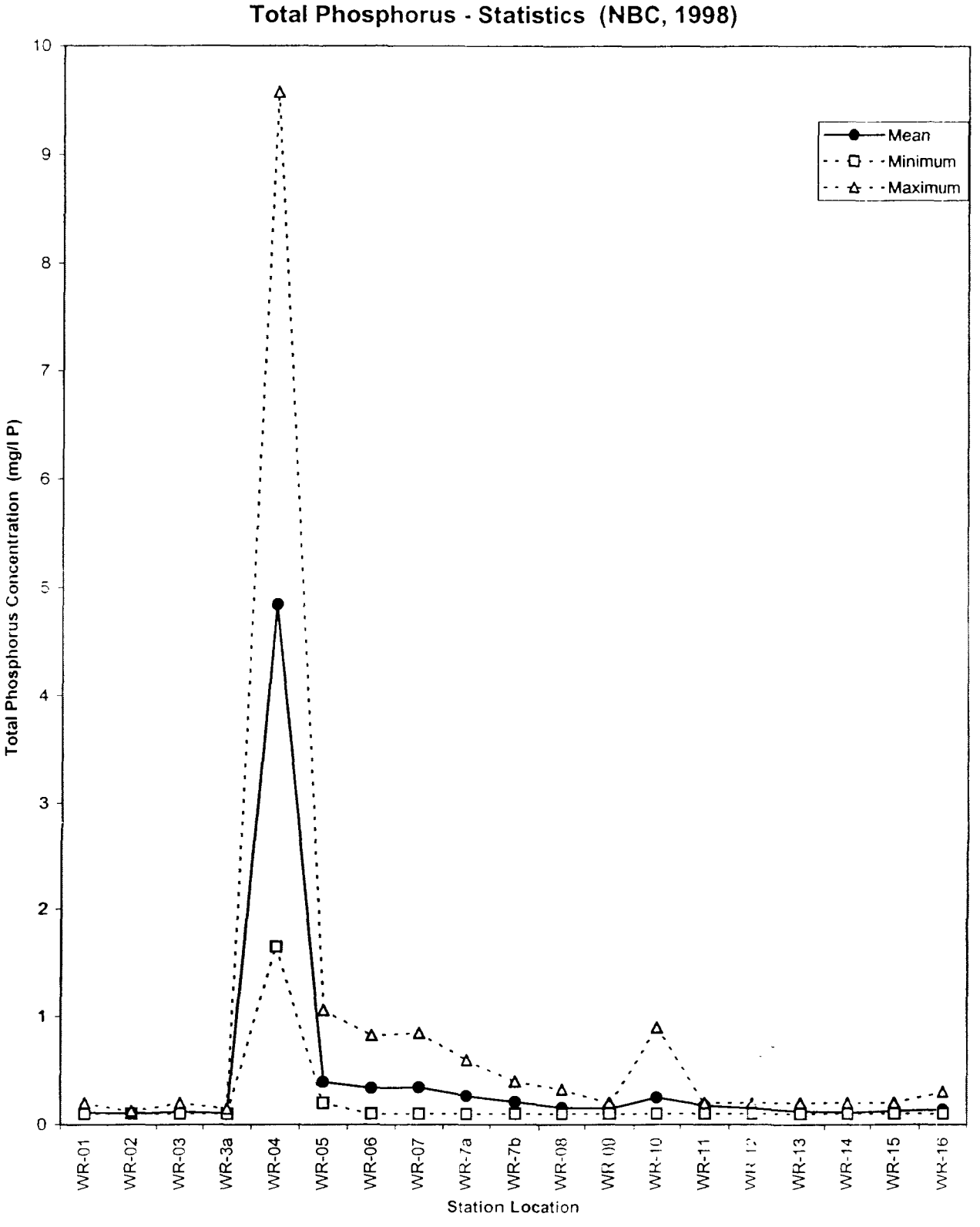
Total Phosphorus - Statistics (NBC, 1998)
Total Phosphorus Concentration (mg/l P)
10
9
8
7
6
5
4
3
2
1
0
Mean
Minimum
Maximum
WR-01
WR-02
WR-03
WR-3a
WR-04
WR-05
WR-06
WR-07
WR-7a
WR-7b
WR-08
WR-10
WR-11
WR-13
WR-14
WR-15
Station Location

Figure 4-75

Total Phosphorus - Statistics (NBC, 1998)

(at higher resolution)

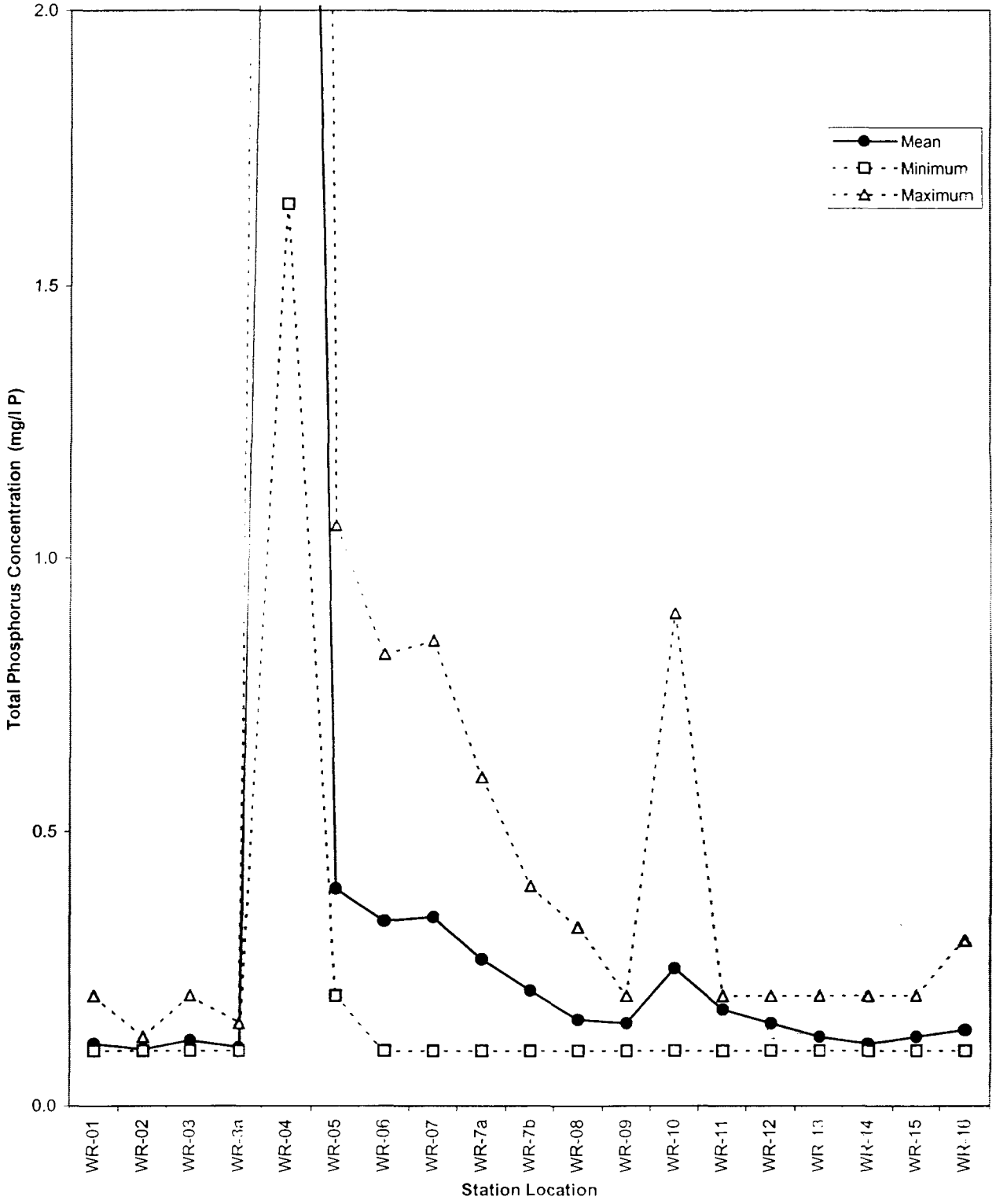

Figure 4-76

Total Phosphorus Concentration - Station W2 (Route 44)

(Kerr and Lee, 1996)

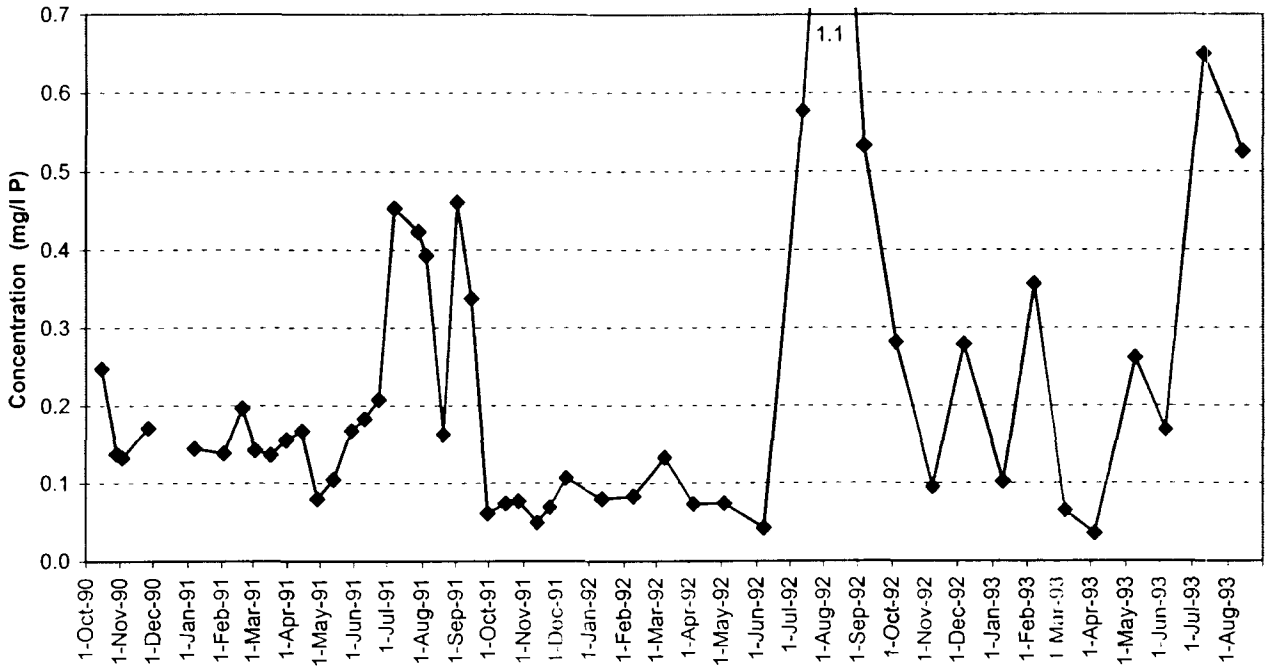

Figure 4-77

Total Phosphorus Concentration - Station W1 (Valley Street)

(Kerr and Lee, 1996)

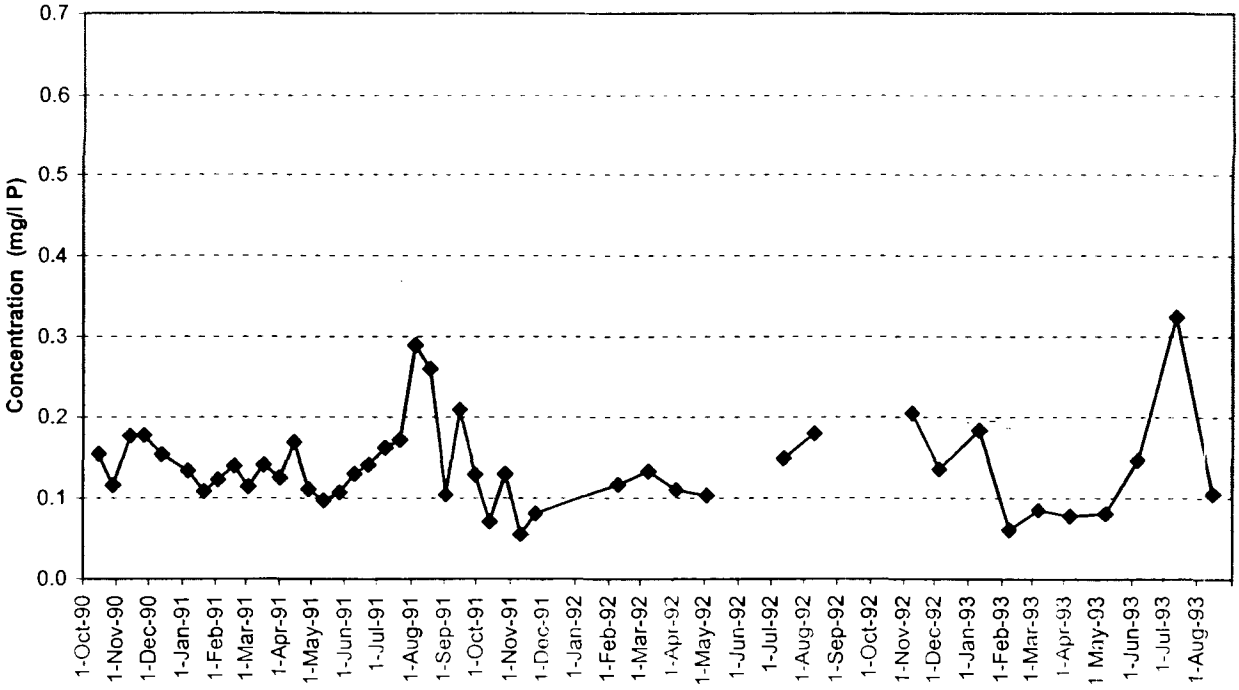

Figure 4-78

Hardness - Dry Weather Data

Station No.	Location	Hardness (mg/l) Mean	Minimum	Maximum
WR-1	Stillwater Reservoir Dam	22	19	25
WR-2	Capron Road	23	20	26
WR-3	Sri Chimroy Peace Bridge	30	19	64
WR-3a	Esmond Mill Drive	22	20	24
EMD	Esmond Mill Drive			
WR-4	Smithfield WWTF Effluent	49	46	51
WWTF	Smithfield WWTF Effluent			
GP	Greystone Pond			
WR-5	Greystone Street	26	23	31
WR-6	Route 44, Centerdale	26	24	28
W2	Route 44, Centerdale	22	10	30
WR-7	Allendale Avenue	27	24	31
WR-7a	Assapumpset Brook	50	45	56
LP	Lymansville Pond			
WR-7b	Lymansville Dam	28	25	31
R1	Manton Dam			
WR-8	Manton Avenue	31	27	36
R2	Manton Avenue			
WOONUP	Manton Avenue			
S-9	Manton Avenue			
WR-9aa	Lincoln Lace & Braid	37		
WR-9ab	Lincoln Lace & Braid			
WR-9ac	Lincoln Lace & Braid	35		
WR-9	Dyerville Complex	31	29	35
W6	Killingly Interchange Stormdrain			
WR-10	Merino Park	39	34	45
WR-10a	Riverside Mills			
WR-11	Olneyville Square	40	32	47
S-8a	Olneyville Square			
WR-12	Delanie Street	36	18	42
WR-13	Valley Street	42	34	54
R3	Valley Street			
WOON	Valley Street			
WOONDN	Valley Street			
S-8b	Valley Street			
W1	Valley Street	28	14	54
WR-14	Atwells Avenue	41	32	49
R4	Atwells Avenue			
S-8	Atwells Avenue			
WR-15	Bath Street	115	40	365
W23	Civic Center Stormdrain			
WR-16	Exchange Street	974	82	1,510
S-7	Exchange Street			

Figure 4-79

Cadmium Concentrations - Dry Weather Data

Station No.	Location	Dissolved Cadmium (ug/l) (*)			Total Cadmium (ug/l)		
		Mean	Minimum	Maximum	Mean	Minimum	Maximum
WR-1	Stillwater Reservoir Dam	<0.4	<0.3	1.2	<0.48	<0.3	0.8
WR-2	Capron Road	<0.3	<0.3	0.3	<0.34	<0.2	0.6
WR-3	Sri Chimroy Peace Bridge	<0.3	<0.3	0.4	<0.39	<0.3	0.9
WR-3a	Esmond Mill Drive	<0.3	<0.3	0.3	<0.31	<0.3	0.4
EMD	Esmond Mill Drive						
WR-4	Smithfield WWTF Effluent	<0.4	<0.3	0.6	<0.58	<0.3	1.4
WWTF	Smithfield WWTF Effluent				<0.52	<0.2	1.5
GP	Greystone Pond						
WR-5	Greystone Street	<0.3	<0.3	0.3	<0.39	<0.3	0.8
WR-6	Route 44, Centerdale	<0.3	<0.2	<0.3	<0.33	<0.2	0.5
W2	Route 44, Centerdale				0.11	0.03	0.4
WR-7	Allendale Avenue	<0.3	<0.3	<0.3	<0.58	<0.3	1.2
WR-7a	Assapumpset Brook	<0.5	<0.3	0.8	<0.67	<0.3	1.1
LP	Lymansville Pond						
WR-7b	Lymansville Dam	<0.4	<0.3	0.7	<0.35	<0.3	0.5
R1	Manton Dam				<5.00	<5.0	<5.0
WR-8	Manton Avenue	<0.4	<0.3	0.7	<0.38	<0.3	0.7
R2	Manton Avenue				<5.00	<5.0	<5.0
WOONUP	Manton Avenue						
S-9	Manton Avenue						
WR-9aa	Lincoln Lace & Braid	<0.4	<0.3	0.7	<0.40	<0.3	0.7
WR-9ab	Lincoln Lace & Braid						
WR-9ac	Lincoln Lace & Braid				<0.45	<0.3	0.7
WR-9	Dyerville Complex	<0.4	<0.3	0.8	<0.40	<0.3	1.0
W6	Killingly Interchange Stormdrain						
WR-10	Merino Park	<0.3	<0.3	0.6	<0.35	<0.3	0.5
WR-10a	Riverside Mills						
WR-11	Olneyville Square	<0.4	<0.3	0.7	<0.43	<0.3	1.1
Cadmium	Olneyville Square						
WR-12	Delanie Street	<0.4	<0.3	0.7	<0.33	<0.30	0.5
WR-13	Valley Street	<0.4	<0.3	0.7	<0.51	<0.30	2.0
R3	Valley Street				<5.00	<5.00	<5.00
WOON	Valley Street	0.3	0.1	0.5	0.48	0.1	1.0
WOONDN	Valley Street						
S-8b	Valley Street						
W1	Valley Street				0.18	0.0	3.0
WR-14	Atwells Avenue	<0.4	<0.3	0.8	<0.35	<0.30	0.7
R4	Atwells Avenue				<5.00	<5.00	6.0
S-8	Atwells Avenue						
WR-15	Bath Street	<0.4	<0.3	0.8	<0.31	<0.30	0.4
W23	Civic Center Stormdrain						
WR-16	Exchange Street	<0.4	<0.3	0.7	<0.43	<0.30	0.8
S-7	Exchange Street						

(*) Without data sampling event on August 12, 1998.

Dissolved Metals Criteria

Metal	Acute Criteria (ug/l) Hardness (mg/l as $CaCO_3$)			Chronic Criteria (ug/l) Hardness (mg/l as $CaCO_3$)		
	25.0	35.0	45.0	25.0	35.0	45.0
Cadmium	0.8	1.2	1.6	0.4	0.5	0.6

Figure 4-80

Cadmium Concentrations - Wet Weather Data

Dissolved Cadmium (ug/l)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam															
S-9	Manton Avenue															
R2	Manton Avenue															
WOONUP	Manton Avenue															
S-8a	Olneyville Square															
W6	Killingly Interch. Drain															
S-8b	Valley Street															
R3	Valley Street															
WOON	Valley Street	0.29	0.17	0.12	0.25	0.08	0.08	0.09	0.04	0.02	0.03	0.5	0.33	0.24	0.86	0.11
WOONDN	Valley Street															
S-8	Atwells Avenue															
R4	Atwells Avenue															
S-7	Exchange Street															
W23	Civic Center Drain															

Dissolved Metals Criteria

	Acute Criteria (ug/l)			Chronic Criteria (ug/l)		
	Hardness (mg/l as $CaCO_3$)			Hardness (mg/l as $CaCO_3$)		
Metal	25.0	35.0	45.0	25.0	35.0	45.0
Cadmium	0.8	1.2	1.6	0.4	0.5	0.6

Total Cadmium (ug/l)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam	<5.0	<5.0				<5.0	<5.0				<5.0	<5.0			
S-9	Manton Avenue															
R2	Manton Avenue	<5.0	<5.0				<5.0	<5.0				<5.0	<5.0			
WOONUP	Manton Avenue															
S-8a	Olneyville Square															
W6	Killingly Interch. Drain							0.1					3.7			
S-8b	Valley Street															
R3	Valley Street	<5.0	<5.0				<5.0	<5.0				<5.0	<5.0			
WOON	Valley Street	0.7	0.6	0.5	0.7	0.7	0.3	0.1	0.1	0.3	0.2	1.0	1.3	1.2	1.3	1.2
WOONDN	Valley Street															
S-8	Atwells Avenue															
R4	Atwells Avenue	<5.0	<5.0				<5.0	<5.0				6.0	<5.0			
S-7	Exchange Street															
W23	Civic Center Drain							0.2					3.7			

Figure 4-81

Dissolved Cadmium Concentration (NBC, 1998)

