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Water Quality in Northern Mississippi Hill Land Streams in the Demonstration Erosion Control (DEC) Project: Calendar Year 2001

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EXECUTIVE SUMMARY

Statement of Purpose

As part of the Demonstration Erosion Control (DEC) Project in the Yazoo Basin, the Water Quality and Ecological Processes Research Unit at the USDA-ARS National Sedimentation Laboratory was requested by the US Army Corps of Engineers, Vicksburg District, to characterize current water quality. The DEC project in the Yazoo Basin is a cooperative interagency project, including the US Army Corps of Engineers, the USDA Natural Resources Conservation Service and the USDA Agricultural Research Service, aimed at flood control and reducing erosion and channel instability. Additional goals of DEC include demonstration of innovative management techniques, total watershed planning and enhancement of water quality and environment. Currently, consistent characterization of water quality is performed in seven hill land stream watersheds as part of a larger database including measures of habitat, animal and plant diversity. Results are used to provide a continual evaluation of DEC water quality conditions and to monitor long-term changes. Such information is also useful in determining total maximum daily loads (TMDLs) within the Yazoo Basin. While the DEC Project is not a watershed regulation project, it is, within its broadest scope, a channel and watershed rehabilitation project. Thus, presentation of water quality information from a compliance perspective provides a basic measurement of watershed conditions.

Evaluation

Samples from each watershed were routinely collected every two weeks or monthly. Physical, chemical and biological water parameters measured were pH, temperature, dissolved oxygen, conductivity, salinity, turbidity, alkalinity, hardness, depth to water, depth of water, total, suspended and dissolved solids, filtered and total orthophosphate, ammonia, nitrate, nitrite, total nitrogen, chlorophyll *a*, fecal coliforms and enterococci. Analyses were performed according to standard water quality methods (APHA, 1998).

Results

Water quality changes were driven by flow conditions and seasonal changes. Fluctuations in temperature, dissolved oxygen, conductivity, and salinity were associated with seasonal changes and low-flow conditions. Changes in pH were often associated with storm events and fluctuations in chlorophyll *a* concentrations. Solids, specifically suspended solids concentrations, primarily exhibited fluctuations with significant storm events (1" or more of rainfall). Fluctuations in nutrient concentrations were commonly associated with application processes and ensuing nutrient runoff after rainfall events. Observed changes in microbial counts during 2001 were due primarily to warmer temperatures in spring, summer and fall as well as storm events.

Most water quality parameters were consistently within acceptable limits of USEPA and MDEQ TMDL water quality criteria guidelines during 2001. Non-compliant values occurring frequently (>10%) during 2001 were observed for turbidity, total orthophosphate, total nitrogen, and chlorophyll *a*, based upon proposed USEPA criteria guidelines, as well as summer fecal coliforms (between May and October), based upon current MDEQ criteria guidelines, in all seven streams studied in the Yazoo basin.

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NOTE

*All report figures are numbered according to the DEC watershed number (e.g. "2" for Long watershed, "4" for Hotophia watershed, etc.). The report was formatted as such to facilitate access to certain information for specific watersheds. Because of this, there are no figures with the numbers 3, 5, 6, 7, 10, 11, 12, 14, 15, or 16. The following is a complete list of watershed names and associated DEC numbers for which information was collected during this report period.

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INTRODUCTION

Impairment of river and stream surface water quality has been a pervasive and persistent problem throughout the United States, especially in areas with highly erodible soils, such as those found in northern Mississippi. Water quality degradation can be attributed to many factors, with sediment transport having a major role. Sedimentation, pathogens, and nutrients are the primary pollutants causing water quality impairment in U.S. rivers and streams. Non-point runoff from urban and agricultural land is considered the primary source of impairment (USEPA 2000a). This research addresses the issue of water quality in north Mississippi streams of the Yazoo Basin that have been designated through the Demonstration Erosion Control (DEC) Project as impacted by at least one of the above mentioned contributing factors.

As part of the DEC Project in the Yazoo Basin (Fig. A), the Water Quality and Ecological Processes Research Unit at the USDA-ARS National Sedimentation Laboratory was requested by the US Army Corps of Engineers, Vicksburg District, to characterize current water quality. The DEC project in the Yazoo Basin is a cooperative interagency project, including the U.S. Army Corps of Engineers, the USDA Natural Resources Conservation Service and the USDA Agricultural Research Service, aimed at flood control and reducing erosion and channel instability. Additional goals of DEC include demonstration of innovative management techniques, total watershed planning and enhancement of water quality and environment (Figs. B, C).

Currently, consistent characterization of water quality is performed in designated watersheds as part of a larger database including habitat, animal and plant diversity. This information has proven valuable in assessing specific problems in DEC watersheds and in evaluating long-term changes resulting from DEC stabilization and rehabilitation efforts. Such information is also useful in determining total maximum daily loads (TMDLs) within the Yazoo Basin. Individual TMDLs are based upon the total daily amount of a material (such as total solids or nutrients) in a body of water from natural, point and non-point sources that would not have a deleterious effect on aquatic life. TMDLs also include a margin of safety to account for uncertainty.

Sediment has been reported as the single most abundant pollutant (by volume) in the Nation's rivers and streams (Fowler and Heady, 1981). For example, the 1996 National Water Quality Inventory stated that about 40% of the nation's surveyed rivers, lakes, and estuaries had water quality impairment, and suspended sediment was the most widespread pollutant impacting surveyed rivers and streams (USEPA, 1997a). Sediment-related problems are the most severe in certain regions developed for agriculture. Highly erodible soils in north Mississippi's geological landscape equate to potentially severe problems with sediment transport in streams. Sediment yield from the northern Mississippi hill land streams is about twice the national average, or about 3000 tons per square mile per year. Most streams in this region have experienced accelerated erosion within the last 30 years, often increasing their channel size three to tenfold. Statistics are not available for northern Mississippi alone, but on a statewide basis, 95% of all stream miles do not fully support aquatic life uses, and 91% do not fully support swimming (MDEQ, 1999). These severe conditions produce an ideal situation for research and development of technology for widespread application. Because water is the basis for life, this issue is in critical need of attention. Maintaining water quality assures agriculture a water supply for crops and livestock. Likewise, it provides a potable supply of drinking water for municipalities. Hence, life itself hinges on the quality of water.