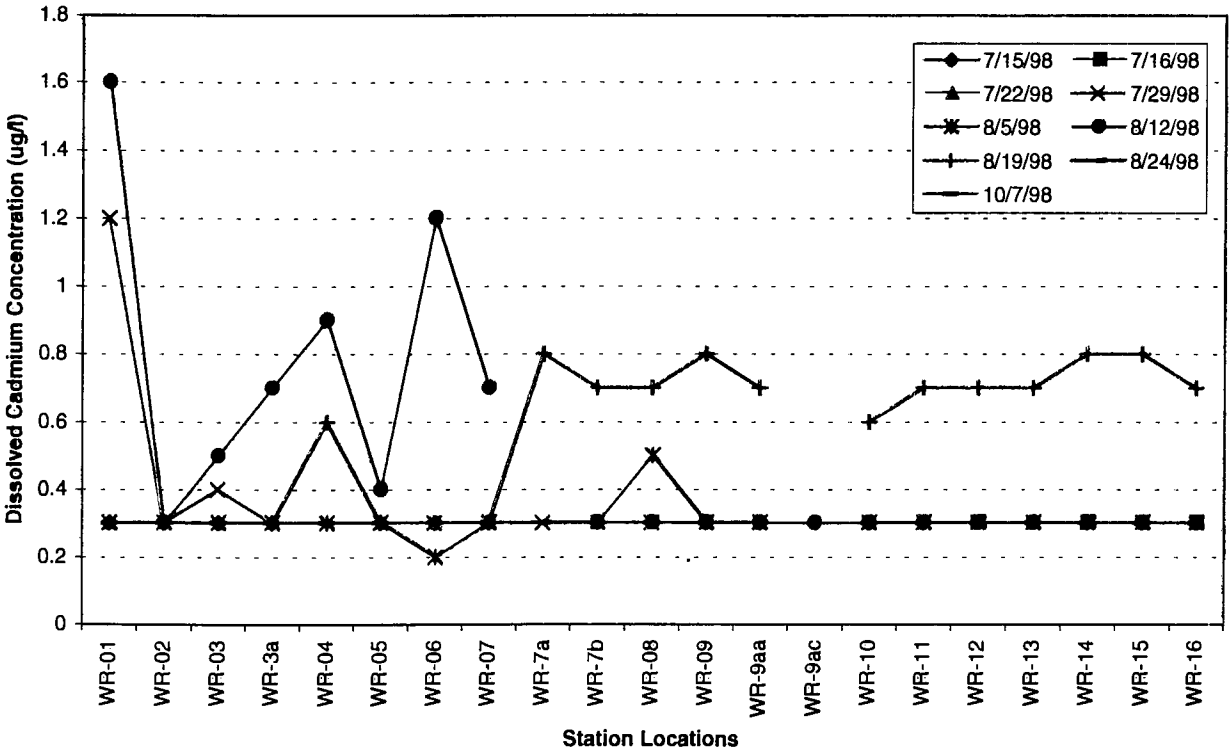

Figure 4-82

Total Cadmium Concentration (NBC, 1998)

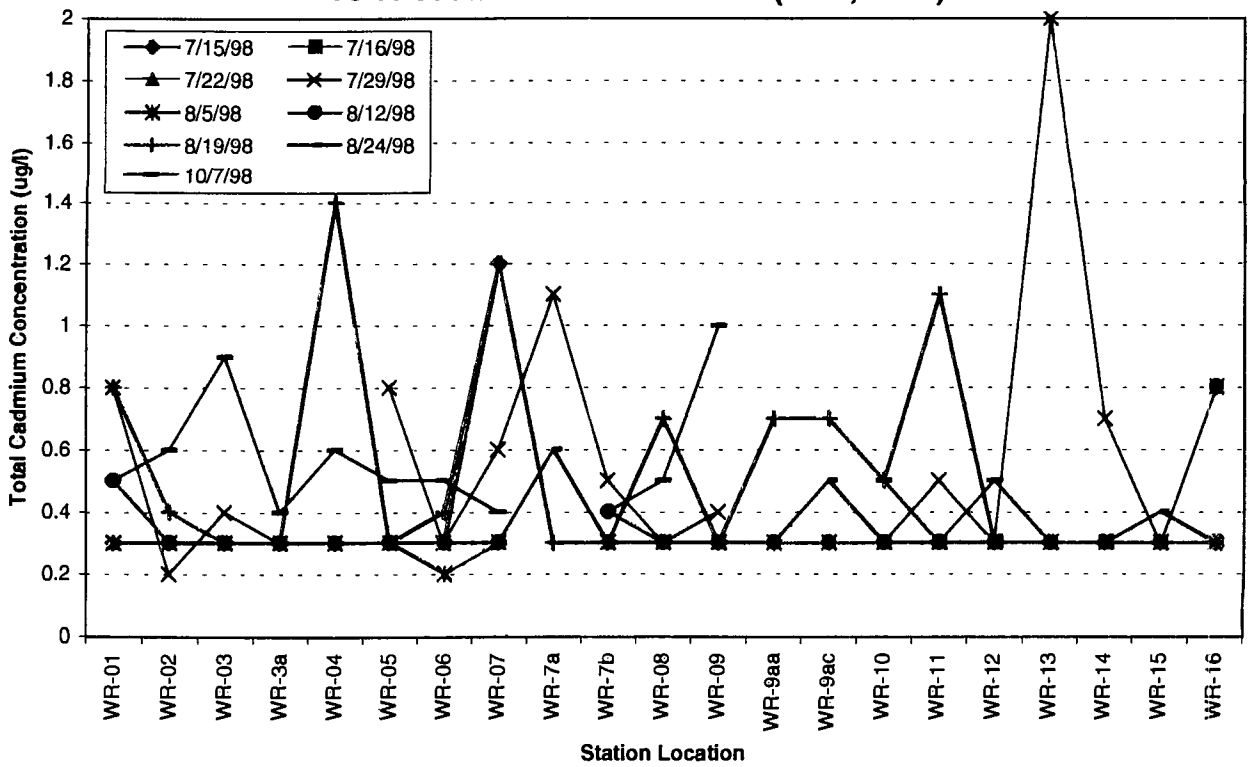

Figure 4-83

Dissolved Cadmium - Statistics (NBC, 1998) *(without 8/12/98 data)*

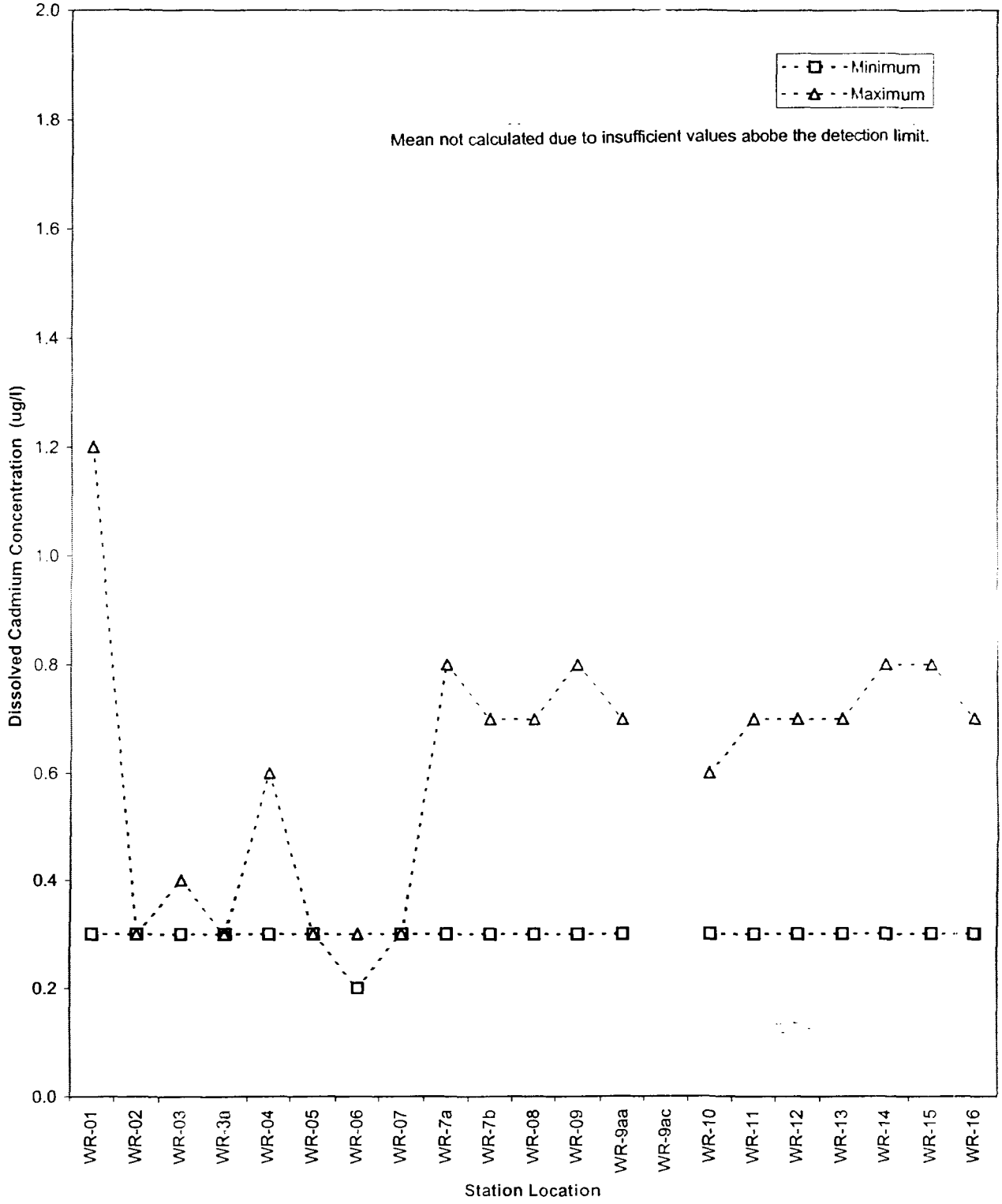

Figure 4-84

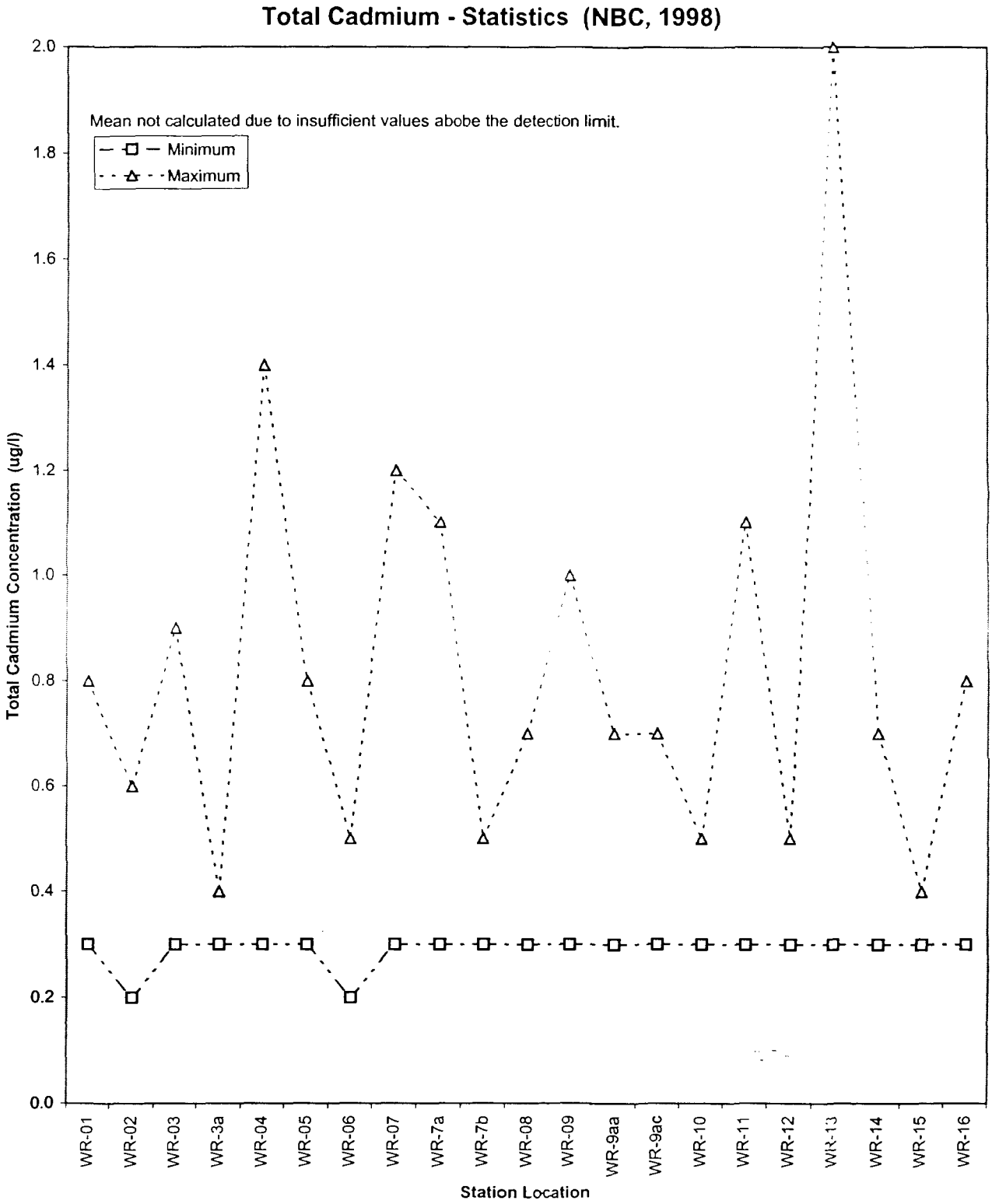
Total Cadmium - Statistics (NBC, 1998)
Mean not calculated due to insufficient values abobe the detection limit.
Minimum
Maximum
Total Cadmium Concentration (ug/l)
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
WR-01
WR-02
WR-03
WR-3a
WR-04
WR-05
WR-06
WR-07
WR-7a
WR-7b
WR-08
WR-09
WR-9aa
WR-9ac
WR-10
WR-11
WR-12
WR-13
WR-14
WR-15
WR-16
Station Location

Figure 4-85

Total Cadmium Concentration - Station W2 (Route 44)

(Kerr and Lee, 1996)

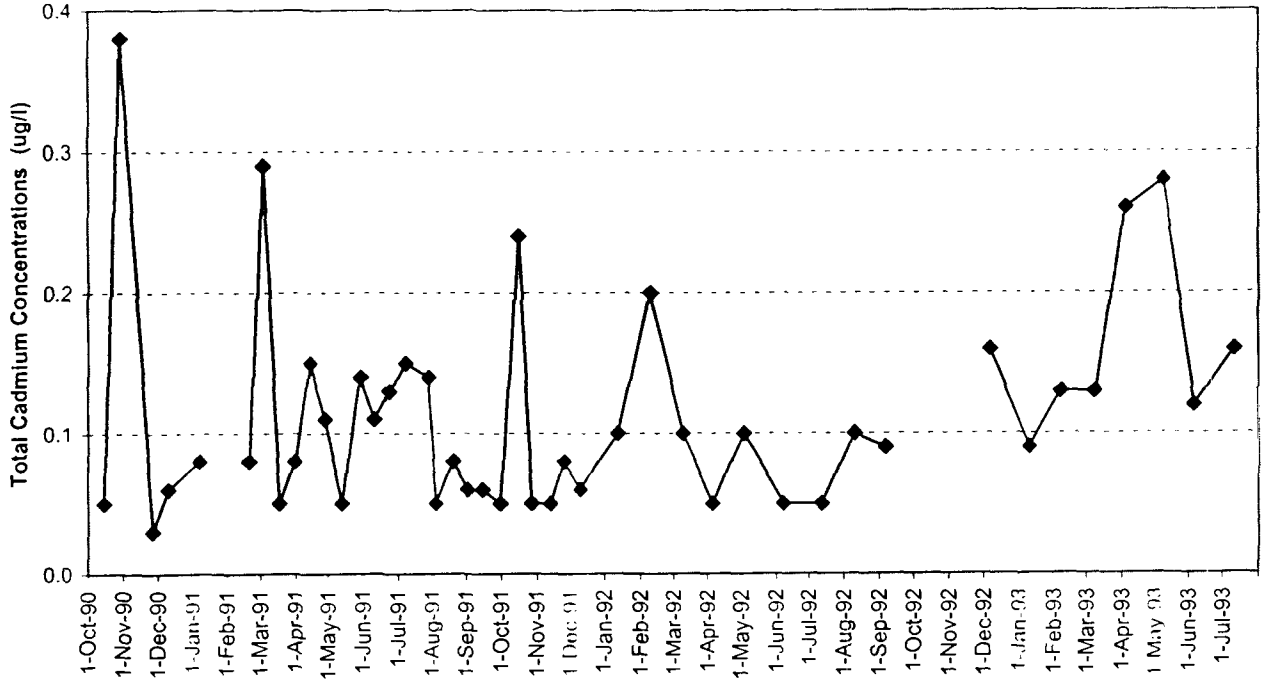

Figure 4-86

Total Cadmium Concentration -Station W1 (Valley Street)

(Kerr and Lee, 1996)

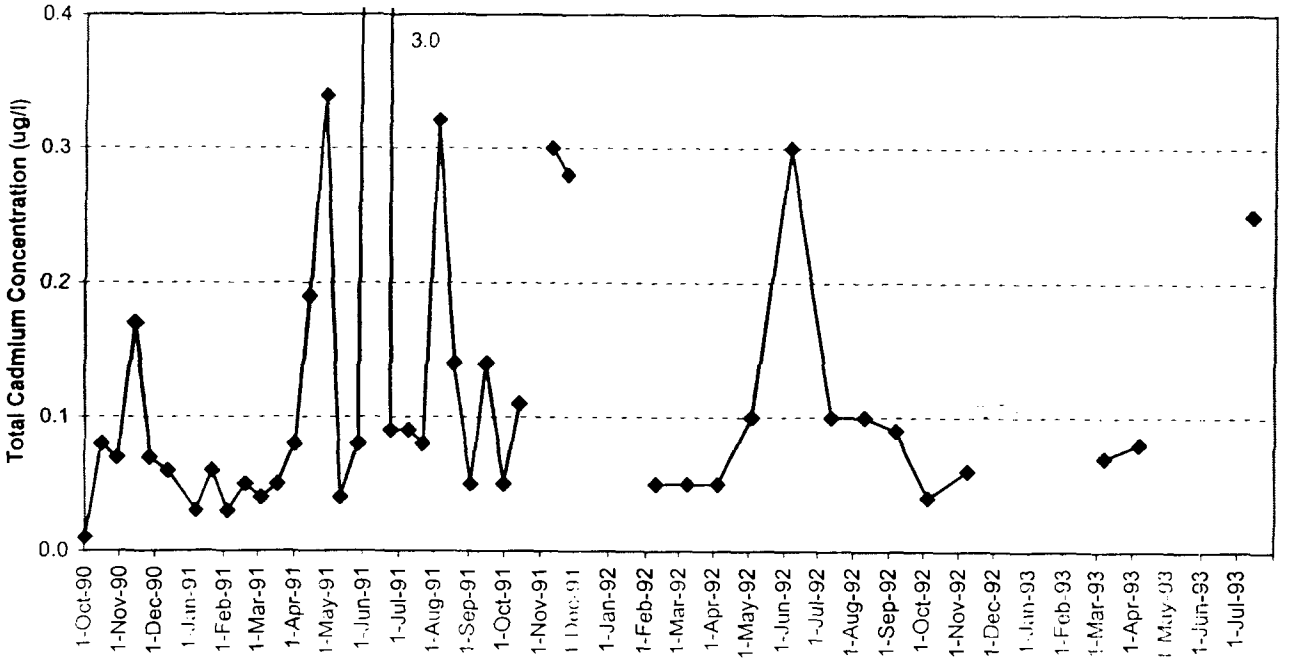

Figure 4-87

Chromium Concentrations - Dry Weather Data

Station No.	Location	Dissolved Chromium (ug/l) Mean	Minimum	Maximum	Total Chromium (ug/l) Mean	Minimum	Maximum
WR-1	Stillwater Reservoir Dam	<1.7	<0.8	3.7	<2.2	<0.8	3.8
WR-2	Capron Road	<1.2	<0.8	2.4	1.3	0.8	2.8
WR-3	Sri Chimroy Peace Bridge	<2.7	<0.8	13.1	<1.8	<0.8	4.8
WR-3a	Esmond Mill Drive	<1.1	<0.8	1.5	<1.4	<0.8	2.6
EMD	Esmond Mill Drive						
WR-4	Smithfield WWTF Effluent	<1.1	<0.8	1.7	<1.5	<0.8	2.3
WWTF	Smithfield WWTF Effluent				<1.5	<0.8	2.3
GP	Greystone Pond						
WR-5	Greystone Street	<1.5	<0.8	3.1	<2.6	<0.8	10.7
WR-6	Route 44, Centerdale	<1.1	<0.8	2.2	<2.1	<0.8	4.0
W2	Route 44, Centerdale				0.8	0.2	2.5
WR-7	Allendale Avenue	<1.3	<0.8	2.8	<3.5	<0.8	13.5
WR-7a	Assapumpset Brook	<2.0	<0.8	4.4	<1.6	<0.8	2.2
LP	Lymansville Pond						
WR-7b	Lymansville Dam	<1.6	<0.8	3.4	2.3	0.8	4.0
R1	Manton Dam				<50.0	<50.0	<50.0
WR-8	Manton Avenue	<1.4	<0.8	3.6	<2.0	<0.8	5.0
R2	Manton Avenue				<50.0	<50.0	<50.0
WOONUP	Manton Avenue						
S-9	Manton Avenue						
WR-9aa	Lincoln Lace & Braid	<0.9	<0.8	1.1	2.1	1.8	2.6
WR-9ab	Lincoln Lace & Braid						
WR-9ac	Lincoln Lace & Braid	0.8			<1.1	<0.8	1.3
WR-9	Dyerville Complex	<1.3	<0.8	2.5	2.0	0.8	3.4
W6	Killingly Interchange Stormdrain						
WR-10	Merino Park	<1.6	<0.8	3.4	<2.3	<0.8	4.1
WR-10a	Riverside Mills						
WR-11	Olneyville Square	<1.5	<0.8	2.7	2.9	0.8	7.0
S-8a	Olneyville Square						
WR-12	Delanie Street	<1.5	<0.8	2.5	<2.5	<0.8	5.1
WR-13	Valley Street	<1.4	<0.8	2.5	2.6	0.4	7.0
R3	Valley Street				<50.0	<50.0	<50.0
WOON	Valley Street	0.84	0.2	1.76	2.8	2.3	3.3
WOONDN	Valley Street						
S-8b	Valley Street						
W1	Valley Street				0.9	0.2	4.2
WR-14	Atwells Avenue	<1.9	<0.8	5	1.9	1.1	2.9
R4	Atwells Avenue				<50.0	<50.0	<50.0
S-8	Atwells Avenue						
WR-15	Bath Street	<2.1	0.8	3.1	3.5	0.8	6.3
W23	Civic Center Stormdrain						
WR-16	Exchange Street	<2.1	<0.8	4	<3.7	<0.8	6.5
S-7	Exchange Street						

Dissolved Metals Criteria

Metal	Acute Criteria (ug/l) Hardness (mg/l as $CaCO_3$) 25.0	35.0	45.0	Chronic Criteria (ug/l) Hardness (mg/l as $CaCO_3$) 25.0	35.0	45.0
Chromium III	176.3	232.3	285.3	57.2	75.3	92.6
Chromium VI	15.0	15.0	15.0	10.0	10.0	10.0