The objectives of this study were twofold. The first objective was to characterize and report current water quality conditions during calendar year 2001 in seven north Mississippi hill land streams located in the Yazoo drainage basin. The second objective was to assess current water quality conditions in relation to current state and national water quality guidelines in order to facilitate determining TMDLs within the Yazoo drainage basin.

MATERIALS AND METHODS

Samples from each watershed (Fig. A) were collected and preserved (using ice) twice each month, with the exception of the Toby Tubby, Burney Branch, and Abiaca watersheds, which were sampled monthly. General site observations were made and noted at each sample collection. Measurements of depth of water and depth to water (recorded from the top of the collection site [bridge rail] to the top of the water's surface), and *in-situ* water chemistry (pH, temperature, dissolved oxygen, conductivity, and salinity using calibrated electronic meters) were recorded at each site.

Preserved water samples were transported to the USDA-ARS National Sedimentation Laboratory, Oxford, Mississippi. Physical and chemical parameters including hardness, alkalinity, turbidity, total solids, dissolved solids, suspended solids, ammonia, nitrates, nitrites, total nitrogen (NO_3-N + NO_2-N + total Kjeldahl nitrogen), filtered orthophosphate, total orthophosphate, chlorophyll *a*, fecal coliforms, and enterococci were analyzed using standard methods (APHA, 1998).

Non-compliance frequency, magnitude and score of pH, turbidity, suspended solids, chlorophyll *a*, total orthophosphate, total nitrogen, winter (January-April and November-December 2001) fecal coliform contamination, and summer (May through October 2001) fecal coliform contamination were calculated. Frequency of non-compliant values was determined as the fraction of total samples that exceeded water quality criteria guidelines (USEPA 1986 and 2000b; MDEQ 1999; See Table 1), both current and proposed, for that specific water quality parameter. Magnitude of non-compliant values was calculated using the following equation (modified from Cao et al. 1999):

$$(1) \qquad x_i = \frac{\overline{X}_i}{c_i}$$

where x_i = magnitude of non-compliance for water quality parameter *i*, $\overline{X}_i$ = mean of values exceeding water quality criteria for water quality parameter *i*, and c_i = water quality criteria value for water quality parameter *i*. A non-compliance score, including both magnitude and frequency, was calculated for each of the eight water quality parameters using equation 2:

$$(2) \qquad \log(y_i) = \frac{x_i}{(1 - f_i)}$$

where y_i = non-compliance score for water quality parameter *i*, and f_i = frequency of non-compliance for water quality parameter *i*.

RESULTS

Otoucalofa

Locations of sampling sites for Otoucalofa Creek are presented in Figure A. Depth to water and water depth in Otoucalofa Creek remained constant throughout the year, fluctuating with periods of drought and rain (Fig. 1-1, D). Otoucalofa Creek water quality measurements of temperature, dissolved oxygen, conductivity, and salinity were consistent according to typical seasonal fluctuations (Figs. 1-1, 1-2). Measurements of pH showed some fluctuations but were due in part to fluctuations in chlorophyll *a* concentrations and storm events (Fig. 1-2, D). Solids (total, dissolved, and suspended) and turbidity remained relatively constant, with noticeable deviations occurring on 3/12/01, 4/16/01, 5/29/01, 9/4/01, and 11/27/01 that were associated with significant rainfall events (approximately 1" or more; Fig. 1-3, D) or rises in stage. Hardness and alkalinity measurements were indicative of "soft" water and typical for stream waters flowing through a region with limited calciferous geologic formations (Fig. 1-4). Filterable and total orthophosphate concentrations remained generally constant over the year, with peaks coinciding with storm events (Fig. 1-4, D). Ammonia, nitrate, nitrite, and total nitrogen concentrations followed similar patterns with peaks associated with storm events or animal remains at or near the sampling locality (Fig. 1-5, D). Site 1,1 had consistently greater nutrient concentrations and associated chlorophyll *a* concentrations due to its location just downstream of the outfall of a wastewater treatment facility serving the city of Water Valley (Fig. 1-2, 1-4, 1-5, 1-7). A fecal coliform peak occurred on 3/12/01 for sites 1,1, 1,3, and 1,4 in association with a storm event (Fig. D). Site 1,1 had several independent fecal coliform peaks above other sampling sites during 2001 (Fig. 1-6). Two significant Enterococci peaks occurred (on 3/12/01 and 5/29/01) and were due to runoff associated with storm events (Fig. 1-6, D).

According to USEPA and Mississippi Department of Environmental Quality (MDEQ) water quality criteria guidelines (see Table 1; USEPA 1986 and 2000b; MDEQ 1999), 14 of 20 water quality parameters measured in this study for Otoucalofa Creek were within acceptable limits (frequency > 90%) (USEPA 1997b; Smith et al. 2001). Exceptions were limited to suspended solids, turbidity, total orthophosphate, chlorophyll *a*, total nitrogen, and summer fecal coliforms (from May to October 2001) (Fig 1-7, G, H). At the watershed level, frequency of non-compliance was greatest for turbidity and lowest for winter fecal coliforms (Table 2, Fig. G). Magnitude of non-compliance was greatest for chlorophyll *a* and lowest for total nitrogen (Table 2). Based upon overall non-compliance scores for Otoucalofa Creek watershed, turbidity, chlorophyll *a*, total orthophosphate, total nitrogen, suspended solids, and summer fecal coliforms were parameters of greatest concern during 2001. Greatest contribution to water quality non-compliance observed in Otoucalofa Creek occurred at site 1,1 (Fig. 1-7).

Examination of long-term data (17 years) for two water quality parameters of concern, suspended solids and total phosphorus concentrations, in Otoucalofa Creek showed no discernible increasing or decreasing trends (Fig. 1-8, 1-9). Long-term values for these two parameters appeared relatively stable with major peaks coinciding with rainfall events and high stream flows in winter and spring. Other significant peaks occurring during 1991-1992 coincided with greater-than average rainfall and high stream flows for those years.

Long

Sampling sites along Long Creek watershed are shown in Figure A. Depth to water and water depth remained relatively constant with a significant increase occurring on 11/27/01 due to a heavy rainfall event (Fig. 2-1, D). Basic water quality parameters of temperature, dissolved oxygen, conductivity, and salinity were consistent according to seasonal fluctuations (Fig. 2-1, 2-2). Measurements of pH fluctuated but were due primarily to fluctuations in chlorophyll *a* concentrations and storm events (Fig. 2-2, D). Turbidity and solids concentrations (total, dissolved, suspended) were relatively constant, but had peaks occurring on 3/12/01, 5/29/01, and 11/27/01 in association with storm events and increases in stream flow (Fig. 2-3). Hardness and alkalinity measurements indicate "soft" water that is typical for stream waters flowing through a region with limited calciferous geologic formations (Fig. 2-4). Filterable orthophosphate concentrations remained generally constant over the year, with a peak occurring on 11/27/01 coinciding with a storm event (Fig. 2-4, D). Total orthophosphate concentrations fluctuated throughout the year with peaks occurring on 3/12/01, 4/16/01, 5/29/01, 9/4/01, 10/16/01, and 11/27/01 (Fig. 2-4) in conjunction with storm events, associated increases in stream flow, turbidity, and suspended solids concentrations (Fig. 2-3, D). Ammonia, nitrate nitrite and total nitrogen concentrations also fluctuated throughout calendar year 2001 (Fig. 2-5), and peaks were usually associated with storm events (Fig. D), nutrient runoff, application or animal remains. Fecal coliforms had a significant increase for several sites on 3/12/01 in association with a storm event (Fig. 2-6, D). Enterococci exhibited peaks on 3/12/01, 5/29/01, 9/18/01, and 12/11/01 (Fig. 2-6).

According to USEPA and MDEQ water quality criteria guidelines (see Table 1; USEPA 1986 and 2000b; MDEQ 1999), Long Creek had 14 of 20 measured water quality parameters within acceptable limits (frequency > 90%) (USEPA 1997b; Smith et al. 2001). Non-compliance frequently occurred (>10%) for suspended solids, turbidity, total orthophosphate, chlorophyll *a*, total nitrogen, and summer fecal coliforms (from May to October 2001) (Fig 2-7, G, H). At the watershed level, frequency of non-compliance was greatest for chlorophyll *a* and lowest for pH (Table 2, Fig. G). Magnitude of non-compliance was greatest for chlorophyll *a* and lowest for pH (Table 2). Based upon overall non-compliance scores for Long Creek watershed the parameters of greatest concern during 2001 were (in descending order) chlorophyll *a*, turbidity, total orthophosphate, total nitrogen, suspended solids, and summer fecal coliforms. Contributions to water quality non-compliance observed in Long Creek were not evident at any one specific site (Fig. 2-7) and appeared to be uniform throughout the watershed.

Hotophia

Sampling stations for Hotophia Creek are presented in Fig. A. Depth to water and water depth exhibited similar fluctuations to Long Creek due to the close proximity of these watersheds (Fig. 2-1, 4-1). Depth measurements remained relatively constant, with the exception of a significant peak on 11/27/01 that was associated with a significant rainfall event (Fig. 4-1, D). As observed in previous watersheds (Otoucalofa and Long creeks), temperature, dissolved oxygen, conductivity, and salinity measurements exhibited typical seasonal fluctuations (Fig. 4-1, 4-2). Measurements of pH and chlorophyll *a* fluctuated similarly but not as closely as observed in Otoucalofa and Long creeks (Fig. 1-2, 2-2, 4-2). Turbidity and solids (total, dissolved, suspended) measurements remained relatively constant during low flow conditions with peaks on 3/12/01, 5/29/01, 9/4/01, 10/16/01, and 11/27/01 coinciding with rainfall events and increases in stream flow (Fig. 4-3, D). As expected, hardness and alkalinity measurements were indicative of "soft" water and typical for stream waters flowing through the north Mississippi loess hill land region with limited calciferous geologic formations (Fig. 4-4). As with Long Creek, filterable orthophosphate concentrations in Hotophia Creek remained generally constant throughout calendar year 2001, with a peak for all sites occurring on 11/27/01 coinciding with a rainfall event (Fig. 2-4, 4-4, D). Total orthophosphate concentrations fluctuated throughout the year. Peaks occurred on 3/19/01, 4/16/01, 5/29/01, 8/20/01, 9/4/01, 10/16/01, and 11/27/01 (Fig. 4-4), due to rainfall events, increases in stream flow, turbidity, and suspended solids concentrations (Fig. 4-3, D). Ammonia, nitrate, nitrite and total nitrogen concentrations also fluctuated throughout 2001 (Fig. 4-5). Patterns of observed nitrogen peaks were not as clear as orthophosphate due to greater complexity of additional nitrogen sources such as nutrient applications, associated runoff during rainfall events, or decomposition of animal remains. Peaks in fecal coliform contamination occurred during spring (Fig. 2-6), while peaks in enterococcal contamination were observed on 3/12/01, 5/29/01, 9/18/01 (4,1), and 12/11/01 (Fig. 4-6).

Hotophia Creek had 15 of 20 measured water quality parameters within acceptable limits (frequency > 90%) (USEPA 1997b; Smith et al. 2001), based upon USEPA and MDEQ water quality criteria guidelines (see Table 1; USEPA 1986 and 2000b; MDEQ 1999). Non-compliant parameters (based upon frequency of non-compliance) were turbidity, chlorophyll *a*, total orthophosphate, total nitrogen, and suspended solids (Table 2, Fig 4-7, G, H). At the watershed level, frequency of non-compliance was greatest for turbidity and lowest for winter and summer fecal coliforms (Table 2, Fig. G). Magnitude of non-compliance was greatest for chlorophyll *a* and lowest for winter and summer fecal coliforms (Table 2). Overall non-compliance scores for Hotophia Creek watershed showed the parameters of greatest concern during 2001 to be (in descending order) chlorophyll *a*, turbidity, total nitrogen, total orthophosphate, and suspended solids (Table 2). As with Long Creek, contributions to water quality non-compliance observed in Hotophia Creek were not evident at any one specific site (Fig. 4-7) and appeared to be similar throughout the watershed.