Figure 4-88

Chromium Concentrations - Wet Weather Data

Dissolved Chromium (ug/l)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam															
S-9	Manton Avenue															
R2	Manton Avenue															
WOONUP	Manton Avenue															
S-8a	Olneyville Square															
W6	Killingly Interch. Drain															
S-8b	Valley Street															
R3	Valley Street															
WOON	Valley Street	0.84	1.07	0.81	1.29	0.41	0.20	0.12	0.12	0.12	0.12	1.80	2.54	2.04	4.72	0.65
WOONDN	Valley Street															
S-8	Atwells Avenue															
R4	Atwells Avenue															
S-7	Exchange Street															
W23	Civic Center Drain															

Dissolved Metals Criteria

	Acute Criteria (ug/l)			Chronic Criteria (ug/l)		
	Hardness (mg/l as $CaCO_3$)			Hardness (mg/l as $CaCO_3$)		
Metal	25.0	35.0	45.0	25.0	35.0	45.0
Chromium III	176.3	232.3	285.3	57.2	75.3	92.6
Chromium VI	15.0	15.0	15.0	10.0	10.0	10.0

Total Chromium (ug/l)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam	<50.0	<50.0				<50.0	<50.0				<50.0	<50.0			
S-9	Manton Avenue															
R2	Manton Avenue	<50.0	<50.0				<50.0	<50.0				<50.0				
WOONUP	Manton Avenue															
S-8a	Olneyville Square															
W6	Killingly Interch. Drain							0.1					29.6			
S-8b	Valley Street															
R3	Valley Street	<50.0	<50.0				<50.0	<50.0				<50.0	<50.0			
WOON	Valley Street	2.8	4.2	2.6	2.3	2.8	2.3	2.3	2.0	1.6	2.6	3.3	5.4	3.6	3.2	3.0
WOONDN	Valley Street															
S-8	Atwells Avenue															
R4	Atwells Avenue	<50.0	<50.0				<50.0	<50.0				<50.0	<50.0			
S-7	Exchange Street															
W23	Civic Center Drain							0.1					93.4			

Figure 4-89

Dissolved Chromium Concentration (NBC, 1998)

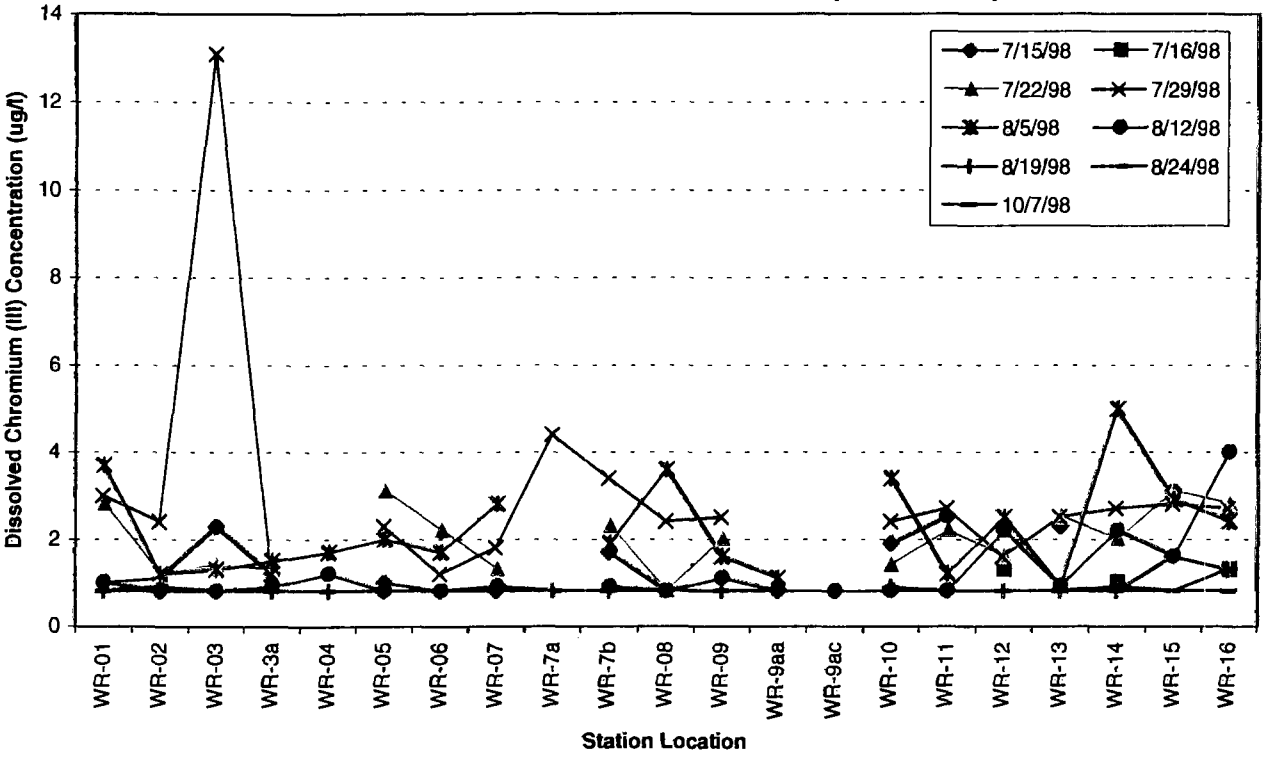

Figure 4-90

Total Chromium Concentration (NBC, 1998)

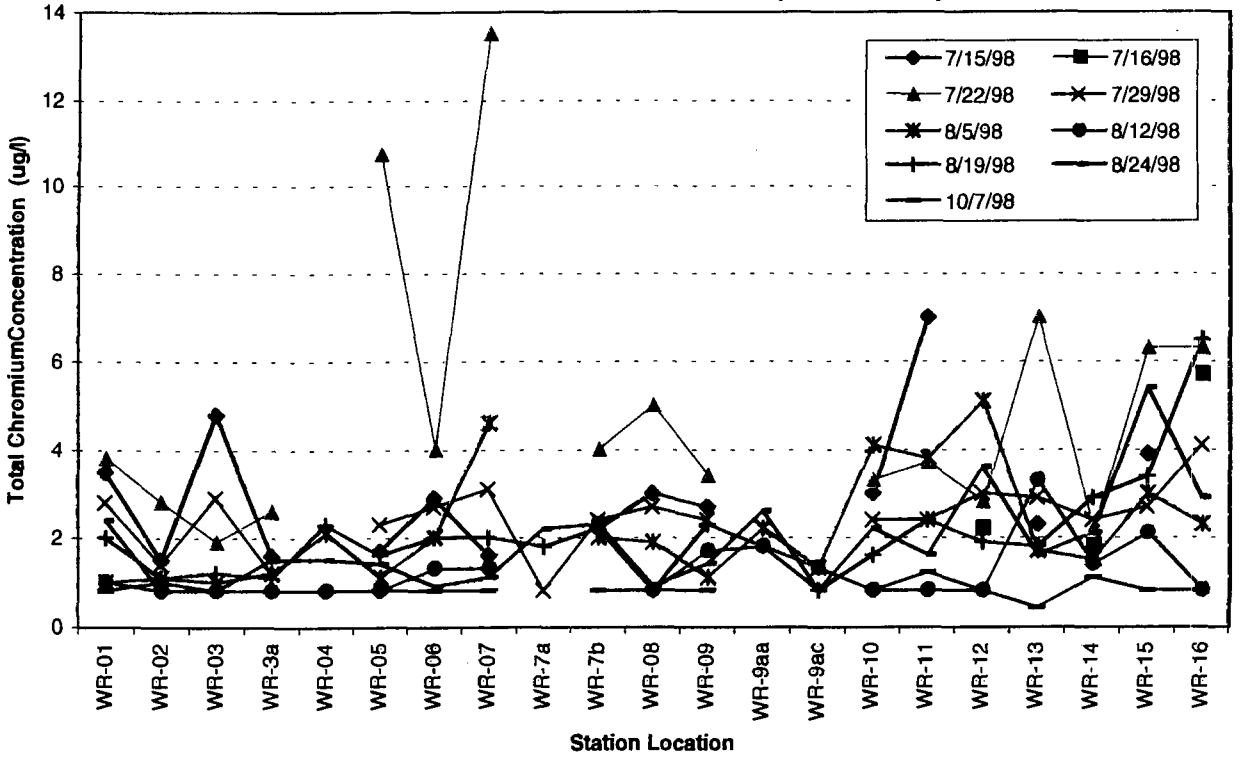

Figure 4-91

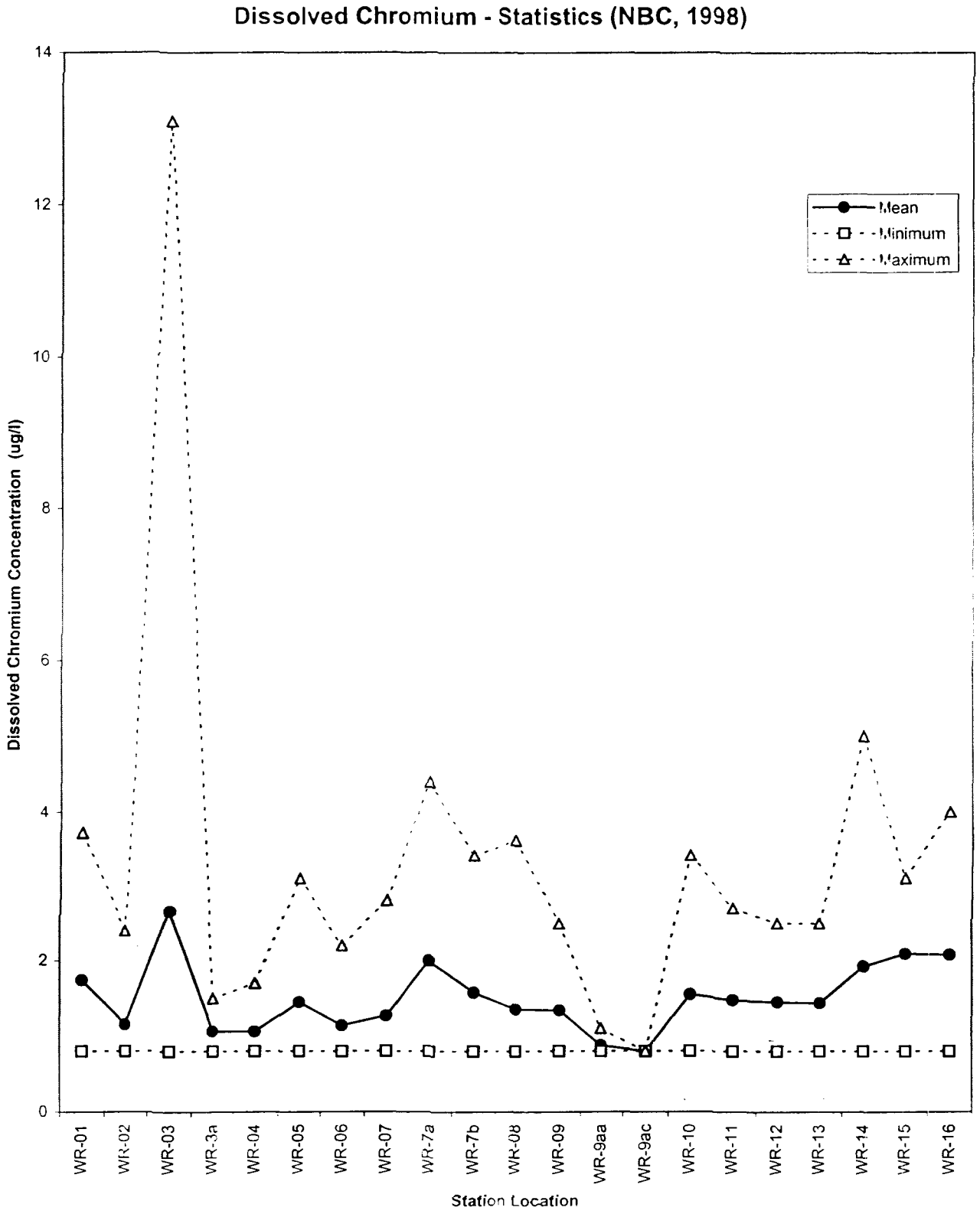
Dissolved Chromium - Statistics (NBC, 1998)
Dissolved Chromium Concentration (ug/l)
14
12
10
8
6
4
2
0
Mean
Minimum
Maximum
WR-01
WR-02
WR-03
WR-3a
WR-04
WR-05
WR-06
WR-07
WR-7a
WR-7b
WR-08
WR-09
WR-9aa
WR-9ac
WR-10
WR-11
WR-12
WR-13
WR-14
WR-15
WR-16
Station Location

Figure 4-92

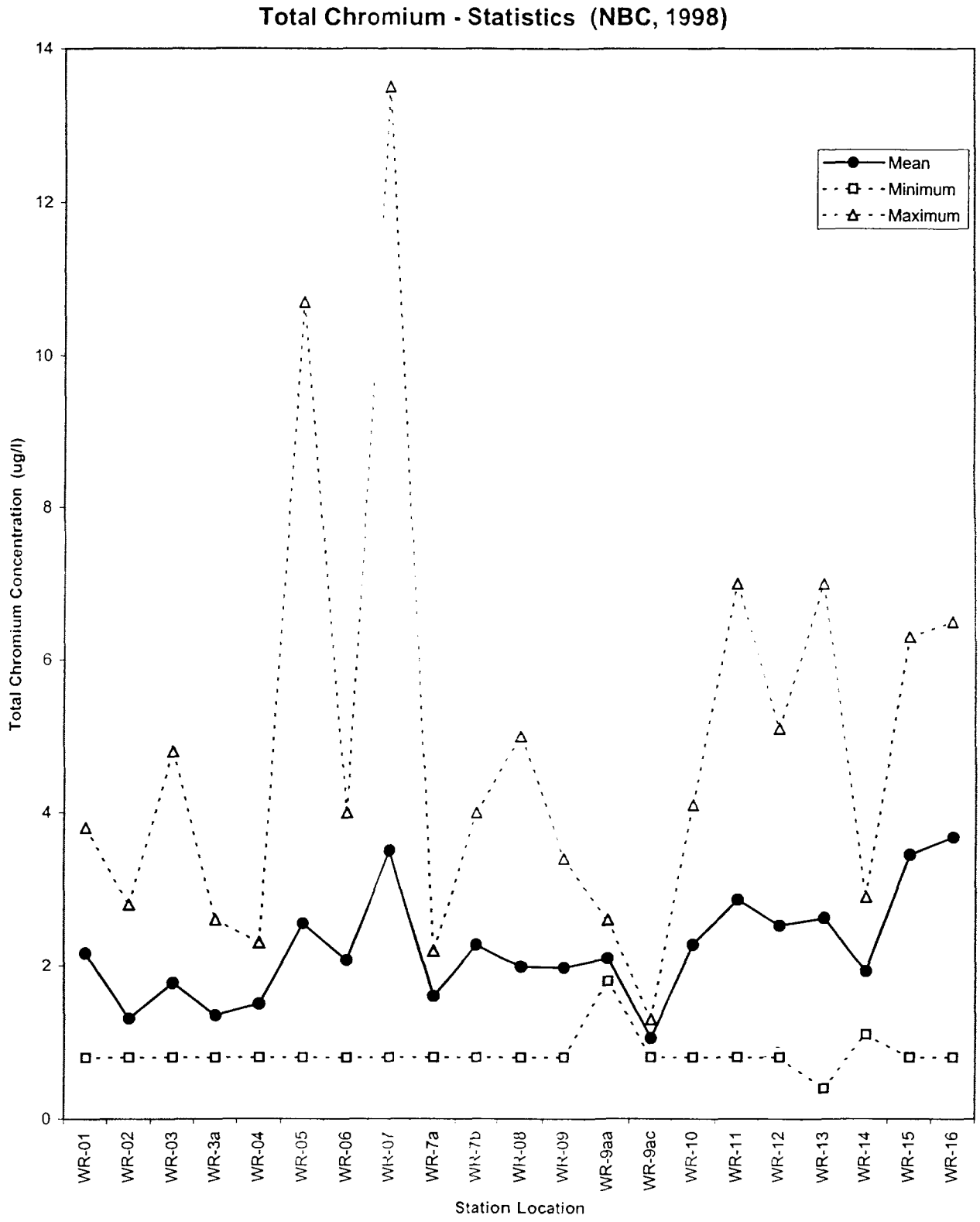
Total Chromium - Statistics (NBC, 1998)
Mean
Minimum
Maximum
Total Chromium Concentration (ug/l)
0
2
4
6
8
10
12
14
WR-01
WR-02
WR-03
WR-3a
WR-04
WR-05
WR-06
WR-07
WR-7a
WR-7b
WR-08
WR-09
WR-9aa
WR-9ac
WR-10
WR-11
WR-12
WR-13
WR-14
WR-15
WR-16
Station Location

Figure 4-93

Total Chromium Concentration - Station W2 (Route 44)

(Kerr and Lee, 1996)

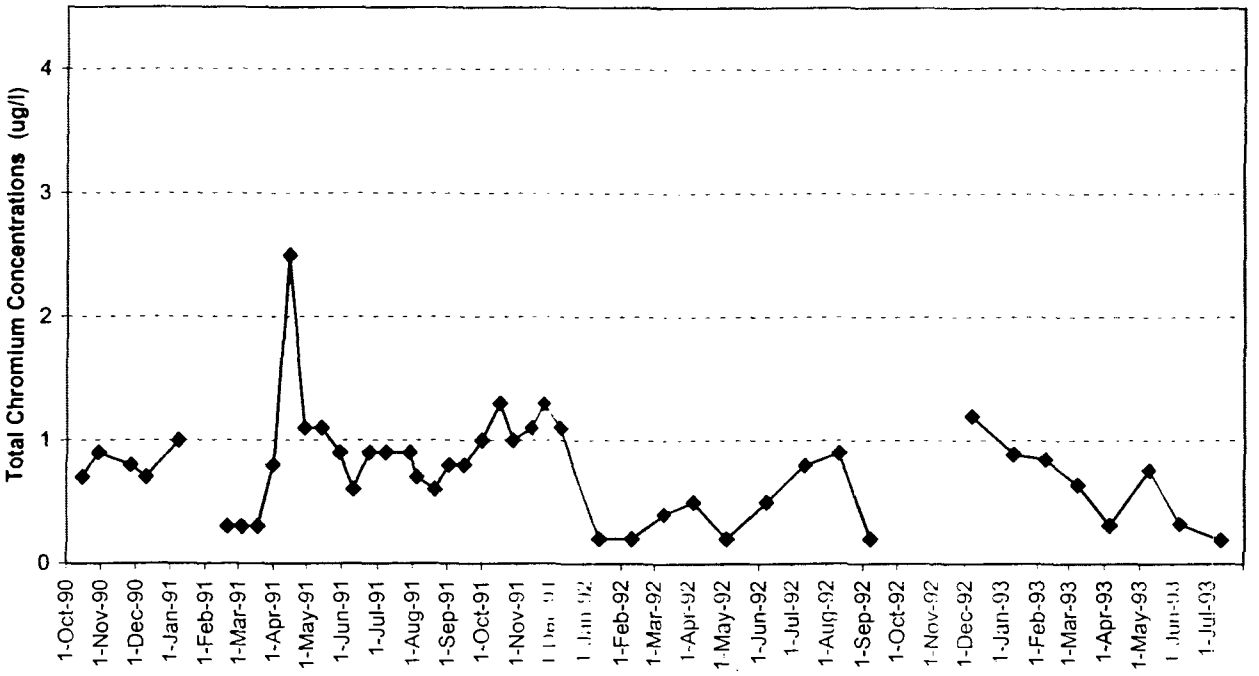

Figure 4-94

Total Chromium Concentration -Station W1 (Valley Street)

(Kerr and Lee, 1996)

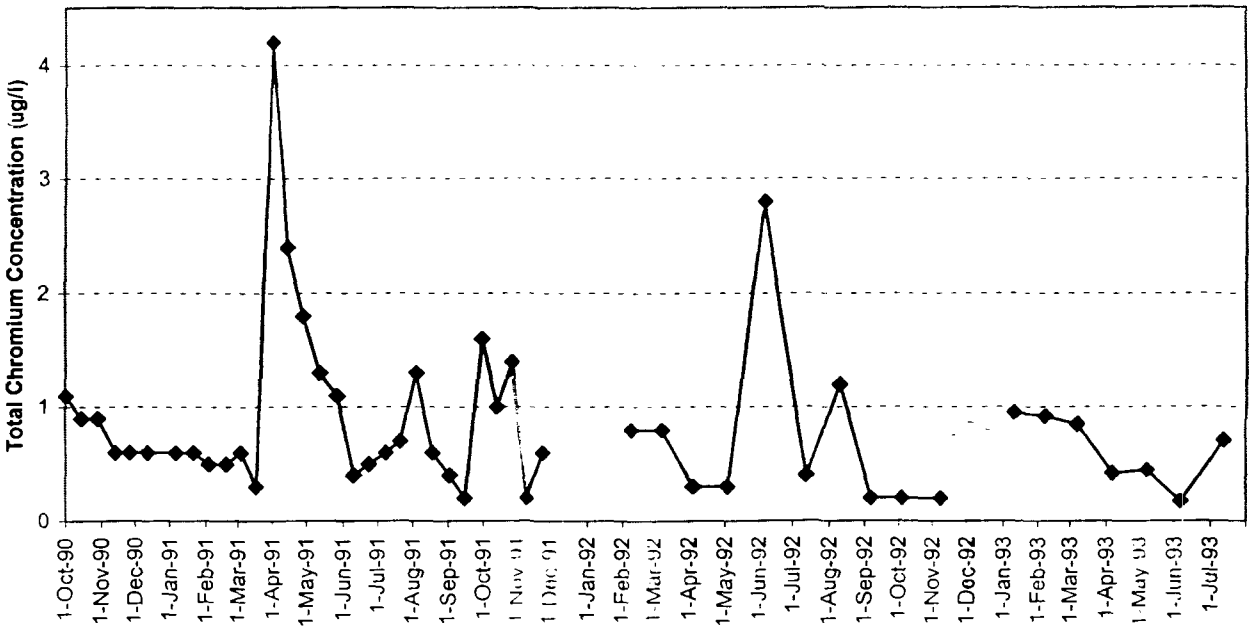

Figure 4-95

Copper Concentrations - Dry Weather Data

Station No.	Location	Dissolved Copper (ug/l) Mean	Minimum	Maximum	Total Copper (ug/l) Mean	Minimum	Maximum
WR-1	Stillwater Reservoir Dam	**<3.1**	<1.9	7	**4.9**	1.6	11.6
WR-2	Capron Road	**<2.7**	<2.1	4.2	**<3.5**	<2.1	6.0
WR-3	Sri Chimroy Peace Bridge	**<2.6**	<2.1	4.6	**<3.3**	1.6	9.0
WR-3a	Esmond Mill Drive	**<2.5**	<1.9	5	**<2.8**	<2.1	4.7
EMD	Esmond Mill Drive						
WR-4	Smithfield WWTF Effluent	**13.9**	11	15.3	**13.4**	3.8	21.1
WWTF	Smithfield WWTF Effluent				**14.7**	2.5	36.3
GP	Greystone Pond						
WR-5	Greystone Street	**<3.2**	<2.1	5.1	**<3.5**	<2.1	5.6
WR-6	Route 44, Centerdale	**<3.8**	<2.1	7.4	**5.1**	2.8	10.8
W2	Route 44, Centerdale				**4.7**	1.1	13.4
WR-7	Allendale Avenue	**<3.7**	<2.1	6.4	**6.4**	2.4	15.2
WR-7a	Assapumpset Brook	**3.4**	2.7	4.2	**<3.8**	<2.10	5.8
LP	Lymansville Pond						
WR-7b	Lymansville Dam	**<6.2**	<2.1	26.3	**4.6**	2.6	7.1
R1	Manton Dam				**<22.0**	<20.0	30.0
WR-8	Manton Avenue	**<3.2**	<2.1	4.7	**<4.8**	<2.10	10.1
R2	Manton Avenue				**<20.0**	<20.0	<20.0
WOONUP	Manton Avenue				**3.8**	2.9	4.7
S-9	Manton Avenue						
WR-9aa	Lincoln Lace & Braid	**3.3**	2.4	4	**5.2**	3.1	9.7
WR-9ab	Lincoln Lace & Braid						
WR-9ac	Lincoln Lace & Braid				**2.7**	2.1	3.8
WR-9	Dyerville Complex	**<4.6**	<2.1	11	**4.7**	2.5	9.4
W6	Killingly Interchange Stormdrain						
WR-10	Merino Park	**<5.3**	<2.1	14.6	**3.8**	2.5	6.6
WR-10a	Riverside Mills						
WR-11	Olneyville Square	**<3.9**	<2.1	6.7	**4.6**	2.3	7.4
S-8a	Olneyville Square						
WR-12	Delanie Street	**<4.5**	<2.1	12.1	**4.2**	2.8	6.1
WR-13	Valley Street	**4.4**	2.1	8.1	**5.2**	3.4	10.7
R3	Valley Street				**<20.0**	<20.0	<20.0
WOON	Valley Street	**9**	2.6	21	**10.8**	3.4	25.1
WOONDN	Valley Street				**3.9**	3.0	4.7
S-8b	Valley Street						
W1	Valley Street				**4.2**	0.5	21.4
WR-14	Atwells Avenue	**5.1**	2.1	13.4	**5.4**	2.9	9.5
R4	Atwells Avenue				**<20.0**	<20.0	<20.0
S-8	Atwells Avenue						
WR-15	Bath Street	**<5.0**	<2.1	8	**5.8**	2.9	14.1
W23	Civic Center Stormdrain						
WR-16	Exchange Street	**<5.2**	<2.1	10.7	**6.3**	3.5	13.0
S-7	Exchange Street						

Dissolved Metals Criteria

Metal	Acute Criteria (ug/l) Hardness (mg/l as $CaCO_3$) 25.0	35.0	45.0	Chronic Criteria (ug/l) Hardness (mg/l as $CaCO_3$) 25.0	35.0	45.0
Copper	4.6	6.3	8.0	3.5	4.6	5.7

Figure 4-96

Copper Concentrations - Wet Weather Data

Dissolved Copper (ug/l)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam															
S-9	Manton Avenue															
R2	Manton Avenue															
WOONUP	Manton Avenue															
S-8a	Olneyville Square															
W6	Killingly Interch. Drain															
S-8b	Valley Street															
R3	Valley Street															
WOON	Valley Street	9.0	9.8	4.2	4.5	2.5	2.6	3.3	2.3	2.0	1.9	21.0	33.2	12.8	12.5	3.2
WOONDN	Valley Street															
S-8	Atwells Avenue															
R4	Atwells Avenue															
S-7	Exchange Street															
W23	Civic Center Drain															

Dissolved Metals Criteria

	Acute Criteria (ug/l)			Chronic Criteria (ug/l)		
	Hardness (mg/l as $CaCO_3$)			Hardness (mg/l as $CaCO_3$)		
Metal	25.0	35.0	45.0	25.0	35.0	45.0
Copper	4.6	5.3	5.0	3.5	4.6	5.7

Total Copper (ug/l)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam	<22.0	<20.0				<20.0	<20.0				30.0	20.0			
S-9	Manton Avenue															
R2	Manton Avenue	<20.0	<20.0				<20.0	<20.0				<20.0	20.0			
WOONUP	Manton Avenue	3.8	4.6	3.8	3.7	3.7	2.9	3.2	2.5	3.1	3.0	4.7	7.7	6.4	4.5	4.3
S-8a	Olneyville Square															
W6	Killingly Interch. Drain							2.8					87.2			
S-8b	Valley Street															
R3	Valley Street	<20.0	<20.0				<20.0	<20.0				<20.0	<20.0			
WOON	Valley Street	10.8	14.5	6.4	6.3	3.9	3.4	6.1	4.1	3.5	3.2	25.1	35.0	14.8	15.4	5.1
WOONDN	Valley Street	3.9	9.4	4.8	3.5	3.5	3.0	2.8	3.2	1.9	3.0	4.7	22.0	8.1	4.3	3.9
S-8	Atwells Avenue															
R4	Atwells Avenue	<20.0	<40.0				<20.0	<20.0				<20.0	100.0			
S-7	Exchange Street															
W23	Civic Center Drain							4.5					83.6			

Figure 4-97

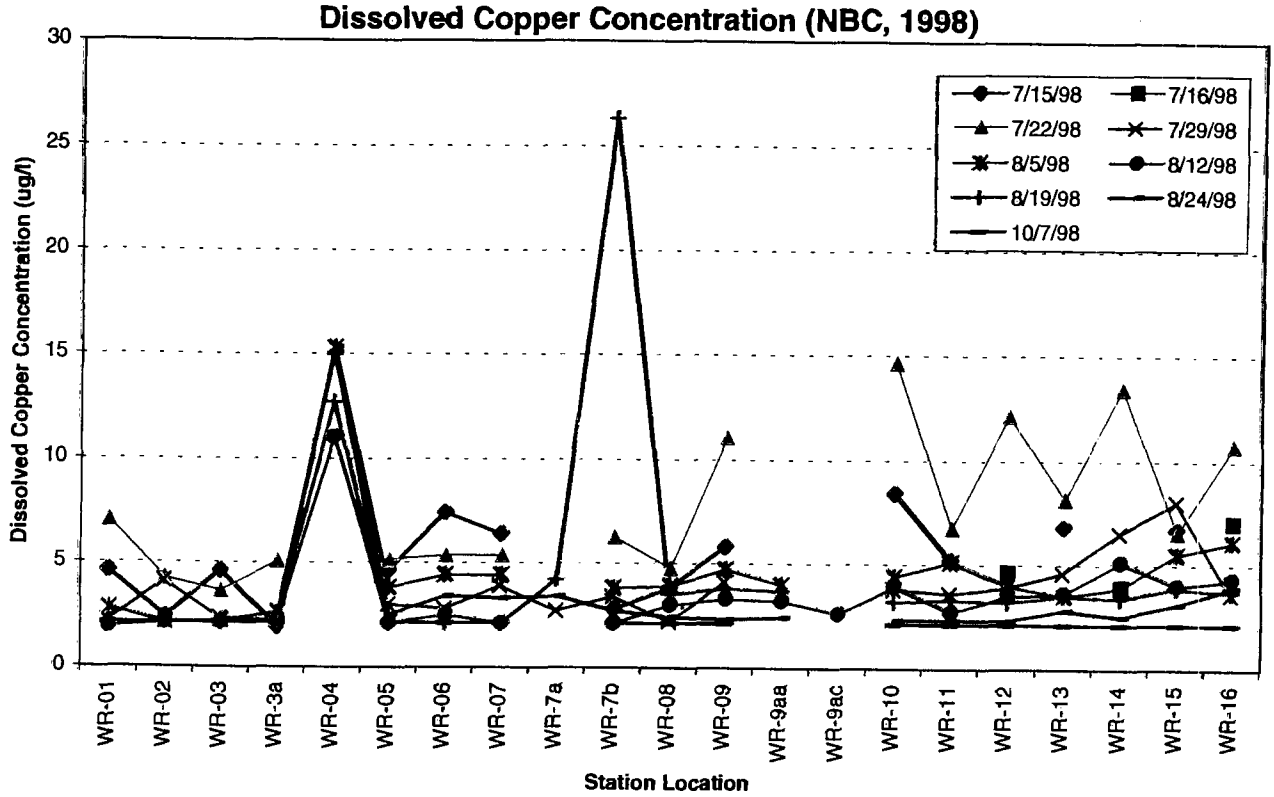

Figure 98

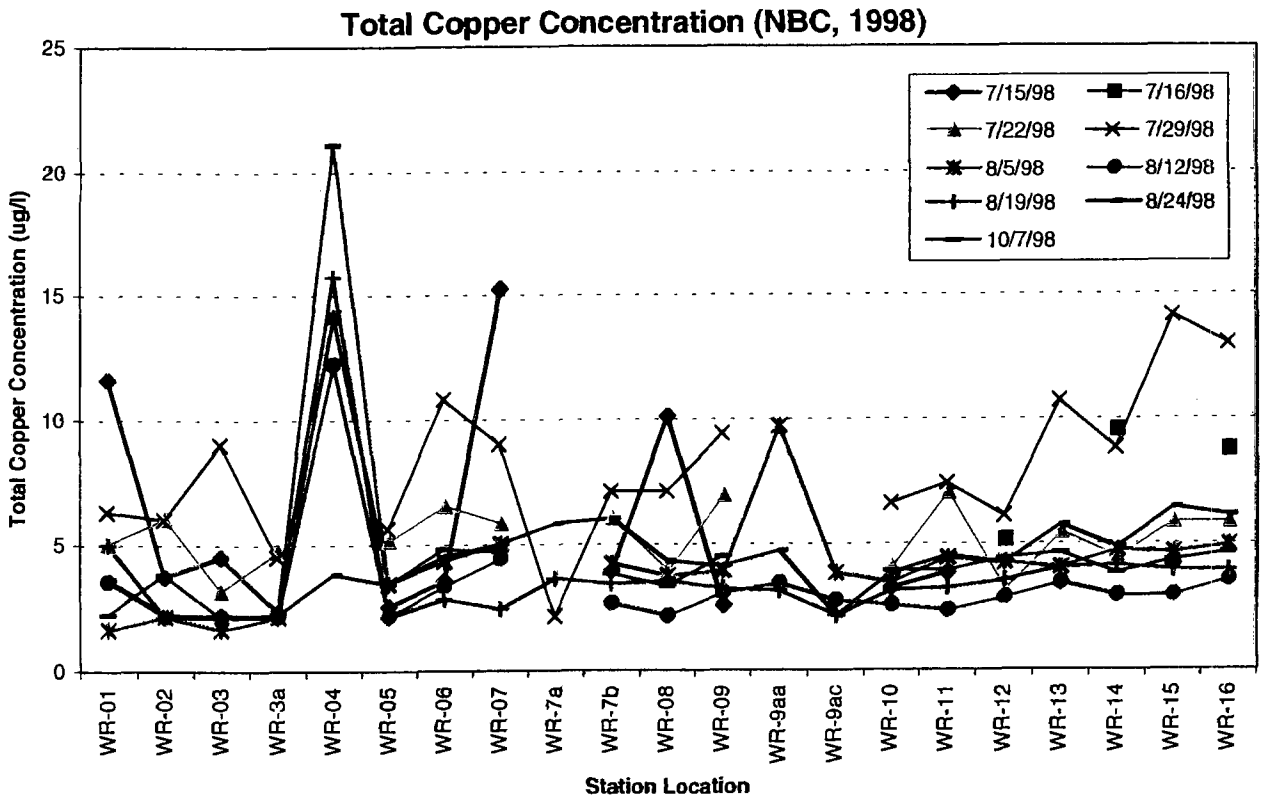

Figure 4-99

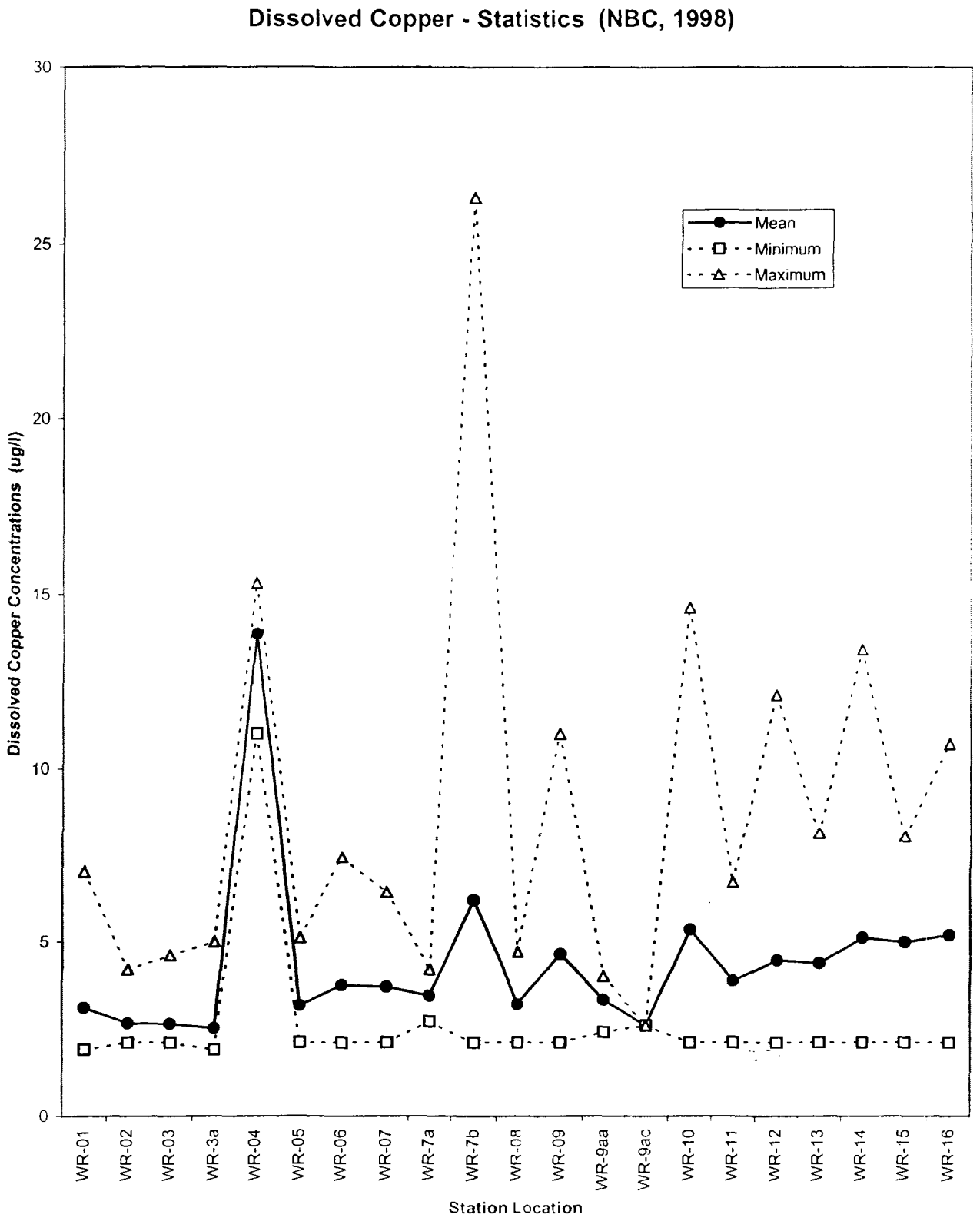
Dissolved Copper - Statistics (NBC, 1998)
Mean
Minimum
Maximum
Dissolved Copper Concentrations (ug/l)
30
25
20
15
10
5
0
WR-01
WR-02
WR-03
WR-3a
WR-04
WR-05
WR-06
WR-07
WR-7a
WR-7b
WR-08
WR-09
WR-9aa
WR-9ac
WR-10
WR-11
WR-12
WR-13
WR-14
WR-15
WR-16
Station Location

Figure 4-100

Total Copper - Statistics (NBC, 1998)

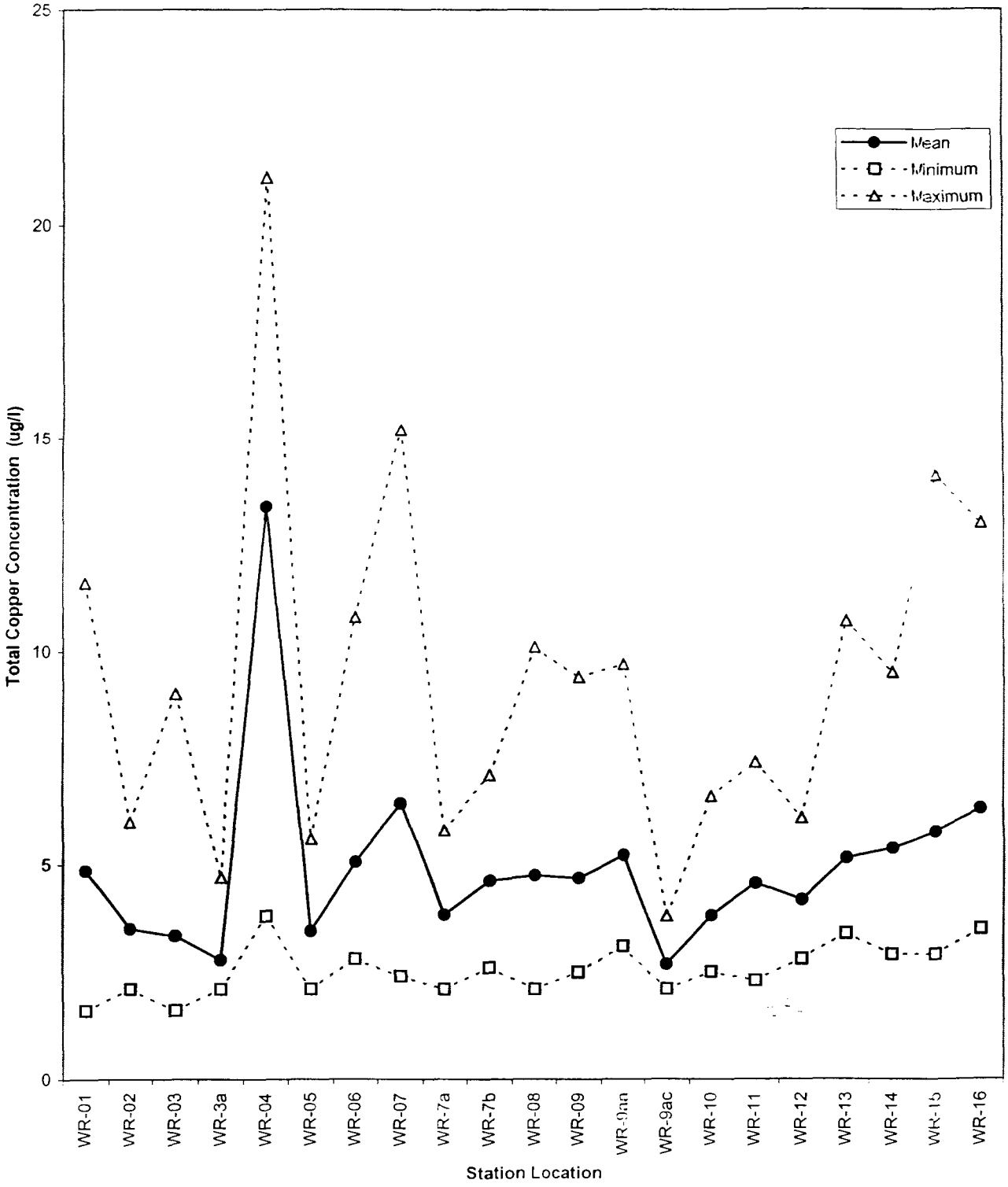

Figure 4-101
Total Copper Concentration - Station W2 (Route 44)
(Kerr and Lee, 1996)

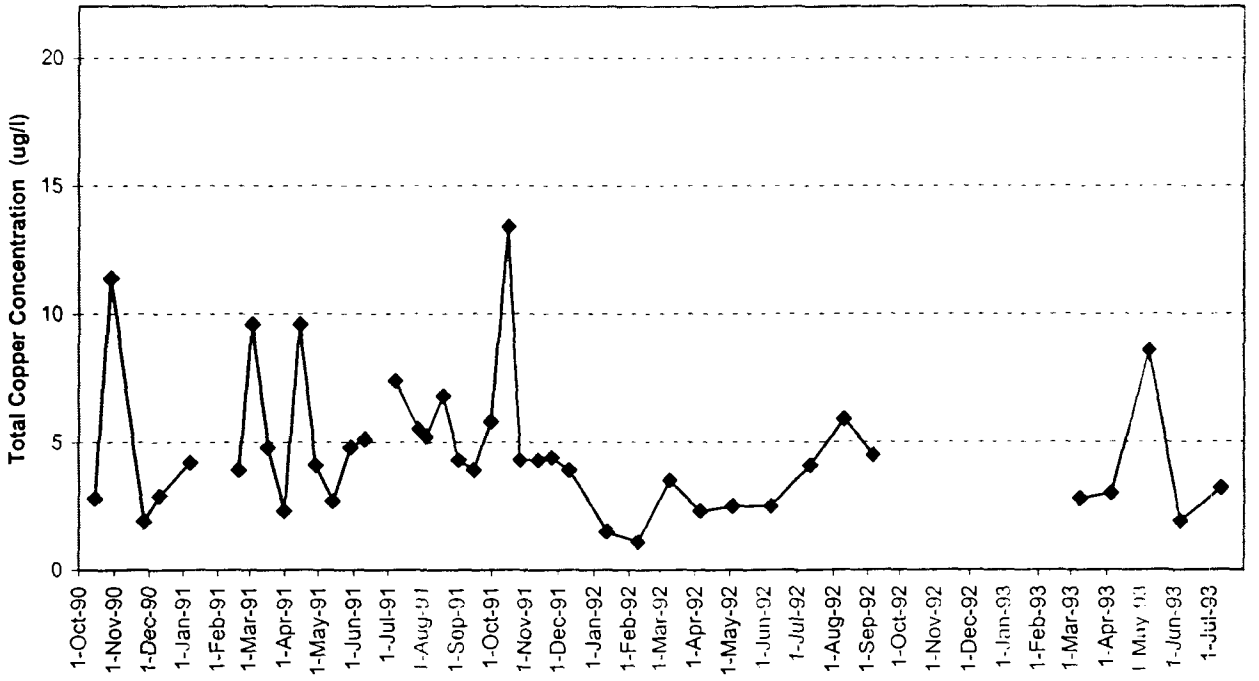

Figure 4-102
Total Copper Concentration -Station W1 (Valley Street)
(Kerr and Lee, 1996)