Abiaca

Abiaca Creek sampling localities are presented in Fig. A. Water depth and depth to water were relatively constant throughout the year except for peaks observed on 1/22/01, 9/4/01, and 11/27 coinciding with rainfall events and increased stream flow (Fig. 8-1, E, F). As exhibited in other watersheds, temperature, dissolved oxygen, conductivity, and salinity showed typical seasonal fluctuations (Fig. 8-1, 8-2). Measurements of pH exhibited fluctuations during calendar year 2001 due partly to fluctuations in chlorophyll *a* concentrations and storm events (Fig. 8-2, E). As expected, turbidity and solids (total, dissolved, suspended) measurements were relatively constant during low flow conditions with peaks occurring on 1/22/01, 9/4/01, and 11/27/01 in conjunction with storm events and increases in stream flow (Fig. 8-3, E, F). Measurements of hardness and alkalinity in Abiaca Creek were comparable to other streams within the Yazoo drainage basin and indicative of "soft" water typical of the north Mississippi loess hills (Fig. 8-4). Within Abiaca Creek, filterable orthophosphate concentrations were generally constant during 2001, with a peak for all sites occurring on 11/27/01, coinciding with a rainfall event and increased stream flow (Fig. 8-4, E,F). As with other DEC streams, total orthophosphate measurements fluctuated throughout the year. Peaks occurred on 1/22/01, 4/16/01, 9/4/01, and 11/27/01 (Fig. 8-4) due to storm events, increases in stream flow, turbidity, and suspended solids concentrations (Fig. 8-3, E, F). Ammonia, nitrate, nitrite and total nitrogen concentrations also fluctuated throughout calendar year 2001 (Fig. 8-5). Patterns of fluctuations in various nitrogen species measured are not as closely associated with rainfall and stream flow as are other water quality parameters and can be associated with nutrient applications or decomposition of animal remains. Both fecal coliforms and enterococci had a significant peak for all sites on 11/27/01 in association with a storm event and increased stream flow (Fig. 8-6, E, F).

Abiaca Creek had only 13 of 20 measured water quality parameters within acceptable limits (non-compliance frequency < 10%) (USEPA 1997b; Smith et al. 2001), based upon USEPA and MDEQ water quality criteria guidelines (see Table 1; USEPA 1986 and 2000b; MDEQ 1999). Non-compliant parameters (as determined by frequency of non-compliance) were turbidity, chlorophyll *a*, total orthophosphate, total nitrogen, summer fecal coliforms, suspended solids, and winter fecal coliforms (January-April 2001 and November-December 2001) (Table 2, Fig 8-7, G, H). At the watershed level, frequency of non-compliance was greatest for turbidity and lowest for winter pH (Table 2, Fig. G, H). Magnitude of non-compliance was greatest for chlorophyll *a* and lowest for pH (Table 2). Overall non-compliance scores for Abiaca Creek watershed showed the parameters of greatest concern during 2001 to be (in descending order) chlorophyll *a*, turbidity, total orthophosphate, winter fecal coliforms, total nitrogen, summer fecal coliforms, and suspended solids (Table 2). Within Abiaca Creek, sites 8,1, 8,2, and 8,6 appeared to contribute a significant fraction of overall water quality non-compliance whereas site 8,5 appeared to contribute a lesser fraction (Fig. 8-7). Remaining sites appeared to be similar throughout the watershed.

Toby Tubby

Locations of Toby Tubby Creek sampling sites are shown in Figure A. Water depth and depth to water in Toby Tubby Creek remained relatively constant throughout the year with shallow peaks occurring on 3/12/02, 5/29/02, and 12/11/02. This was associated with rainfall and ensuing increases in stream flow (Fig. 9-1, E, F). Basic water quality parameters of temperature, dissolved oxygen, conductivity, and salinity exhibited typical seasonal fluctuations (Fig. 9-1, 9-2). Measurements of pH fluctuated throughout 2001 due, in part, to rainfall events and fluctuations in chlorophyll *a* concentrations (Fig 9-2. E). Turbidity and solids (total and suspended) measurements were relatively constant with peaks occurring on 3/12/01, 5/29/01, and 12/11/01 coinciding with rainfall events and associated increases in stream flow (Fig. 9-3, E, F). Measurements of hardness and alkalinity in Toby Tubby Creek shared a similar pattern with other streams within the Yazoo drainage basin that indicate "soft" water flowing through the north Mississippi loess hills, a region with limited calciferous geologic formations (Fig. 9-4). Within Toby Tubby Creek, filterable orthophosphate concentrations fluctuated throughout 2001 due, in part, to nutrient applications (Fig. 9-4). Total orthophosphate measurements were relatively constant. Peaks occurred on 3/12/01, 6/25/01, 9/18/01 (site 9,3), and 12/11/01 (Fig. 9-4) due to storm events, increases in stream flow, turbidity, suspended solids concentrations, and nutrient applications (Fig. 9-3, E, F).

As with other DEC watersheds, ammonia, nitrate, nitrite and total nitrogen concentrations fluctuated throughout calendar year 2001 (Fig. 9-5). Patterns of fluctuations in various measured nitrogen species are not as closely associated with rainfall and stream flow as are other water quality parameters and can be attributed to nutrient applications or decomposition of animal remains. Site 9,3 had consistently greater nutrient concentrations and associated chlorophyll *a* concentrations due to the close proximity of the sampling site to the city of Oxford (Fig. 9-2, 9-4, 9-5, 9-7). Contamination of fecal coliforms and enterococci in Toby Tubby Creek were consistent except for a peak at site 9,3 on 9/18/01 for fecal coliforms and 5/29/01 for enterococci. A peak for enterococci at all sites was observed on 12/11/01 in association with an increase in stream flow (Fig. 9-6, F).

Toby Tubby Creek exhibited 14 of 20 measured water quality parameters within acceptable limits (non-compliance frequency < 10%) (USEPA 1997b; Smith et al. 2001), according to USEPA and Mississippi Department of Environmental Quality (MDEQ) water quality criteria guidelines (see Table 1; USEPA 1986 and 2000b; MDEQ 1999). Exceptions were limited to suspended solids, turbidity, total orthophosphate, chlorophyll *a*, total nitrogen, and summer fecal coliforms (from May to October 2001) (Table 2, Fig 9-7, G, H). At the watershed level, frequency of non-compliance was greatest for turbidity and lowest for winter fecal coliforms (Table 2, Fig. G, H). Magnitude of non-compliance was greatest for summer fecal coliforms and lowest for winter fecal coliforms (Table 2). Based upon overall non-compliance scores for Toby Tubby Creek watershed (in descending order), turbidity, chlorophyll *a*, summer fecal coliforms, total orthophosphate, suspended solids, and total nitrogen were parameters of greatest concern during 2001 (Table 2). Greatest contribution to water quality non-compliance observed in Toby Tubby Creek occurred at site 9,3 which is in close proximity to the city of Oxford (Fig. 9-7).