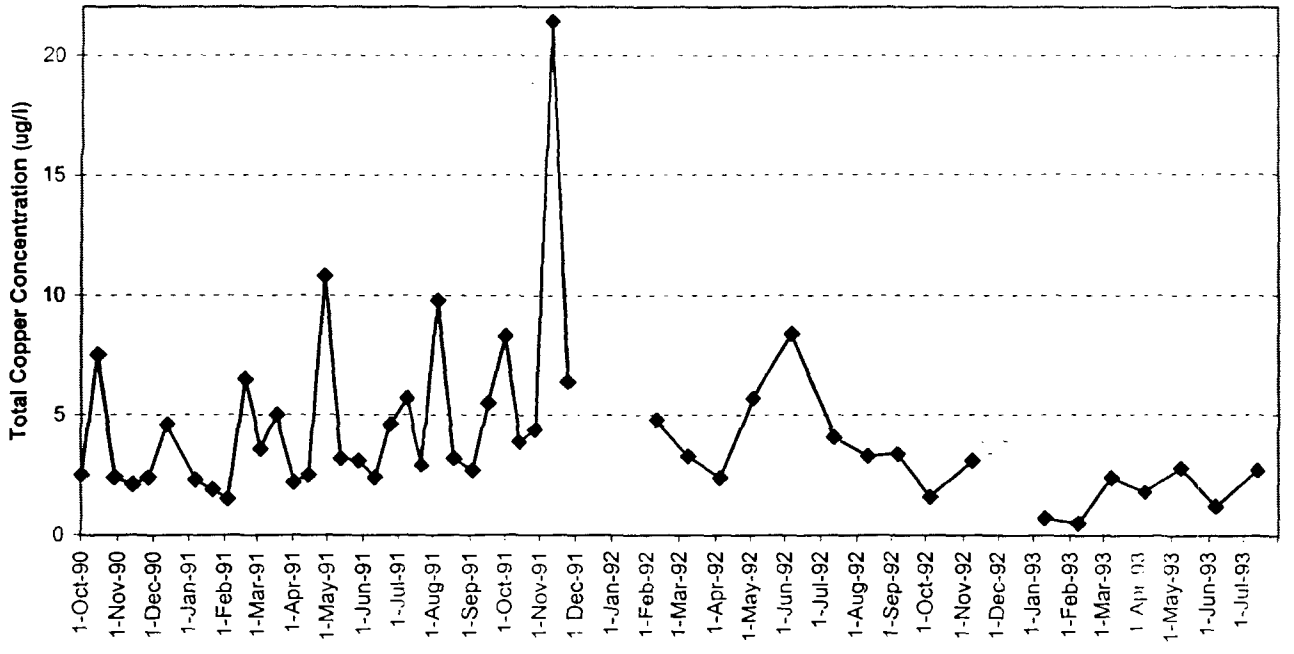

Figure 4-103

Lead Concentrations - Dry Weather Data

Station No.	Location	Dissolved Lead (ug/l) (*)			Total Lead (ug/l)		
		Mean	Minimum	Maximum	Mean	Minimum	Maximum
WR-1	Stillwater Reservoir Dam	<1.9	<1.9	2.2	<2.6	<1.9	4.2
WR-2	Capron Road	<1.9	<1.9	<1.9	<4.5	<1.9	6.8
WR-3	Sri Chimroy Peace Bridge	<2.1	<1.9	3.2	<3.8	<1.9	11
WR-3a	Esmond Mill Drive	<1.9	<1.9	<1.9	<2.8	<1.9	5.1
EMD	Esmond Mill Drive						
WR-4	Smithfield WWTF Effluent	<1.9	<1.9	1.9	<3.0	<1.9	7.4
WWTF	Smithfield WWTF Effluent				3.6	1.7	8.7
GP	Greystone Pond						
WR-5	Greystone Street	<2.0	<1.9	2.2	<2.3	<1.9	3
WR-6	Route 44, Centerdale	<2.0	<1.9	2.6	<4.6	<1.9	14.4
W2	Route 44, Centerdale				1.8	0.2	6
WR-7	Allendale Avenue	<1.9	<1.9	<1.9	<4.0	<1.9	6.6
WR-7a	Assapumpset Brook	<1.9	<1.9	<1.9	<3.1	<1.9	5.4
LP	Lymansville Pond						
WR-7b	Lymansville Dam	<2.0	<1.9	2.4	<3.6	<1.9	5.5
R1	Manton Dam				<50.0	<50.0	<50.0
WR-8	Manton Avenue	<1.9	<1.9	<1.9	<3.2	<1.9	6.2
R2	Manton Avenue				<50.0	<50.0	<50.0
WOONUP	Manton Avenue				1.1	0.6	1.3
S-9	Manton Avenue						
WR-9aa	Lincoln Lace & Braid	<1.9	<1.9	<1.9	<4.0	<1.9	7.8
WR-9ab	Lincoln Lace & Braid						
WR-9ac	Lincoln Lace & Braid	<1.9			<1.9	<1.9	1.9
WR-9	Dyerville Complex	<2.4	<1.9	3.8	<3.5	<1.9	5.8
W6	Killingly Interchange Stormdrain						
WR-10	Merino Park	<2.1	<1.9	3.1	<3.3	<1.9	6.7
WR-10a	Riverside Mills						
WR-11	Olneyville Square	<1.9	<1.9	<1.9	<4.7	<1.9	9
S-8a	Olneyville Square						
WR-12	Delanie Street	<1.9	<1.9	<1.9	<3.4	<1.9	5.8
WR-13	Valley Street	<1.9	<1.9	<1.9	<5.9	<1.9	30.1
R3	Valley Street				<50.0	<50.0	<50.0
WOON	Valley Street	1.2	0.8	1.6	3.7	2.34	5.98
WOONDN	Valley Street				1.6	0.6	3.9
S-8b	Valley Street						
W1	Valley Street				3.2	0.3	10.1
WR-14	Atwells Avenue	<1.9	<1.9	<1.9	<4.5	<1.9	15
R4	Atwells Avenue				<58.0	<50.0	80
S-8	Atwells Avenue						
WR-15	Bath Street	<2.3	<1.9	4.5	<4.9	<1.9	16.3
W23	Civic Center Stormdrain						
WR-16	Exchange Street	<2.2	<1.9	4.2	<5.5	<1.9	15.8
S-7	Exchange Street						

(*) Without data sampling event on October 7, 1998.

Dissolved Metals Criteria

Metal	Acute Criteria (ug/l) Hardness (mg/l as $CaCO_3$)			Chronic Criteria (ug/l) Hardness (mg/l as $CaCO_3$)		
	25.0	35.0	45.0	25.0	35.0	45.0
Lead	13.9	20.3	26.8	0.5	0.8	1.0

Figure 4-104

Lead Concentrations - Wet Weather Data

Dissolved Lead (ug/l)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam															
S-9	Manton Avenue															
R2	Manton Avenue															
WOONUP	Manton Avenue															
S-8a	Olneyville Square															
W6	Killingly Interch. Drain															
S-8b	Valley Street															
R3	Valley Street															
WOON	Valley Street	1.2	3.7	1.7	2.3	1.1	[illegible]	1.4	1	0.7	0.8	1.6	8.6	3.6	7.8	1.3
WOONDN	Valley Street															
S-8	Atwells Avenue															
R4	Atwells Avenue															
S-7	Exchange Street															
W23	Civic Center Drain															

Dissolved Metals Criteria

	Acute Criteria (ug/l)			Chronic Criteria (ug/l)		
	Hardness (mg/l as $CaCO_3$)			Hardness (mg/l as $CaCO_3$)		
Lead	13.9	20.3	26.8	0.5	0.8	[illegible]

Total Lead (ug/l)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam	<50.0	<50.0				<50.0	<50.0				<50.0	<50.0			
S-9	Manton Avenue															
R2	Manton Avenue	<50.0	<50.0				<50.0	<50.0				<50.0	70			
WOONUP	Manton Avenue	1.1	3.1	3.3	2.5	1.6	0.6	1.6	0.9	1.7	1.4	1.3	5.7	18.9	4.7	1.7
S-8a	Olneyville Square															
W6	Killingly Interch. Drain							0.3					95.4			
S-8b	Valley Street															
R3	Valley Street	<50.0	<50.0				<50.0	<50.0				<50.0	60			
WOON	Valley Street	3.65	13.2	5.6	4.1	4.3	2.3	4.8	2.8	2.3	3.1	6	22.7	9.1	8.2	5.5
WOONDN	Valley Street	1.6	10.5	4.1	1.9	3.2	0.6	2.2	1.8	0.4	1.9	3.9	28.6	8.6	2.4	4.5
S-8	Atwells Avenue															
R4	Atwells Avenue	<58.0	<99.0				<50.0	<50.0				80	320			
S-7	Exchange Street															
W23	Civic Center Drain							12.4					205.9			

Figure 4-105

Dissolved Lead Concentration (NBC, 1998)

(without October 7, 1998 data)

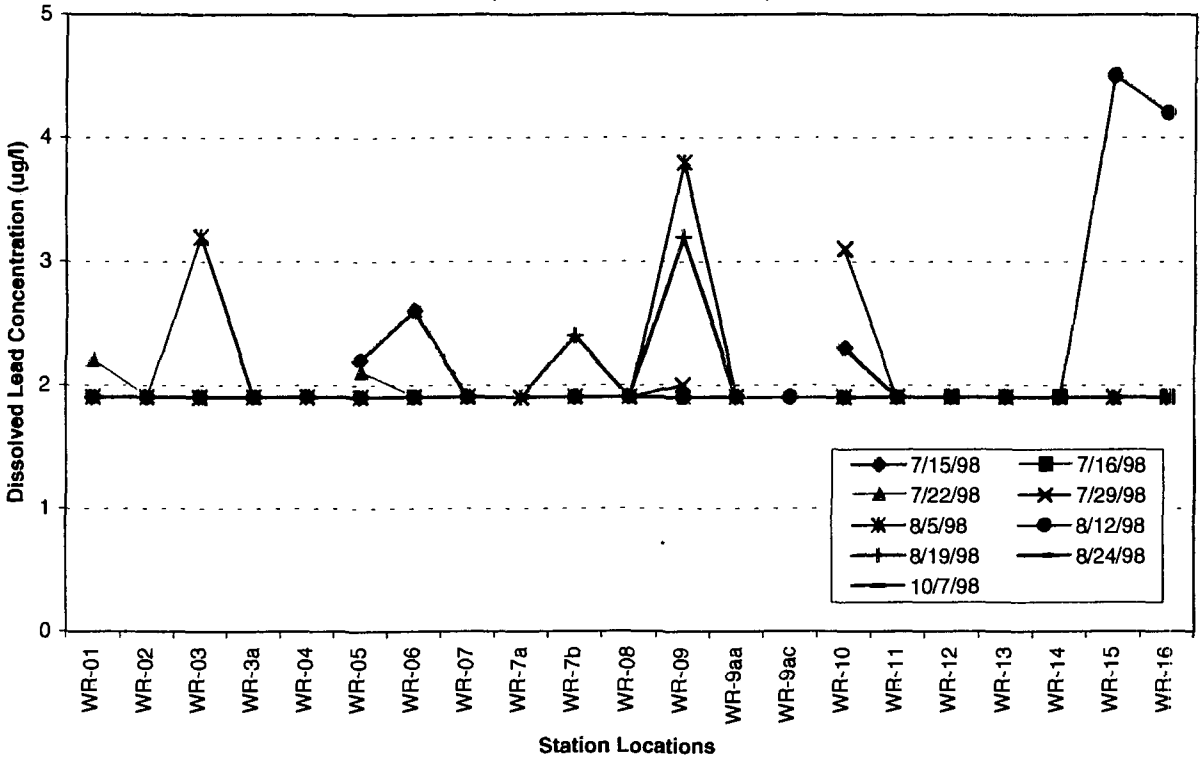

Figure 4-106

Total Lead Concentration (NBC, 1998)

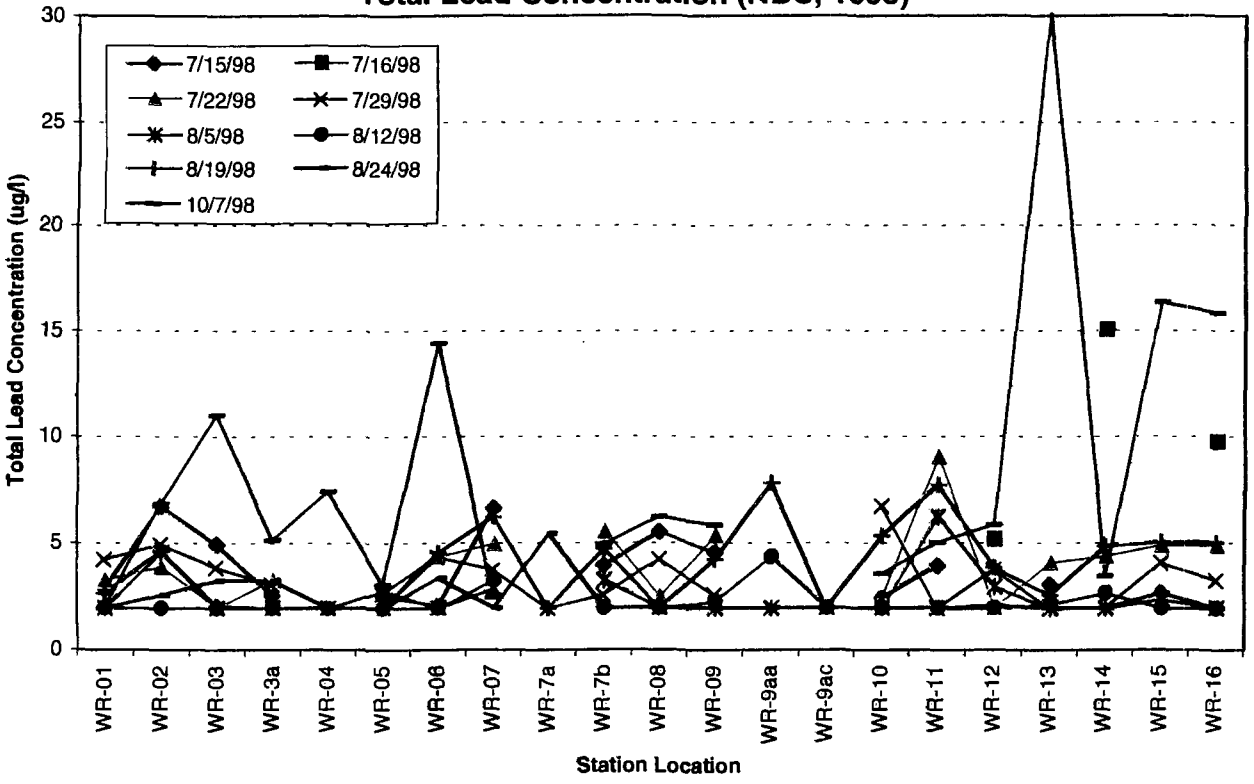

Figure 4-107

Dissolved Lead - Statistics (NBC, 1998) *(without 10/7/98 data)*

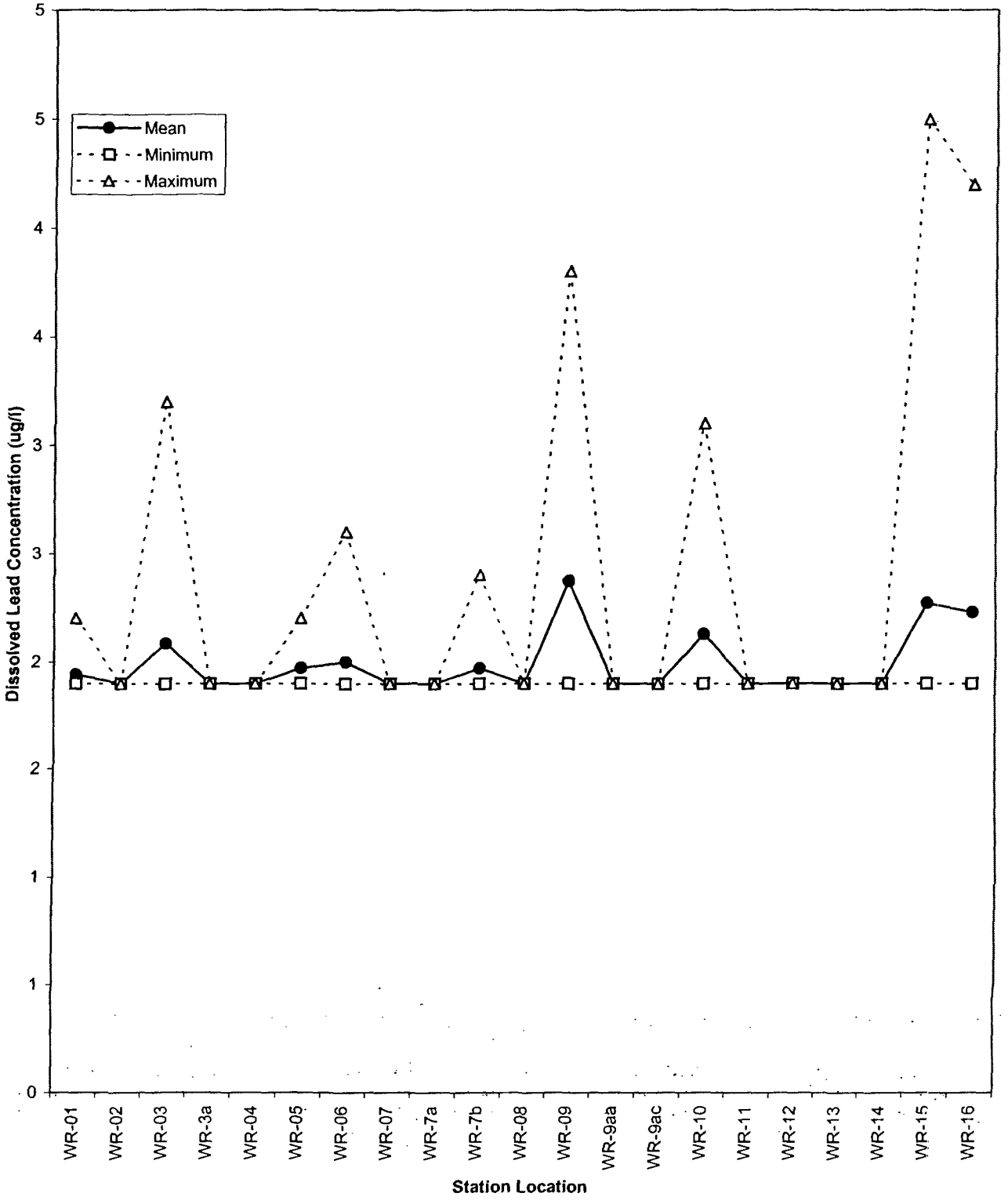

Figure 4-108

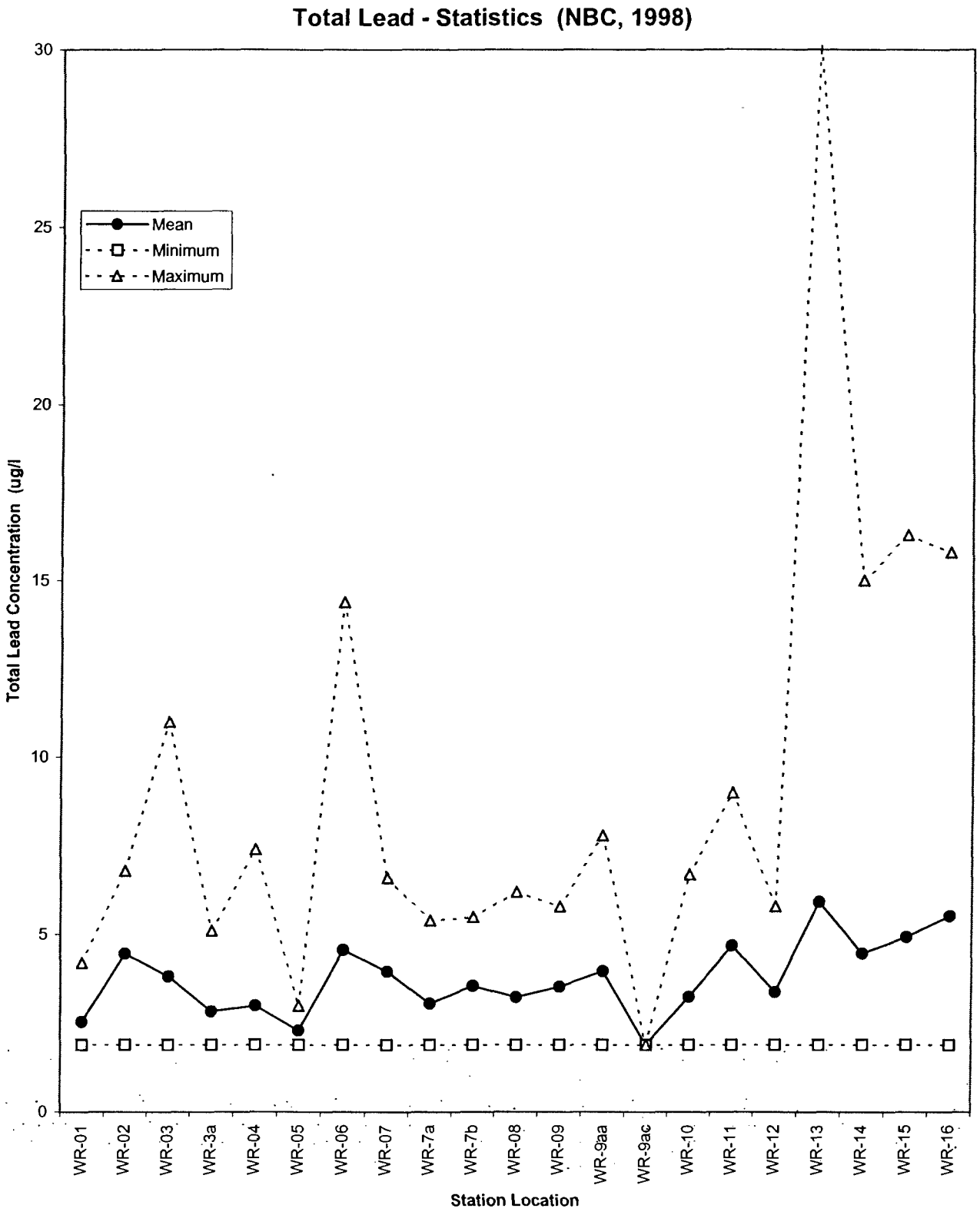
Total Lead - Statistics (NBC, 1998)
Mean
Minimum
Maximum
Total Lead Concentration (ug/l
30
25
20
15
10
5
0
WR-01
WR-02
WR-03
WR-3a
WR-04
WR-05
WR-06
WR-07
WR-7a
WR-7b
WR-08
WR-09
WR-9aa
WR-9ac
WR-10
WR-11
WR-12
WR-13
WR-14
WR-15
WR-16
Station Location

Figure 4-109
Total Lead Concentration - Station W2 (Route 44)
(Kerr and Lee, 1996)

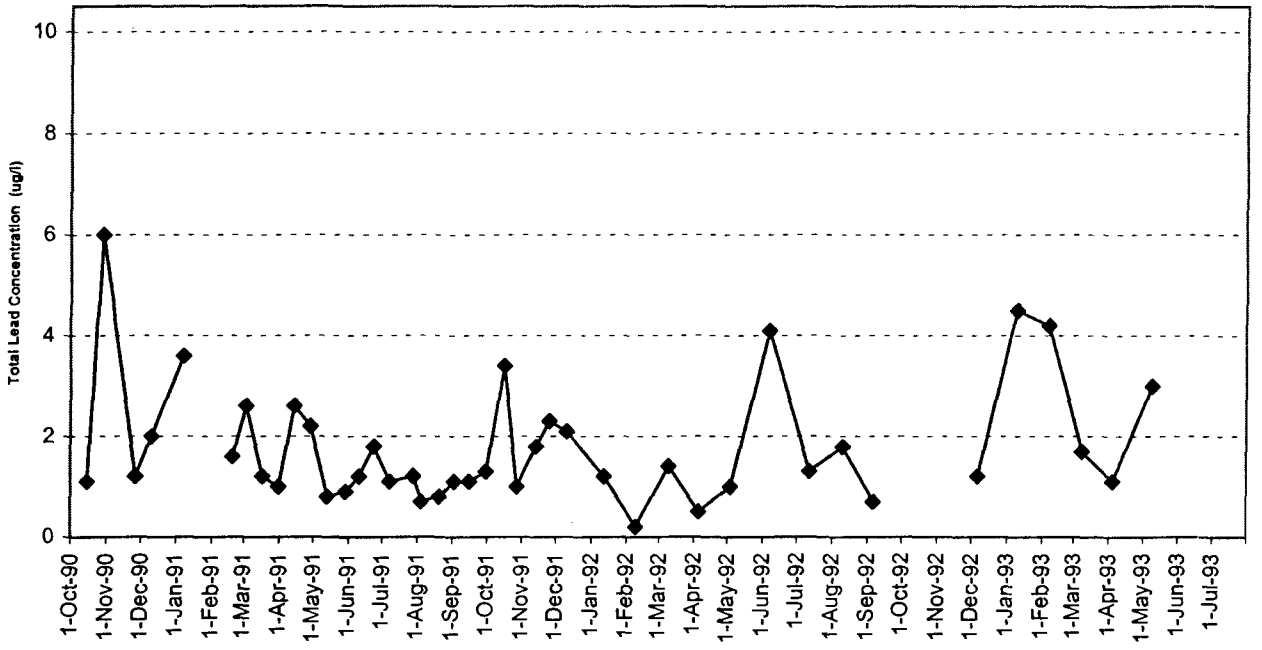

Figure 4-110
Total Lead Concentration -Station W1 (Valley Street)
(Kerr and Lee, 1996)

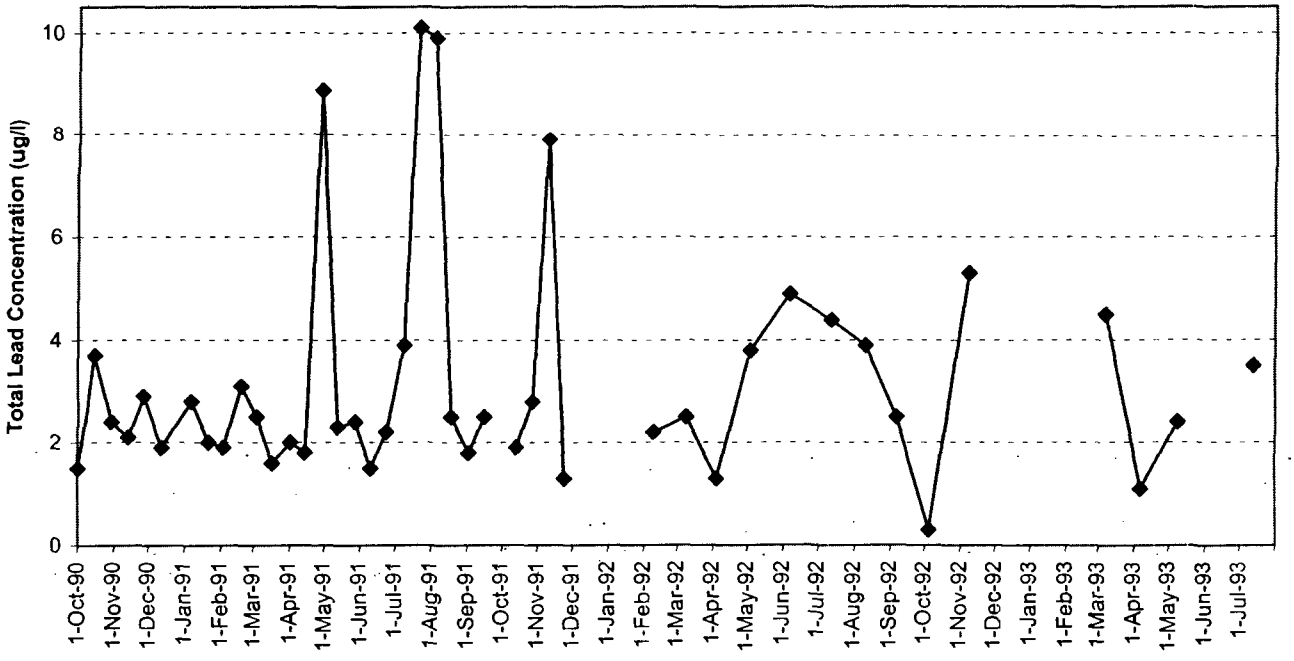

Figure 4-111

Nickel Concentrations - Dry Weather Data

Station No.	Location	Dissolved Nickel (ug/l) (*)			Total Nickel (ug/l)		
		Mean	Minimum	Maximum	Mean	Minimum	Maximum
WR-1	Stillwater Reservoir Dam	<2.8	<1.7	5.0	<3.1	<1.4	5.3
WR-2	Capron Road	<2.7	<1.9	4.5	<2.2	<1.7	3.6
WR-3	Sri Chimroy Peace Bridge	<2.7	<1.9	5.7	<2.7	<1.4	5.3
WR-3a	Esmond Mill Drive	<2.0	<1.9	2.1	<2.5	<1.9	4.1
EMD	Esmond Mill Drive						
WR-4	Smithfield WWTF Effluent	3.4	2.9	3.9	<3.7	<1.9	5.0
WWTF	Smithfield WWTF Effluent				<19.6	<4.4	52.8
GP	Greystone Pond						
WR-5	Greystone Street	<2.3	<1.9	3.2	<2.9	<1.9	5.1
WR-6	Route 44, Centerdale	<2.3	<1.9	3.1	<3.3	<1.9	6.7
W2	Route 44, Centerdale				2.0	0.2	5.1
WR-7	Allendale Avenue	<3.5	<1.9	5.9	3.5	2.0	8.8
WR-7a	Assapumpset Brook	<2.2	<1.9	2.9	<2.5	<1.9	3.0
LP	Lymansville Pond						
WR-7b	Lymansville Dam	<3.3	<1.9	5.5	3.3	1.9	4.1
R1	Manton Dam				<40.0	<40.0	<40.0
WR-8	Manton Avenue	<2.5	<1.9	3.4	4.0	2.0	12.6
R2	Manton Avenue				<40.0	<40.0	<40.0
WOONUP	Manton Avenue				4.5	2.8	7.2
S-9	Manton Avenue						
WR-9aa	Lincoln Lace & Braid	<2.3	<1.9	2.5	3.3	2.7	3.9
WR-9ab	Lincoln Lace & Braid						
WR-9ac	Lincoln Lace & Braid				<2.3	<1.9	2.7
WR-9	Dyerville Complex	<3.9	<1.9	6.7	3.8	2.4	6.8
W6	Killingly Interchange Stormdrain						
WR-10	Merino Park	<3.8	<1.9	7.6	<2.7	<1.9	3.7
WR-10a	Riverside Mills						
WR-11	Olneyville Square	<4.1	<1.9	8.3	4.2	2.7	8.0
S-8a	Olneyville Square						
WR-12	Delanie Street	<5.8	<1.9	18.6	<3.1	<1.9	3.6
WR-13	Valley Street	<3.7	<1.9	6.3	3.6	2.2	5.0
R3	Valley Street				<40.0	<40.0	<40.0
WOON	Valley Street	6.0	3.2	7.8	7.1	4.0	8.8
WOONDN	Valley Street				4.1	2.6	5.7
S-8b	Valley Street						
W1	Valley Street				2.3	0.2	8.8
WR-14	Atwells Avenue	<4.0	<1.9	8.3	3.4	2.0	4.6
R4	Atwells Avenue				<40.0	<40.0	<40.0
S-8	Atwells Avenue						
WR-15	Bath Street	5.3	2.9	9.8	6.8	2.6	16.8
W23	Civic Center Stormdrain						
WR-16	Exchange Street	5.0	3.8	6.4	7.2	2.4	20.6
S-7	Exchange Street						

(*) Without data sampling event on August 12 and October 7, 1998.

Dissolved Metals Criteria

Metal	Acute Criteria (ug/l) Hardness (mg/l as $CaCO_3$)			Chronic Criteria (ug/l) Hardness (mg/l as $CaCO_3$)		
	25.0	35.0	45.0	25.0	35.0	45.0
Nickel	438.1	582.3	720.3	48.7	64.7	80.0

Figure 4-112

Nickel Concentrations - Wet Weather Data

Dissolved Nickel (ug/l)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam															
S-9	Manton Avenue															
R2	Manton Avenue															
WOONUP	Manton Avenue															
S-8a	Olneyville Square															
W6	Killingly Interch. Drain															
S-8b	Valley Street															
R3	Valley Street															
WOON	Valley Street	6.0	5.1	5.8	4.5	4.1	3.2	2.8	3.5	3.0	2.6	7.8	11.3	6.9	5.3	6.2
WOONDN	Valley Street															
S-8	Atwells Avenue															
R4	Atwells Avenue															
S-7	Exchange Street															
W23	Civic Center Drain															

Dissolved Metals Criteria

	Acute Criteria (ug/l)			Chronic Criteria (ug/l)		
	Hardness (mg/l as $CaCO_3$)			Hardness (mg/l as $CaCO_3$)		
Metal	25.0	35.0	45.0	25.0	35.0	45.0
Nickel	438.1	582.3	720.3	48.7	64.7	80.0

Total Nickel (ug/l)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam	<40.0	<40.0				<40.0	<40.0				<40.0	<40.0			
S-9	Manton Avenue															
R2	Manton Avenue	<40.0	<68.0				<40.0	<40.0				<40.0	230.0			
WOONUP	Manton Avenue	4.5	3.9	3.1	3.5	2.2	2.8	3.2	2.2	2.5	2.1	7.2	6.0	3.7	5.1	2.2
S-8a	Olneyville Square															
W6	Killingly Interch. Drain							0.2					37.0			
S-8b	Valley Street															
R3	Valley Street	<40.0	<55.0				<40.0	<40.0				<40.0	150.0			
WOON	Valley Street	7.1	6.9	6.4	5.2	5.7	4.0	3.4	3.7	3.2	4.6	8.8	13.6	8.1	6.3	6.8
WOONDN	Valley Street	3.9	9.4	4.8	3.5	3.5	3.0	2.8	3.2	3.0	3.0	4.7	22.0	8.1	5.2	3.9
S-8	Atwells Avenue															
R4	Atwells Avenue	<40.0	<57.0				<40.0	<40.0				<40.0	130.0			
S-7	Exchange Street															
W23	Civic Center Drain							0.3					33.8			

Figure 4-113

Dissolved Nickel Concentration (NBC, 1998)

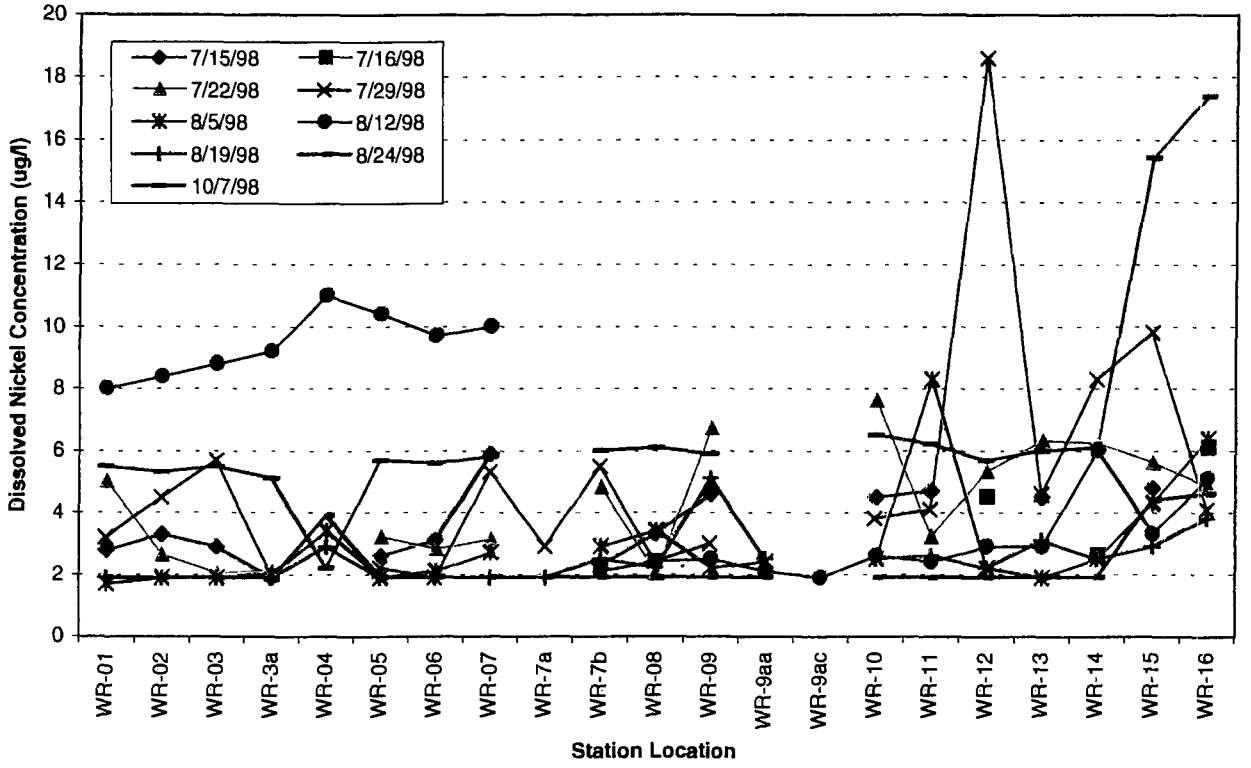

Figure 4-114

Total Nickel Concentration (NBC, 1998)