Burney Branch

Locations of Burney Branch Creek sampling sites are presented in Figure A. Similar to other DEC watersheds, Burney Branch Creek water depth and depth to water remained relatively constant throughout the year with a small peak observed on 3/12/01 and 12/11/01 in conjunction with storm events and associated increases in stream flow (Fig. 13-1, E, F). Several basic water quality parameters of temperature, dissolved oxygen, conductivity, and salinity remained consistent according to typical seasonal fluctuations (Fig 13-1, 13-2). Site 13,3 showed consistently greater conductivity and dissolved solids measurements than sites 13,1 and 13,2 due to its close proximity just downstream of a wastewater treatment facility serving the University of Mississippi in Oxford, Mississippi (Fig 13-2, 13-3). Measurements of pH in Burney Branch Creek fluctuated throughout 2001 due, in part, to rainfall events and fluctuations in chlorophyll *a* concentrations (Fig 13-2. E). Turbidity and solids (total and suspended) measurements were relatively constant with a significant peak occurring on 3/12/01 coinciding with a rainfall event and associated increase in stream flow (Fig. 13-3, E, F). Again, site 13,3 showed consistently greater turbidity and solids measurements than sites 13,1 and 13,2 because of its location just downstream of the University of Mississippi wastewater treatment facility (Fig. 13-4, 13-7). Measurements of hardness and alkalinity in Burney Branch Creek shared a similar pattern with other streams within the Yazoo drainage basin and were indicative of "soft" water flowing through the north Mississippi loess hills, a region with limited calciferous geologic formations (Fig. 13-4). Filterable orthophosphate concentrations remained relatively constant throughout 2001 with a noticeable peak occurring on 3/12/01 in association with a storm event and ensuing increase in stream flow (Fig. 13-4, E, F). Total orthophosphate measurements also remained relatively constant with a peak occurring on 3/12/01 due to a storm event and increase in stream flow (Fig. 13-4, E, F). Orthophosphate concentrations (filterable and total) were consistently much greater at site 13,3, again due to the site's location just downstream of the University of Mississippi wastewater treatment facility (Fig. 13-4, 13-7). Ammonia, nitrate, nitrite and total nitrogen concentrations at sites 13,1 and 13,2 fluctuated throughout 2001 (Fig. 13-5). Patterns of fluctuations in various nitrogen species measured are not as closely associated with rainfall and stream flow as other water quality parameters and may be attributed to urban nutrient applications. Similar to orthophosphates, Burney Branch Creek site 13,3 showed consistently greater nitrogen concentrations than all other sites, again, because of its location just downstream of the University of Miississippi wastewater treatment facility (Fig. 13-5, 13-7). Microbial analyses revealed fluctuations in fecal coliform and enterococci contamination with peaks generally coinciding with storm events and increases in stream flow (13-6, E, F).

Fourteen of 20 water quality parameters for Burney Branch Creek were frequently (non-compliance <10%) (USEPA 1997b; Smith et al. 2001) within acceptable limits of USEPA (USEPA 1986 and 2000b) and MDEQ (MDEQ 1999) water quality criteria guidelines (Table 1). Non-compliance often (>25%) occurred for total orthophosphate, chlorophyll *a*, and summer fecal coliforms. Non-compliant water quality parameters were limited to suspended solids, turbidity, total orthophosphate, chlorophyll *a*, total nitrogen, and summer fecal coliforms (from May to October 2001) (Table 2, Fig 9-7, G, H). At the watershed level, frequency of non-compliance was greatest for total nitrogen and lowest for pH (Table 2, Fig. G, H). Magnitude of non-compliance was greatest for total orthophosphate and lowest for pH (Table 2). Based upon overall non-compliance scores for Burney Branch Creek watershed (in descending order), total orthophosphate, total nitrogen, summer fecal coliforms, turbidity, chlorophyll *a*, and suspended solids were parameters of greatest concern during 2001 (Table 2). Greatest contribution to water quality non-compliance observed in Burney Branch Creek occurred at site 13,3, just downstream of a wastewater treatment facility serving the University of Mississippi in the city of Oxford (Fig. 13-7).

Yalobusha

Locations of sampling sites for Yalobusha River are presented in Fig. A. Water depth and depth to water remained relatively constant throughout the year with peaks observed on 1/22/01, 3/12/01, 4/16/01, 10/16/01, and 11/27/01 in association with storm events and increases in stream flow (Fig. 17-1, E, F). Site 17,1 (Grenada Lake) had a decrease in depth to water in spring as reservoir levels increased, leveling out throughout the summer and increasing in fall (as waters levels decreased) due to flood control practices. As observed in other DEC watersheds, temperature, dissolved oxygen, conductivity and salinity in Yalobusha River remained relatively constant with expected seasonal fluctuations throughout 2001 (Fig. 17-1, 17-2). Measurements of pH had fluctuations throughout the year due in part to fluctuations in chlorophyll *a* concentrations and storm events (Fig. 17-2, E). Turbidity and solids (total, dissolved and suspended) measurements were relatively constant with significant peaks observed on 1/8/01, 3/12/01, 5/29/01, 8/20/01, and 11/27/01, coinciding with storm events and associated increases in stream flow (Fig. 17-3, E, F). Measurements of hardness and alkalinity in Yalobusha River were comparable to other DEC streams within the Yazoo drainage basin that indicate "soft" water flowing through the north Mississippi loess hills, a region with limited calciferous geologic formations (Fig. 17-4). Filterable and total orthophosphate concentrations exhibited fluctuations throughout 2001 with increases occurring primarily during storm events, ensuing increases in stream flow, turbidity, suspended solids concentrations, and nutrient applications (Fig. 17-3, 17-4, E, F). Comparable to other DEC watersheds, ammonia, nitrate nitrite and total nitrogen concentrations in Yalobusha River also fluctuated throughout calendar year 2001 (Fig. 17-5). Patterns of fluctuations in various nitrogen species measured are not as closely associated with rainfall and stream flow as are other water quality parameters and can also be associated with nutrient applications or decomposition of animal remains. Microbial analyses revealed both fecal coliforms and enterococci had significant peaks for all sites on 11/27/01 in association with a storm event and increased stream flow (Fig. 17-6, E, F).