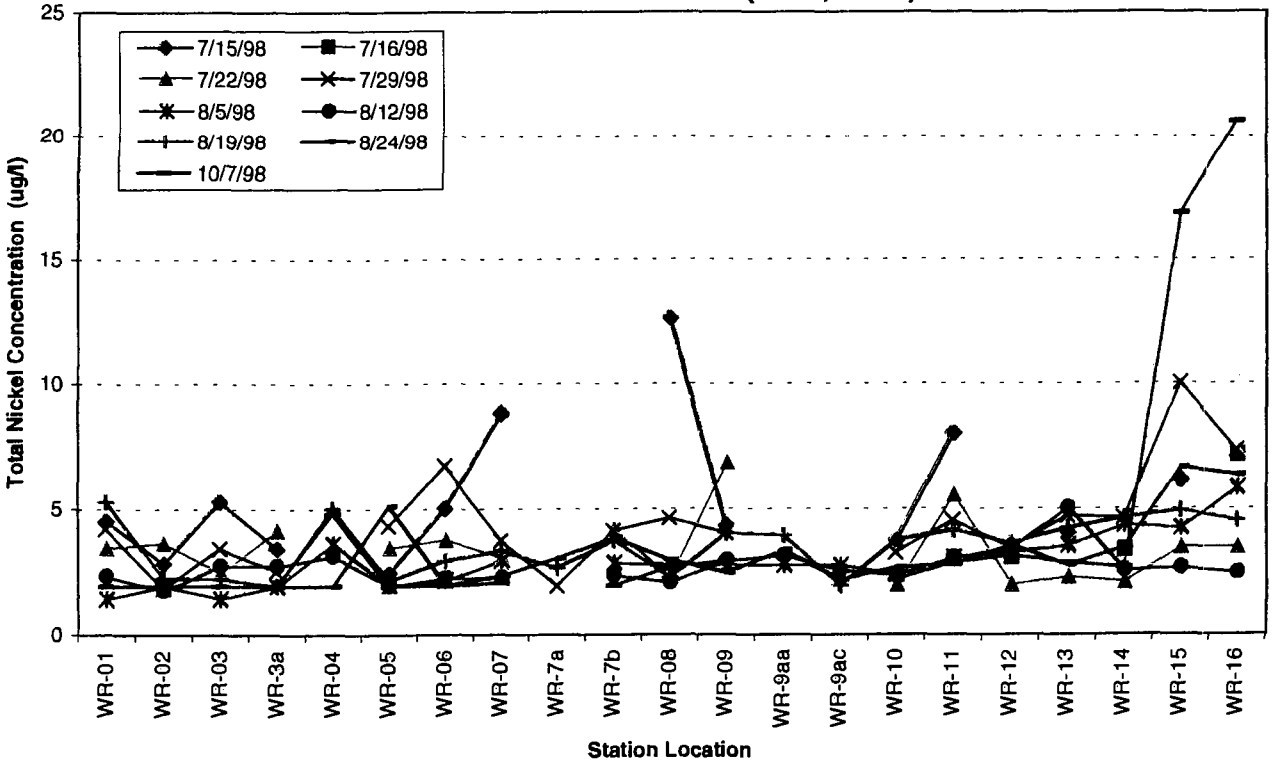

Figure 4-115

Dissolved Nickel - Statistics (NBC, 1998) *(without 8/12/98 and 10/7/98 data)*

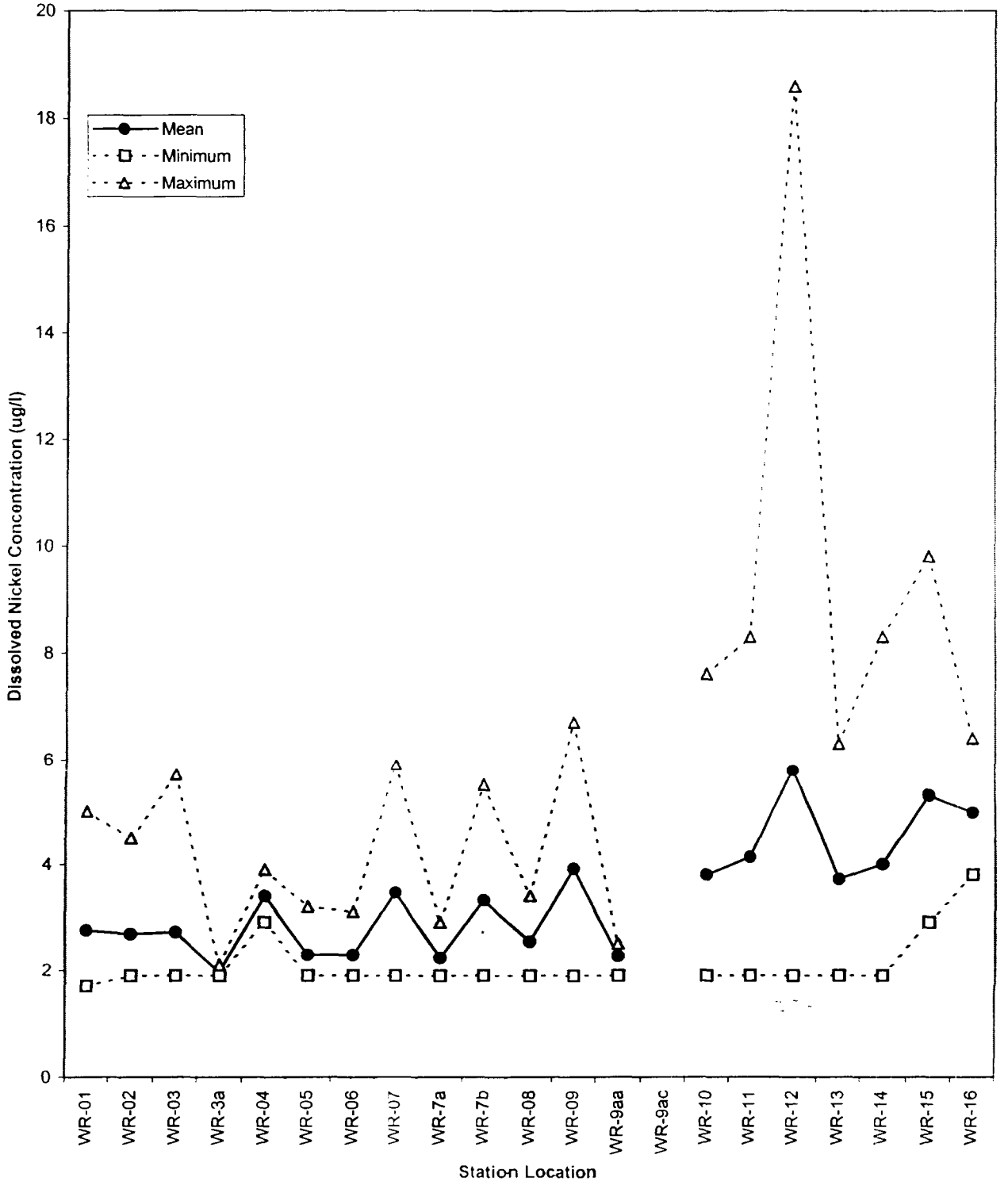

Figure 4-116

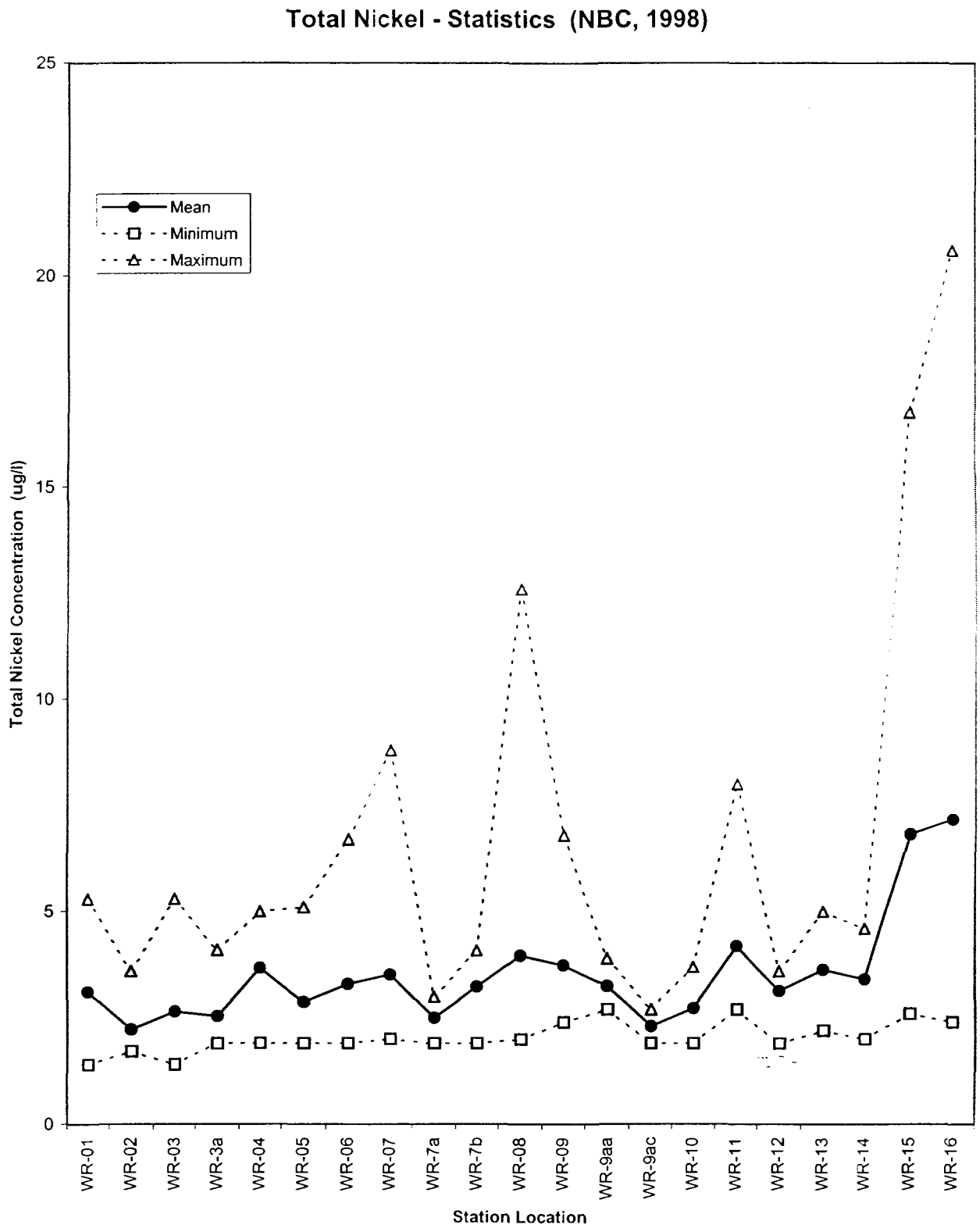
Total Nickel - Statistics (NBC, 1998)
Mean
Minimum
Maximum
Total Nickel Concentration (ug/l)
25
20
15
10
5
0
WR-01
WR-02
WR-03
WR-3a
WR-04
WR-05
WR-06
WR-07
WR-7a
WR-7b
WR-08
WR-09
WR-9aa
WR-9ac
WR-10
WR-11
WR-12
WR-13
WR-14
WR-15
WR-16
Station Location

Figure 4-117

Total Nickel Concentration - Station W2 (Route 44)

(Kerr and Lee, 1996)

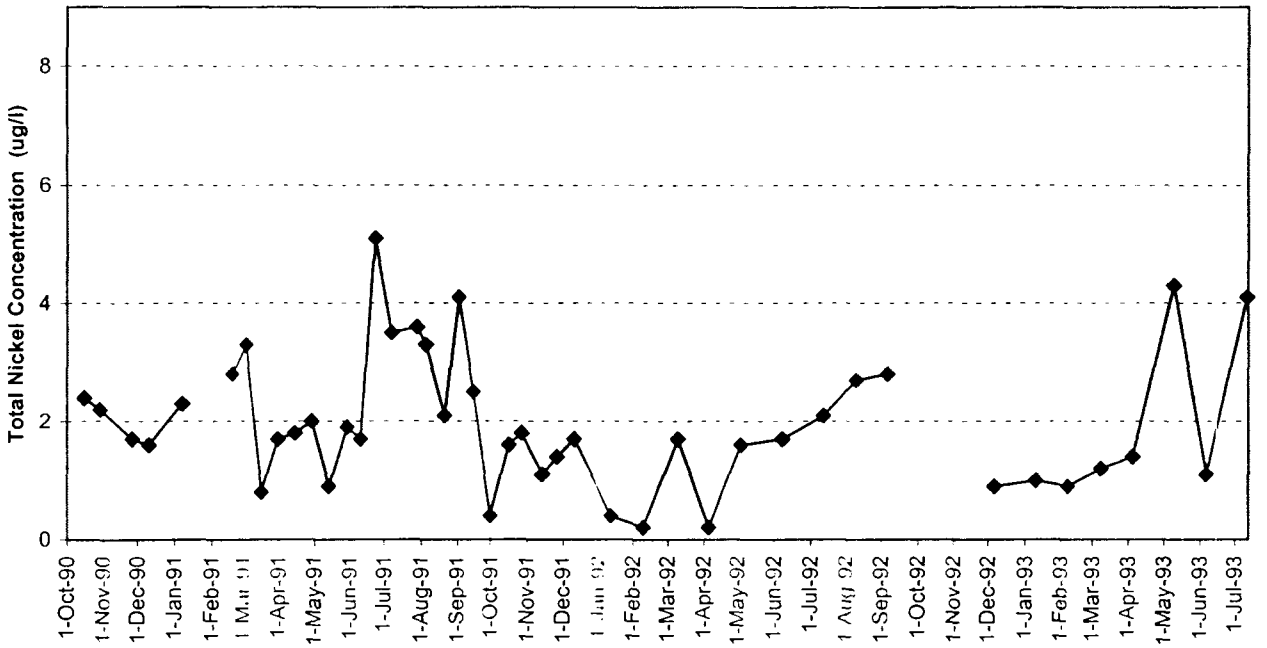

Figure 4-118

Total Nickel Concentration -Station W1 (Valley Street)

(Kerr and Lee, 1996)

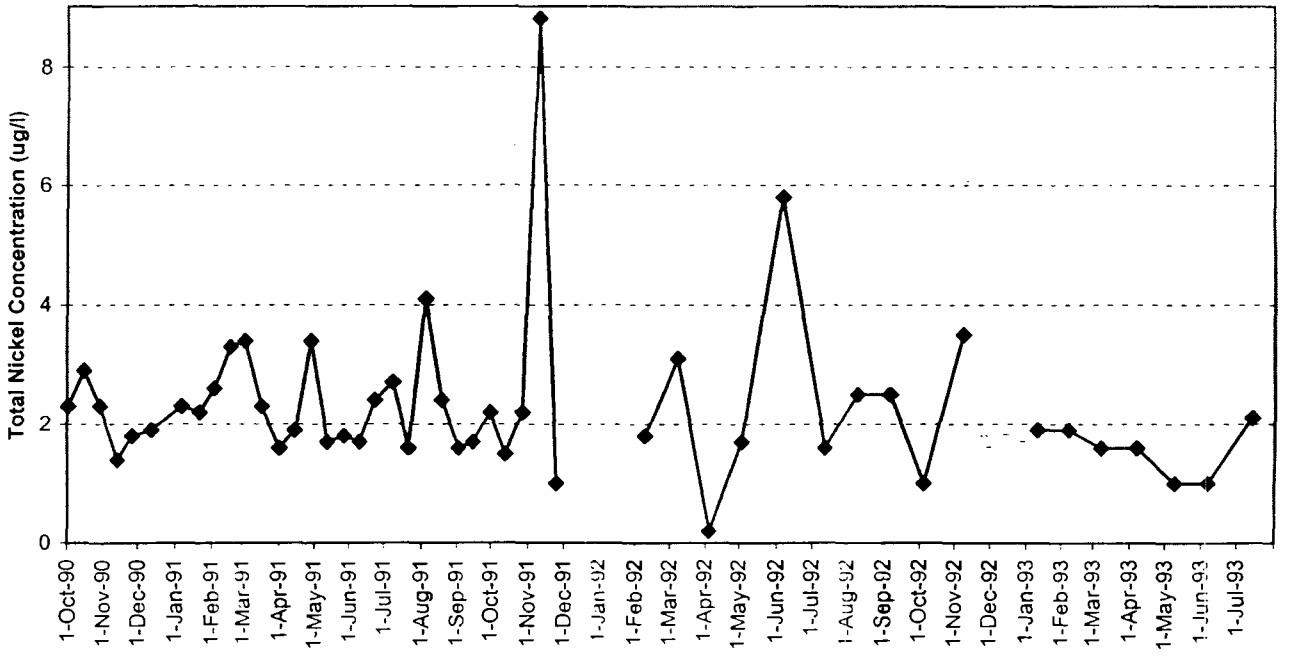

Figure 4-119

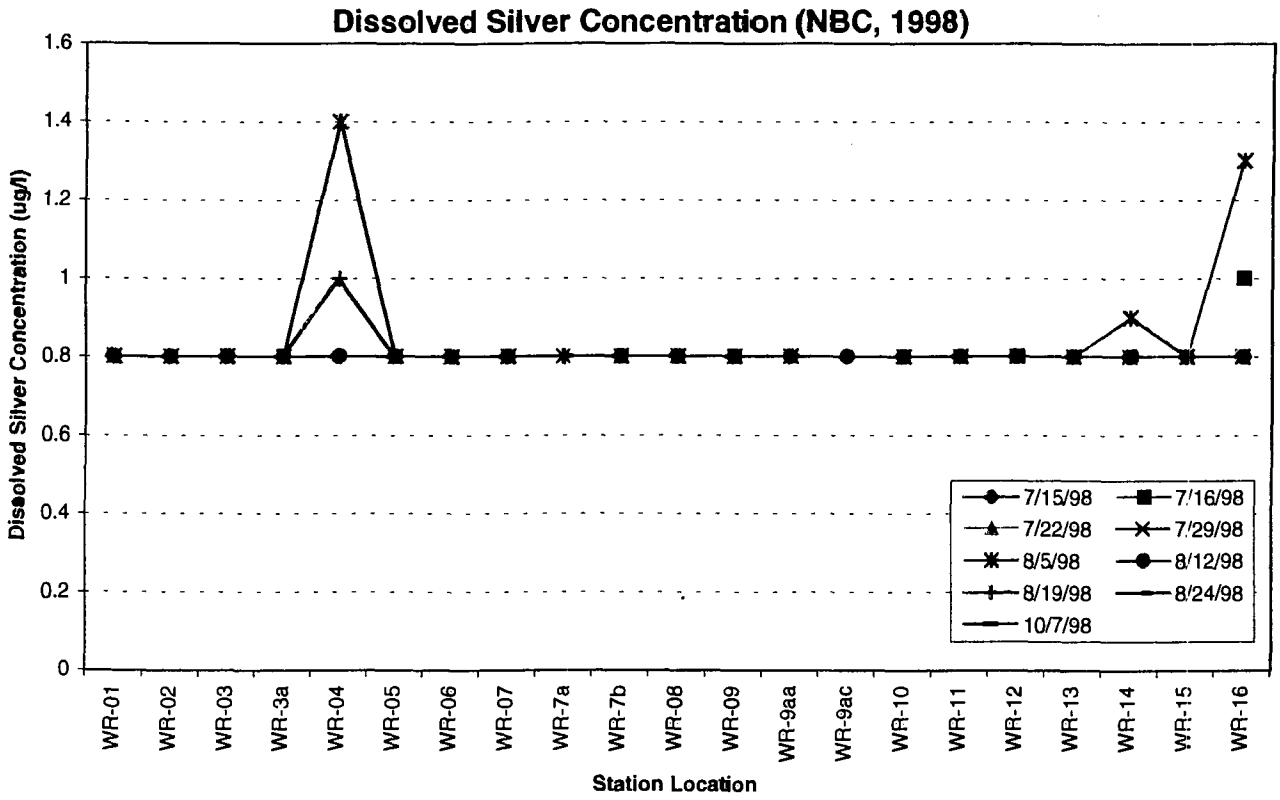

Figure 4-120

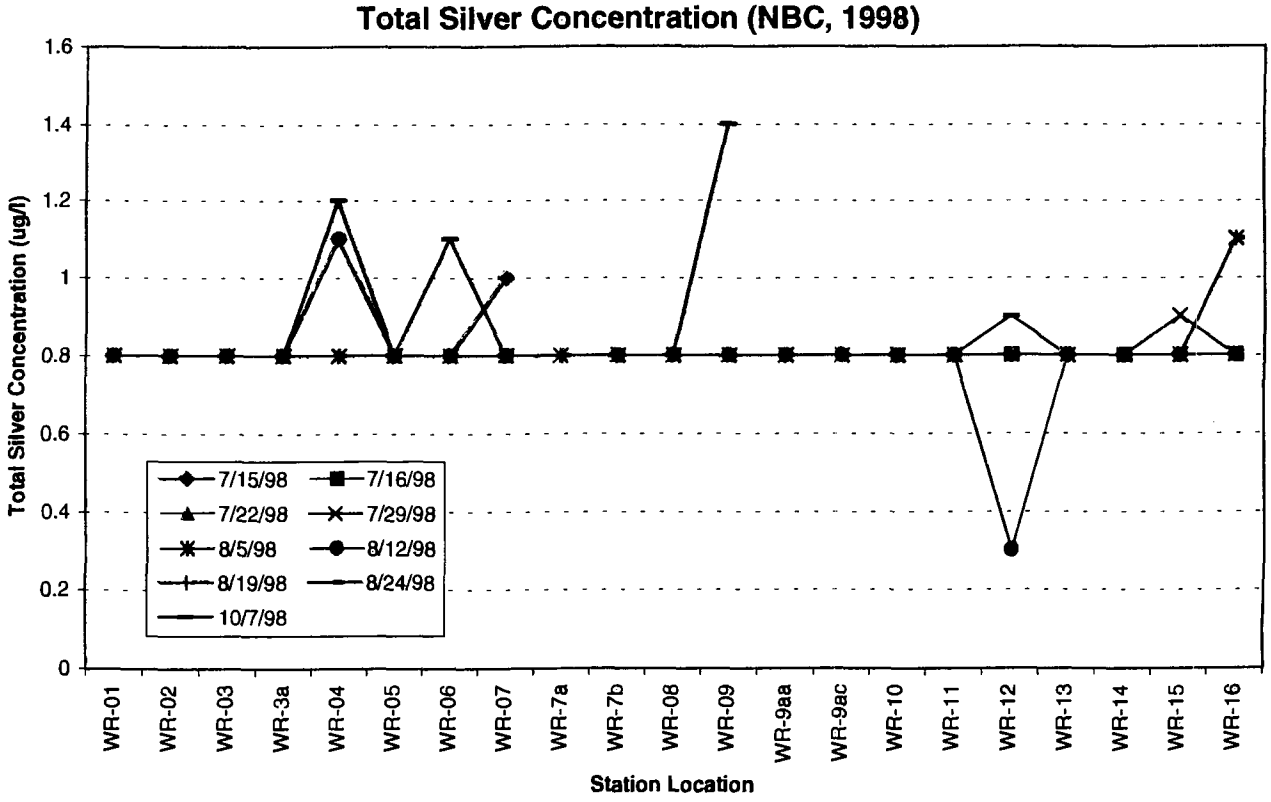

Figure 4-121

Zinc Concentrations - Dry Weather Data

Station No.	Location	Dissolved Zinc (ug/l)			Total Zinc (ug/l)		
		Mean	Minimum	Maximum	Mean	Minimum	Maximum
WR-1	Stillwater Reservoir Dam	12.5	4.1	22.2	12.2	3.7	21.8
WR-2	Capron Road	9.8	1.9	20.6	12.1	5.0	20.3
WR-3	Sri Chimroy Peace Bridge	7.9	3.7	16.4	9.0	3.7	15.6
WR-3a	Esmond Mill Drive	9.3	3.9	14.0	10.5	5.8	19.0
EMD	Esmond Mill Drive						
WR-4	Smithfield WWTF Effluent	49.7	45.4	54.1	43.3	11.6	57.4
WWTF	Smithfield WWTF Effluent				<40.3	<10.3	126.0
GP	Greystone Pond						
WR-5	Greystone Street	14.6	8.5	20.9	12.9	10.1	16.0
WR-6	Route 44, Centerdale	15.0	9.5	25.2	16.0	10.2	23.3
W2	Route 44, Centerdale						
WR-7	Allendale Avenue	16.6	11.9	29.2	19.6	13.4	32.0
WR-7a	Assapumpset Brook	7.2	6.1	7.8	<7.5	<1.9	10.5
LP	Lymansville Pond						
WR-7b	Lymansville Dam	15.3	10.5	25.8	15.6	8.8	21.5
R1	Manton Dam				40.0	6.0	70.0
WR-8	Manton Avenue	12.7	9.7	17.4	14.8	10.0	22.2
R2	Manton Avenue				58.0	6.0	150.0
WOONUP	Manton Avenue						
S-9	Manton Avenue						
WR-9aa	Lincoln Lace & Braid	13.5	10.2	21.9	15.7	9.0	30.8
WR-9ab	Lincoln Lace & Braid						
WR-9ac	Lincoln Lace & Braid	10.8			9.2	6.1	10.6
WR-9	Dyerville Complex	26.8	8.5	16.7	17.1	9.0	34.3
W6	Killingly Interchange Stormdrain						
WR-10	Merino Park	17.2	8.8	26.0	16.0	7.7	29.2
WR-10a	Riverside Mills						
WR-11	Olneyville Square	14.2	8.6	20.8	16.2	7.1	25.9
S-8a	Olneyville Square						
WR-12	Delanie Street	14.6	8.7	21.8	16.0	10.2	27.6
WR-13	Valley Street	15.7	10.6	21.1	17.3	11.0	24.6
R3	Valley Street				44.0	14.0	69.0
WOON	Valley Street						
WOONDN	Valley Street						
S-8b	Valley Street						
W1	Valley Street						
WR-14	Atwells Avenue	17.7	9.4	27.1	16.1	10.9	26.5
R4	Atwells Avenue				49.0	12.0	81.0
S-8	Atwells Avenue						
WR-15	Bath Street	19.4	12.1	27.6	22.8	11.2	43.6
W23	Civic Center Stormdrain						
WR-16	Exchange Street	18.9	12.5	22.4	22.9	10.6	42.8
S-7	Exchange Street						

Dissolved Metals Criteria

Metal	Acute Criteria (ug/l) Hardness (mg/l as $CaCO_3$)			Chronic Criteria (ug/l) Hardness (mg/l as $CaCO_3$)		
	25.0	35.0	45.0	25.0	35.0	45.0
Zinc	35.4	47.0	58.2	32.3	42.9	53.1

Figure 4-122

Zinc Concentrations - Wet Weather Data

Dissolved Zinc (ug/l)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam															
S-9	Manton Avenue															
R2	Manton Avenue															
WOONUP	Manton Avenue															
S-8a	Olneyville Square															
W6	Killingly Interch. Drain															
S-8b	Valley Street															
R3	Valley Street															
WOON	Valley Street															
WOONDN	Valley Street															
S-8	Atwells Avenue															
R4	Atwells Avenue															
S-7	Exchange Street															
W23	Civic Center Drain															

Dissolved Metals Criteria

	Acute Criteria (ug/l)			Chronic Criteria (ug/l)		
	Hardness (mg/l as $CaCO_3$)			Hardness (mg/l as $CaCO_3$)		
Metal	25.0	35.0	45.0	25.0	35.0	45.0
Zinc	35.4	47.0	58.2	32.3	42.9	53.1

Total Zinc (ug/l)		Mean Concentration					Minimum Concentration					Maximum Concentration				
Station No.	Location	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom	Dry Weather	During Storm	24h After Strom	48h After Storm	Days 3-5 After Strom
R1	Manton Dam	40	98				6	30				70	290			
S-9	Manton Avenue															
R2	Manton Avenue	58	67				6	30				150	120			
WOONUP	Manton Avenue															
S-8a	Olneyville Square															
W6	Killingly Interch. Drain							40					700			
S-8b	Valley Street															
R3	Valley Street	44	72				14	30				69	130			
WOON	Valley Street															
WOONDN	Valley Street															
S-8	Atwells Avenue															
R4	Atwells Avenue	49	121				12	40				81	300			
S-7	Exchange Street															
W23	Civic Center Drain							30					1,000			

Figure 4-123

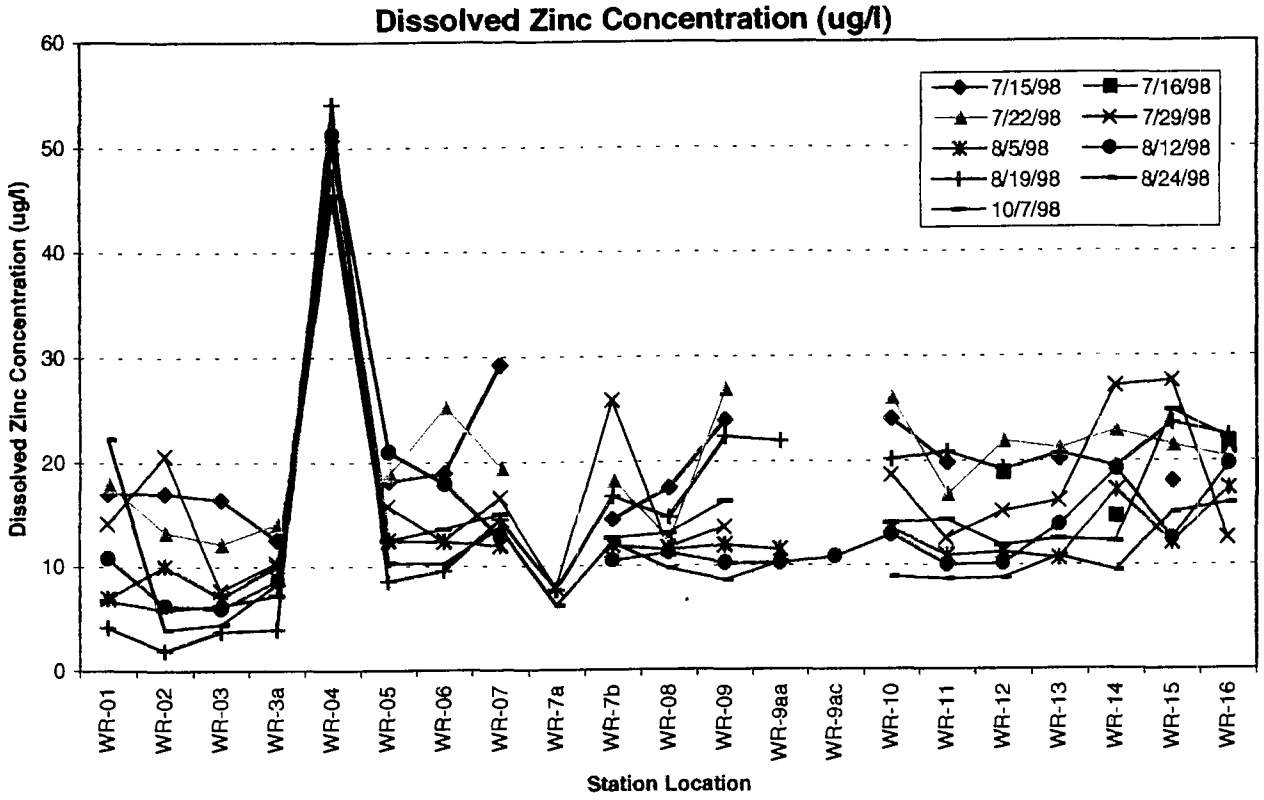

Figure 4-124

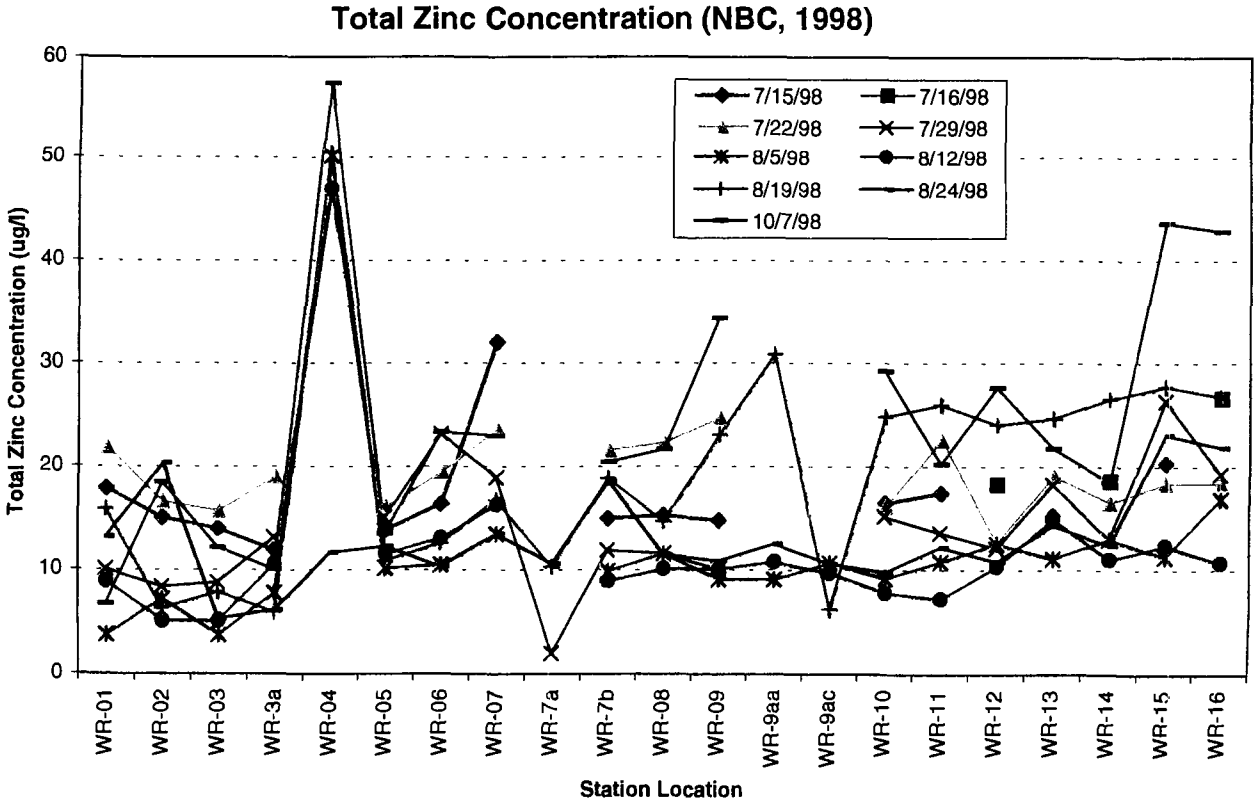

Figure 4-125

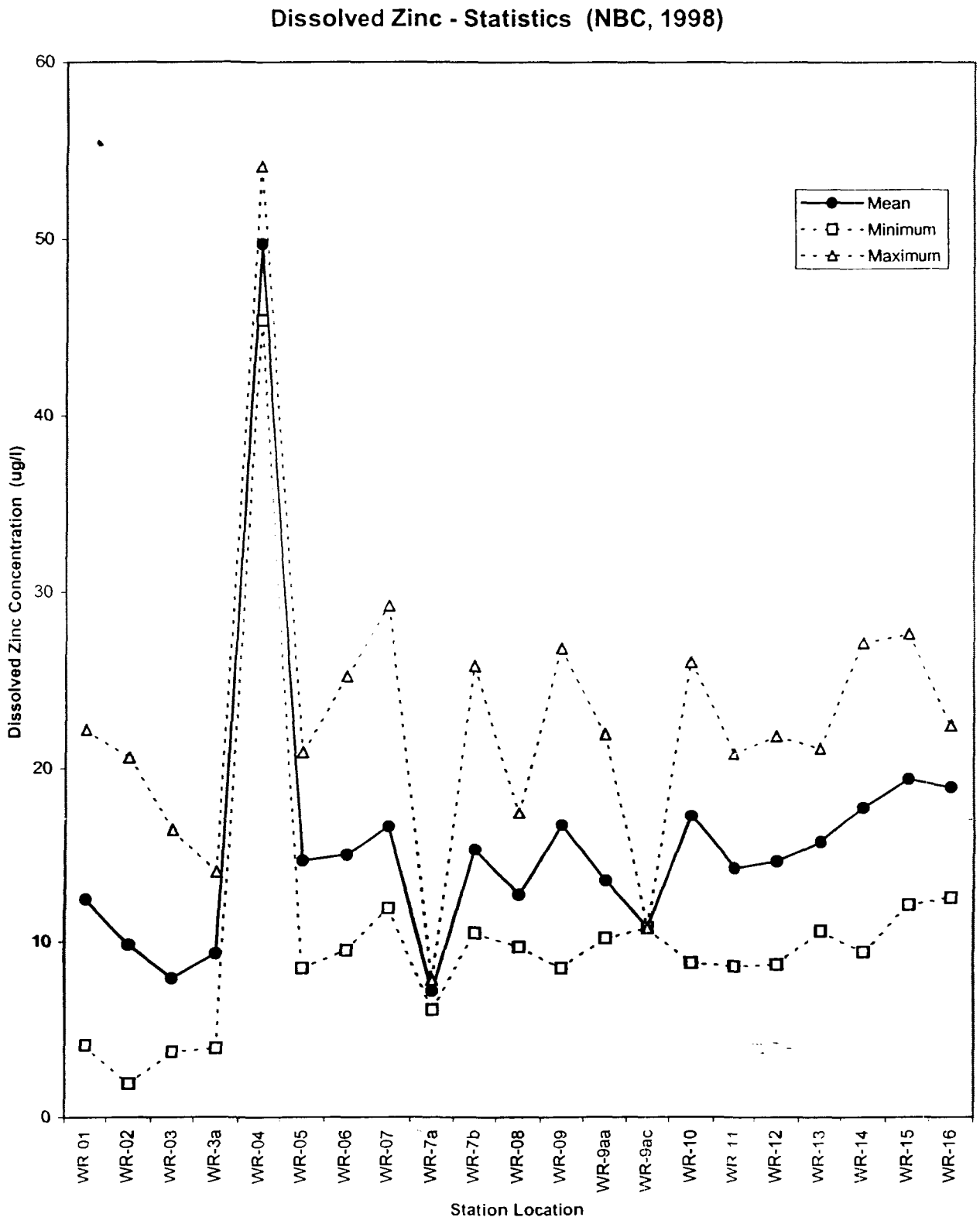
Dissolved Zinc - Statistics (NBC, 1998)
Mean
Minimum
Maximum
Dissolved Zinc Concentration (ug/l)
0
10
20
30
40
50
60
WR 01
WR-02
WR-03
WR-3a
WR-04
WR-05
WR-06
WR-07
WR-7a
WR-7b
WR-08
WR-09
WR-9aa
WR-9ac
WR-10
WR 11
WR-12
WR-13
WR-14
WR-15
WR-16
Station Location

Figure 4-126

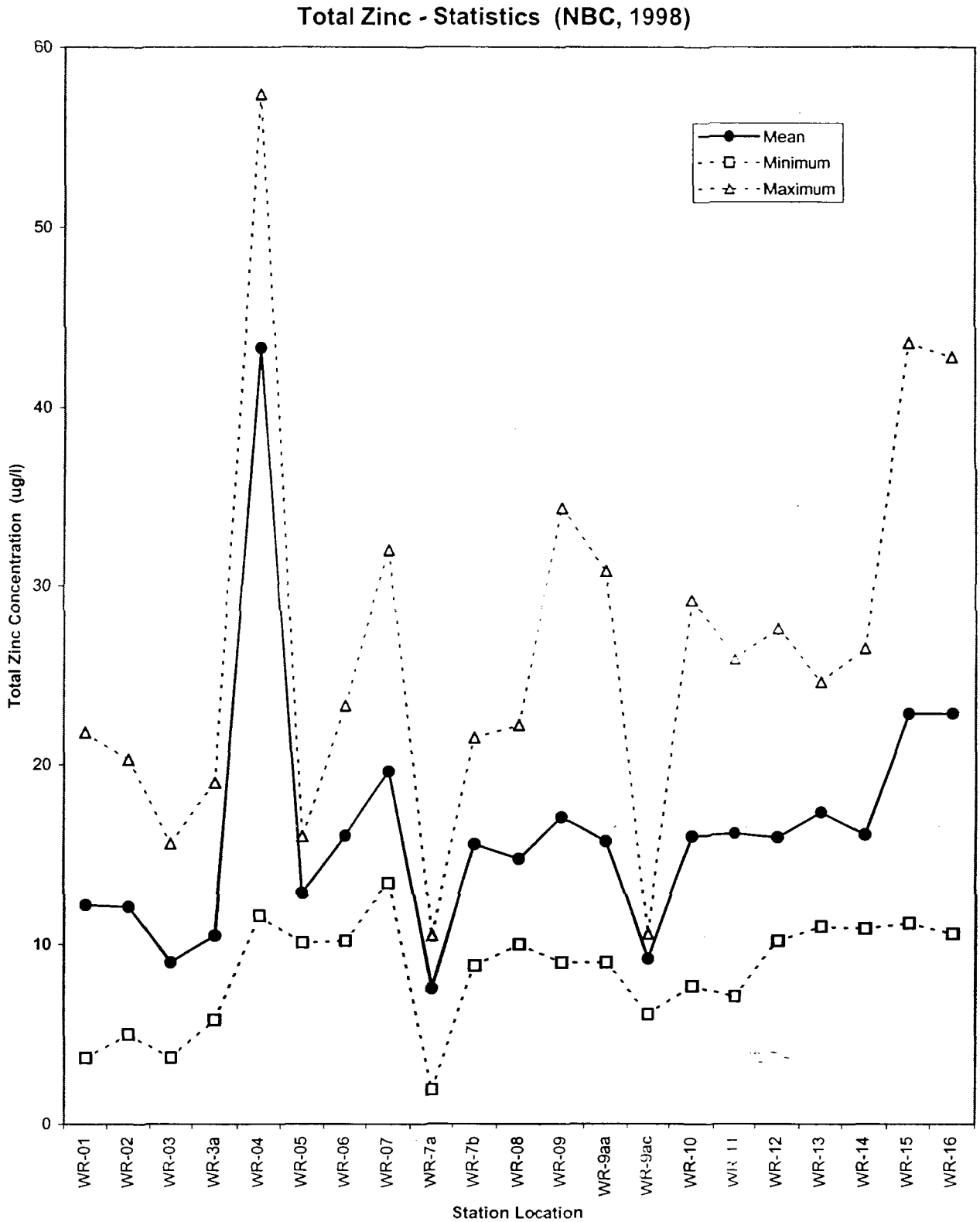
Total Zinc - Statistics (NBC, 1998)
Mean
Minimum
Maximum
Total Zinc Concentration (ug/l)
0
10
20
30
40
50
60
WR-01
WR-02
WR-03
WR-3a
WR-04
WR-05
WR-06
WR-07
WR-7a
WR-7b
WR-08
WR-09
WR-9aa
WR-9ac
WR-10
WR-12
WR-13
WR-14
WR-15
WR-16
Station Location

Figure 4-12

Inorganic Compounds in Water Samples at Davis Landfill (*)

Source: CDM, 1994

Compound	Maximum Concentration at Stations Upstream of Landfill	Maximum Concentration at Stations Downstream of Landfill		
		Nine Foot Brook	Unnamed Brook	Station SW-17 (**)
	ug/l	ug/l	ug/l	ug/l
Dissolved Sample Component				
Aluminum	240	155	375	115
Antimony	--	60 J	--	--
Arsenic	--	--	--	--
Barium	23.7	45.6	124	19.1
Beryllium	--	--	--	--
Calcium	3,120	8,870	38,000	9,300
Chromium	--	12.2	--	--
Cobalt	--	--	11.8	--
Copper	6.4 J	--	--	--
Iron	238	1,400	19,800	136
Lead	3.0 J	3.0 J	4.0 J	--
Magnesium	606	10,600	13,600	3,010
Manganese	91.8 J	1,120	2,700	214
Mercury	--	--	0.3 J	--
Nickel	--	9.2 J	12.2 J	--
Potassium	532	25,500	36,100	6,980
Selenium	--	4.3 J	--	--
Silver	--	--	--	--
Sodium	3,720 J	54,700	69,300	15,800 J
Thallium	2 J	--	--	--
Vanadium	--	--	--	--
Zinc	11.1	18.3	155 J	3.5 J
Total Sample				
Aluminum	1,060	21,600	2,030	260
Antimony	--	--	--	--
Arsenic	8 J	11.9	--	--
Barium	14.5	74.8	291	12.2
Beryllium	--	5	--	--
Calcium	3,140	62,600	222,400	10,500
Chromium	7.1 J	15.3 J	--	--
Cobalt	--	14.6 J	14 J	--
Copper	--	44.4 J	--	--
Iron	27,600	51,800	196,000	896 J
Lead	4.3 J	171	6.2 J	3.3 J
Magnesium	602	10,800	13,600	3,330
Manganese	94.5 J	6,460	4,390 J	245 J
Mercury	--	0.99	--	--
Nickel	--	43.2 J	4.0 J	--
Potassium	485	25,000	35,100	7,580
Selenium	4.1 J	--	4.5 J	--
Silver	--	--	21.2 J	--
Sodium	3,510	54,400	69,000	18,200
Thallium	--	--	2.0 J	--
Vanadium	--	68.2	2.3 J	--
Zinc	16.7 J	401.0	67.3	21.0 J

(*) See Appendix 5 for all data. Samples at this site were collected by CDM (1994) on May 5, 1992 and October 15, 1992.

(**) Station SW-17 is located on Nine Foot Brook, furthest downstream from the landfill.

-- = Not Detected

J = Value is below the reporting limit.

Figure 4-128

WOONASQUATUCKET SEDIMENT SAMPLING

INORGANIC ANALYTICAL RESULTS

(Source: EPA 1998)

Site	Esmond Dam	Allendale Dam	Lymansville Dam	Manton Dam	Dyerville Dam	Olneyville Dam	Lonigan Dam	Freshwater LEL	Freshwater SEL
Site #	DAM001	DAM002	DAM003	DAM004	DAM005	DAM006	DAM007		
Sample #	6197	6198	6199	6200	6202	6203	6205		
Aluminum (mg/kg)	18,700	11,100	18,300	5,490	10,700	7,300	5,310	...	...
Antimony (mg/kg)	10u	11u	10u	10u	9u	10u	10u	...	...
Arsenic (mg/kg)	35.0u	10.6u	35.0u	10.4u	20.0u	9.9u	10.1u	6.0	33.0
Barium (mg/kg)	375	218	310	98	116	138	106	...	...
Beryllium (mg/kg)	5.4	2.5	3.8	1.0	1.5	1.2	0.9	...	...
Calcium (mg/kg)	4,830	3,480	4,650	2,160	2,450	2,750	2,260	...	...
Cadmium (mg/kg)	4.2	3u	4.6	3u	4.0	3u	3u	0.6	10.0
Chromium, Total (mg/kg)	[illegible]	136	204	62	385	63	48	26	110
Cobalt (mg/kg)	18.0	12.6	17.4	7.5	9.1	9.2	6.8	...	...
Copper (mg/kg)	196	136	206	48	210	89	88	16	110
Iron (mg/kg)	[illegible]	24,700	25,500	12,300	15,300	17,200	15,400	20,000	40,000
Lead (mg/kg)	[illegible]	250	414	128	307	205	275	31	250
Manganese (mg/kg)	980	1,340	997	500	598	1,000	879	460	1,100
Magnesium (mg/kg)	2,910	2,260	3,620	1,450	2,770	2,130	1,570	...	...
Mercury, Total (mg/kg)	0.63	0.50	0.73	0.16	1.06	0.26	0.36	0.20	2.00
Nickel (mg/kg)	53	38	76	27	35	29	28	16	75
Selenium (mg/kg)	10.0u	10.6u	10.0u	10.4u	8.0u	9.0u	10.1u	...	...
Silver (mg/kg)	3.0u	3.2u	5.0u	3.1u	2.6u	3.0u	3.0u	...	...
Thallium (mg/kg)	10.0u	10.6u	10.0u	10.4u	8.6u	9.9u	10.1u	...	...
Vanadium (mg/kg)	39.5	33.0	47.6u	16.4	28.4	24.6	30.0u	...	...
Zinc (mg/kg)	616	568	757	237	1,930	386	346	120	820
Total Cyanide (mg/kg)	12.8u	6.4u	7.5u	2.4u	2.6u	3.3u	2.8u	...	...
SEM/AVS Ratio (Cu, Zn, Pb, Cd, Cr, Hg, Ni)	0.45	0.80	0.71	0.68	2.50	0.38	0.83	...	...

u = non detected above associated reporting limit, approximate value

... = Not Applicable

3,000 Above LEL (Lower Effects Level)

3,000 Above SEL (Severe Effects Level)

LEL and SEL Levels obtained from: Persaud, D., R. Jaagumagi, and A. Hayton, Ontario Ministry of Environment and Energy Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario, August 1993.

Sediment samples were collected October 23 to 24, 1997.

Figure 4-129

Summary of Analytical Results of Expanded Site Inspection (*)

Centredale Manor

(Stations are listed from upstream to downstream)

(Source: Roy F. Weston, 1999)

Location	Station Number	Sediment Sample	Soil Sample	Total Semivolatile Organic Compounds	Total Pesticides	Total PCBs	Dioxins (**)	Hexachloro-xanthene
				ug/kg				
Central Esmond Dam	SD- 37	●		101,610	31		0.003	
Greystone Mill Dam	SD- 35	●		3,300			0.003	
Adjacent to Greystone Mill, north	SD- 34	●		600			0.20	
Adjacent to Greystone Mill, south	*SD- 33*	●		1,000		7,800	0.09	
Centredale Manor	SD- 30	●			80	1,400	15.80	94
	SD- 29	●			6	65	0.06	
	SD- 27	●			20		1.30	50
	SD- 26	●					0.09	
	SS- 01		●	830				
	SS- 02		●	450	140		4.70	263
	SS- 03		●					10
	SS- 04		●	14,620			6.30	168
	SS- 05		●	970			3.40	63
	SS- 06		●	1,400			3.00	48
Allendale Dam	SD- 25	●		510	6	170	5.20	89
	SD- 24	●		1,350	20	260	5.80	135
	SD- 23	●		3,530	14	320	10.10	365
	SD- 22	●		4,270	44	440	7.50	163
	SD- 21	●		330	5		4.10	99
	SD- 20	●		1,790	12	200	3.60	76
Boys and Girls Club	SD- 19	●		920	14		0.02	
	SD- 18	●		470	13		8.00	167
Lymansville Dam	SD- 17	●			27		0.62	15
	SD- 15	●			6		0.47	15
	SD- 14	●			54		0.03	
	SD- 13	●			13		0.12	
	SD- 12	●					0.02	
	SD- 11	●			36		0.27	
	SD- 10	●		700	4		0.16	
Manton Dam	SD- 9	●					0.03	
Dyerville Dam	SD- 8	●		390			0.21	
	SD- 7	●					0.06	
Menino Park	SD- 6	●					0.02	
	SD- 5	●			5		0.02	
Olneyville Dam	SD- 4	●		870	13		0.42	7
Donigian Memorial Park, Valley Street	SD- 3	●		4,790			0.03	
	SD- 2	●		840	13		0.09	22
Water Place Park	SD- 1	●		49,750	60		0.12	49

(*) The data summary is based on data presented in Tables 2 to 4 in Appendix 12.

(**) Values presented for dioxins are the 2,3,7,8-tetrachlorodibenzo dioxin toxicity equivalence on a dry-weight basis.