Yalobusha River had 13 of 20 water quality measurements that were often within acceptable limits (non-compliance frequency <10%) (USEPA 1997b; Smith et al. 2001) of USEPA (USEPA 1986 and 2000b) and MDEQ (MDEQ 1999) water quality guidelines throughout 2001. Non-compliant water quality parameters were limited to suspended solids, turbidity, chlorophyll *a*, total orthophosphate, total nitrogen, winter fecal coliforms, and summer fecal coliforms during calendar year 2001 (Table 2, Fig 17-7, G, H). At the watershed level, frequency of non-compliance was greatest for turbidity and lowest for pH (Table 2, Fig. G, H). Magnitude of non-compliance was greatest for chlorophyll *a* and lowest for pH (Table 2). Overall non-compliance scores for Yalobusha River watershed showed the parameters of greatest concern during 2001 to be (in descending order) turbidity, chlorophyll *a*, total orthophosphate, total nitrogen, winter fecal coliforms, summer fecal coliforms, and suspended solids (Table 2). Contributions to water quality non-compliance observed in Yalobusha were not limited to any one specific site (Fig. 17-7) and appeared to be relatively uniform throughout the watershed.

SUMMARY

Water quality parameters were measured for watersheds of seven hill land streams and rivers in the Yazoo drainage basin during 2001. Expected patterns in yearly fluctuations in temperature, dissolved oxygen, conductivity, and salinity were associated with typical seasonal changes. Changes in pH measurements were primarily associated with storm events and fluctuations in chlorophyll *a* concentrations. Turbidity and solids, specifically suspended solids concentrations, exhibited fluctuations coinciding with significant storm events and ensuing increases in runoff stream flow. Measurements of hardness and alkalinity within the Yazoo drainage basin were indicative of "soft" water flowing through the north Mississippi loess hills, a region with limited calciferous geologic formations. Patterns of filterable orthophosphate concentrations were commonly associated with nutrient applications and sediment-laden runoff during storm events. Total orthophosphate measurements typically fluctuated in conjunction with turbidity and solids due to storm events and associated increases in stream flow. Patterns of various nitrogen species measured (ammonia, nitrate, nitrite, and total nitrogen) were not as closely associated with storm events and increased stream flow as other water quality parameters (*e.g.* suspended solids, total orthophosphate). Nitrogen species were influenced by other factors such as nutrient applications or decomposition of animal remains at or near sampling stations. Individual sites within specific watersheds (*e.g.* Otoucalofa Creek site 1,1 and Burney Branch site 13,3) in close proximity to wastewater treatment facilities exhibited significantly elevated nutrient concentrations above ambient conditions. Observed changes in microbial contamination during 2001 were due primarily to storm events and increases in stream flow.

Comparisons of water quality data collected during 2001 with water quality criteria guidelines proposed by USEPA (USEPA 2000b) and current water quality guidelines by MDEQ (MDEQ 1999) were made to estimate the acceptability of current water quality parameters within DEC watersheds. Most water quality parameters were consistently within acceptable limits of USEPA (USEPA 1986; 2000b) and MDEQ (1999) water quality criteria guidelines during 2001. Non-compliant water quality parameters (non-compliance frequency >10%) during 2001 were observed for turbidity, chlorophyll *a*, total orthophosphate, total nitrogen, summer (from May to October) fecal coliforms, and suspended solids in all seven streams studied in the Yazoo drainage basin. Additional measures of magnitude of non-compliance and overall non-compliance scores were determined to more accurately aid in assessing a stream segment (as impaired or non-impaired) and further facilitate determinations of total maximum daily loads (TMDLs) for these water quality parameters. A single calendar year of water quality data is not sufficient for statistical comparisons of stream impairment among the DEC watersheds. However, descriptive comparisons of stream impairment based upon overall non-compliance scores for this study suggest watersheds in close proximity to denser populations (*e.g.* Yalobusha River near Calhoun City, Derma, and Vardeman; Abiaca Creek near Greenwood and Cruger; Otoucalofa Creek near Water Valley) have greater impairment than watersheds in less densely populated regions (*e.g.* Long, Hotophia and Toby Tubby). In addition, watersheds receiving effluent from wastewater treatment facilities (*i.e.* Burney Branch Creek and Otoucalofa Creek) showed greater impairment, especially for nutrients, than comparably sized watersheds without point-source discharges (*i.e.* Toby Tubby Creek and Long Creek). If currently proposed USEPA nutrient water quality criteria (USEPA 200b) are accepted by MDEQ, then several streams within the study area would be possible candidates for nutrient TMDLs.

Evaluation of water quality during 2001 was performed in hill land watersheds of the Yazoo basin as part of a larger database including habitat, fisheries, benthic invertebrate populations and plant diversity. Specific studies and experiments such as the current aspect of water quality data characterization are useful in helping to determine potential TMDLs within the Yazoo Basin. Results of the current study show stream system stability since most streams depend on shallow groundwater seepage for base flow. However, caution should be exercised, since the use of data from a single year is considered preliminary and should be evaluated in light of long-term watershed changes.

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Table 1. Water quality criteria for selected physical and chemical parameters.

Parameter	Criteria	Source
pH (pH units)	6	MDEQ (revised from 1999)
Turbidity (NTU)	7.03	USEPA (2000b proposed nutrient criteria)
Suspended solids (mg/L)	82	USEPA (1986 water quality criteria)
Chlorophyll *a* (μg/L)	0.93	USEPA (2000b proposed nutrient criteria)
Total orthophosphate (mg/L)	0.112	USEPA (2000b proposed nutrient criteria)
Total nitrogen (mg/L)	0.69	USEPA (2000b proposed nutrient criteria)
Fecal coliform (colonies/100 ml)[1]	4000	MDEQ (1999)
Fecal coliform (colonies/100 ml)[2]	400	MDEQ (1999)

[1]Winter fecal coliform criteria (January-April and November-December) where no more than 10% of samples examined during any month may exceed 4000 colonies/100 ml for waters meeting fish and wildlife criteria.
[2]Summer fecal coliform criteria (May through October) where no more than 10% of samples examined during any month may exceed 400 colonies/100 ml for waters meeting fish and wildlife criteria.

Table 2. Number of non-compliant samples (total number of samples), frequency, magnitude, and scores of selected water quality non-compliances for each Demonstration Erosion Control (DEC) watershed during 2001 based upon Mississippi Department of Environmental Quality (MDEQ) or US Environmental Protection Agency (USEPA) water quality criteria. See Note within text for an explanation of watershed identification numbers.

		Watershed Identification Number						
Water quality parameter		1	2	4	8	9	13	17
pH[1]	non-compliant samples (N)	13 (134)	4 (200)	1 (75)	8 (96)	3 (34)	3 (39)	24 (315)
	frequency (%)	9.7	2	1.3	8.3	8.8	7.7	7.6
	magnitude	2.34	1.41	1.26	1.59	1.48	1.86	1.78
	non-compliance score	0.41	0.16	0.11	0.24	0.21	0.3	0.28
Suspended solids (mg/L)[2]	non-compliant samples (N)	19 (139)	21 (197)	8 (74)	20 (95)	5 (34)	8 (39)	74 (317)
	frequency (%)	13.7	10.7	10.8	21.1	14.7	20.5	23.3
	magnitude	5.06	3.18	2.96	2.6	3.63	3.43	2.79
	non-compliance score	0.77	0.55	0.52	0.52	0.63	0.63	0.56
Turbidity (NTU)[3]	non-compliant samples (N)	132 (140)	153 (200)	69 (75)	90 (96)	33 (34)	26 (39)	306 (319)
	frequency (%)	94.3	76.5	92	93.8	97.1	66.7	95.9
	magnitude	8.49	6.45	6.11	10.9	9.4	11.15	14.11
	non-compliance score	2.17	1.45	1.88	2.24	2.51	1.52	2.54
Chlorophyll *a* (μg/L)[3]	non-compliant samples (N)	117 (138)	172 (200)	66 (75)	89 (97)	26 (33)	27 (39)	293 (318)
	frequency (%)	84.8	86	88	91.8	78.8	69.2	92.1
	magnitude	11.97	9.29	10.27	15.01	6.57	9.73	17.84
	non-compliance score	1.9	1.82	1.93	2.26	1.49	1.5	2.35
Total orthophosphate (mg/L)[3]	non-compliant samples (N)	95 (131)	120 (190)	53 (72)	73 (88)	18 (34)	25 (34)	244 (293)
	frequency (%)	72.5	63.2	73.6	83	52.9	73.5	83.3
	magnitude	4.47	3	2.11	4.59	3.29	15.98	4.24
	non-compliance score	1.21	0.91	0.9	1.43	0.84	1.78	1.4

Table 2. Continued.

Water quality parameter		Watershed Identification Number 1	2	4	8	9	13	17
Total nitrogen (mg/L)[3]	non-compliant samples (N)	102 (137)	115 (192)	57 (71)	59 (93)	16 (34)	32 (35)	246 (299)
	frequency (%)	74.5	59.9	80.3	63.4	47.1	91.4	82.3
	magnitude	1.99	1.87	1.79	1.93	1.8	4.09	2.22
	non-compliance score	0.89	0.67	0.96	0.72	0.53	1.68	1.1
Fecal coliform (colonies/100 ml)[4]	non-compliant samples (N)	3 (38)	4 (56)	0 (21)	7 (40)	0 (17)	2 (21)	11 (77)
	frequency (%)	7.9	7.1	0	17.5	0	9.5	14.3
	magnitude	2.92	2.73	0	9.97	0	2.05	9.02
	non-compliance score	0.5	0.47	0	1.08	0	0.36	1.02
Fecal coliform (colonies/100 ml)[5]	non-compliant samples (N)	6 (28)	8 (40)	0 (15)	9 (32)	2 (14)	10 (14)	24 (74)
	frequency (%)	21.4	20	0	28.1	14.3	71.4	32.4
	magnitude	3.72	2.46	0	2.78	15.13	9.41	3.31
	non-compliance score	0.68	0.49	0	0.59	1.25	1.52	0.69

[1]MDEQ revised from 1999 water quality criteria (See Table 1).
[2]USEPA 1986 water quality criteria (See Table 1).
[3]USEPA 2000b nutrient criteria (See Table 1).
[4]Winter fecal coliform (January-April and November-December) MDEQ 1999 water quality criteria (See Table 1).
[5]Summer fecal coliform (May through October) MDEQ 1999 water quality criteria (See Table 1).

Figure A. Map of Demonstration Erosion Control (DEC) project watersheds and sampling locations for each watershed during 2001. See Note within text for an explanation of watershed identification numbers.

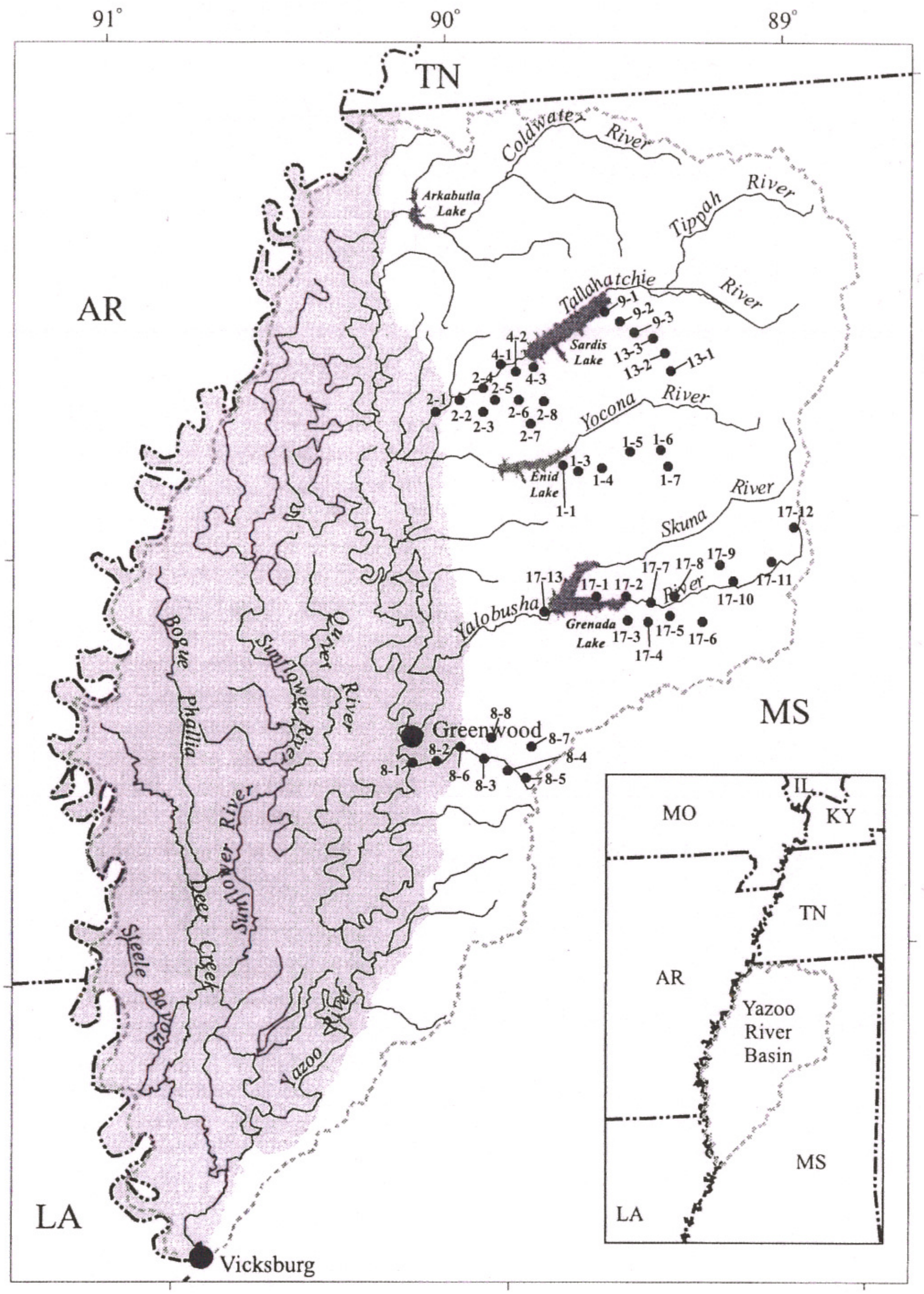


Fig. 1-1. 2001 depth to water, water depth, temperature, and dissolved oxygen measurements for Otoucalofa Creek.

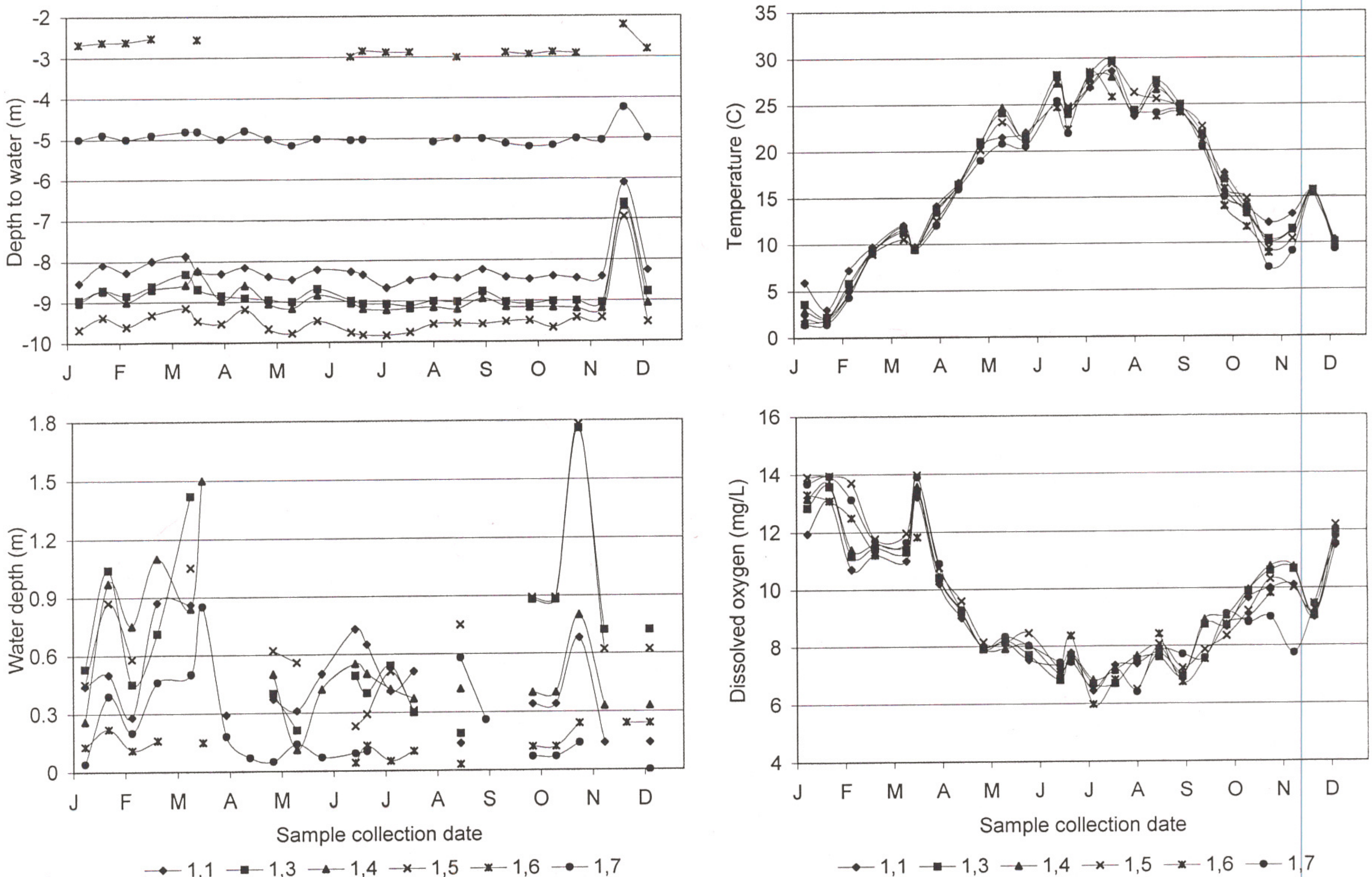


Fig. 1-2. 2001 conductivity, salinity, pH, and chlorophyll *a* measurements for Otoucalofa Creek.

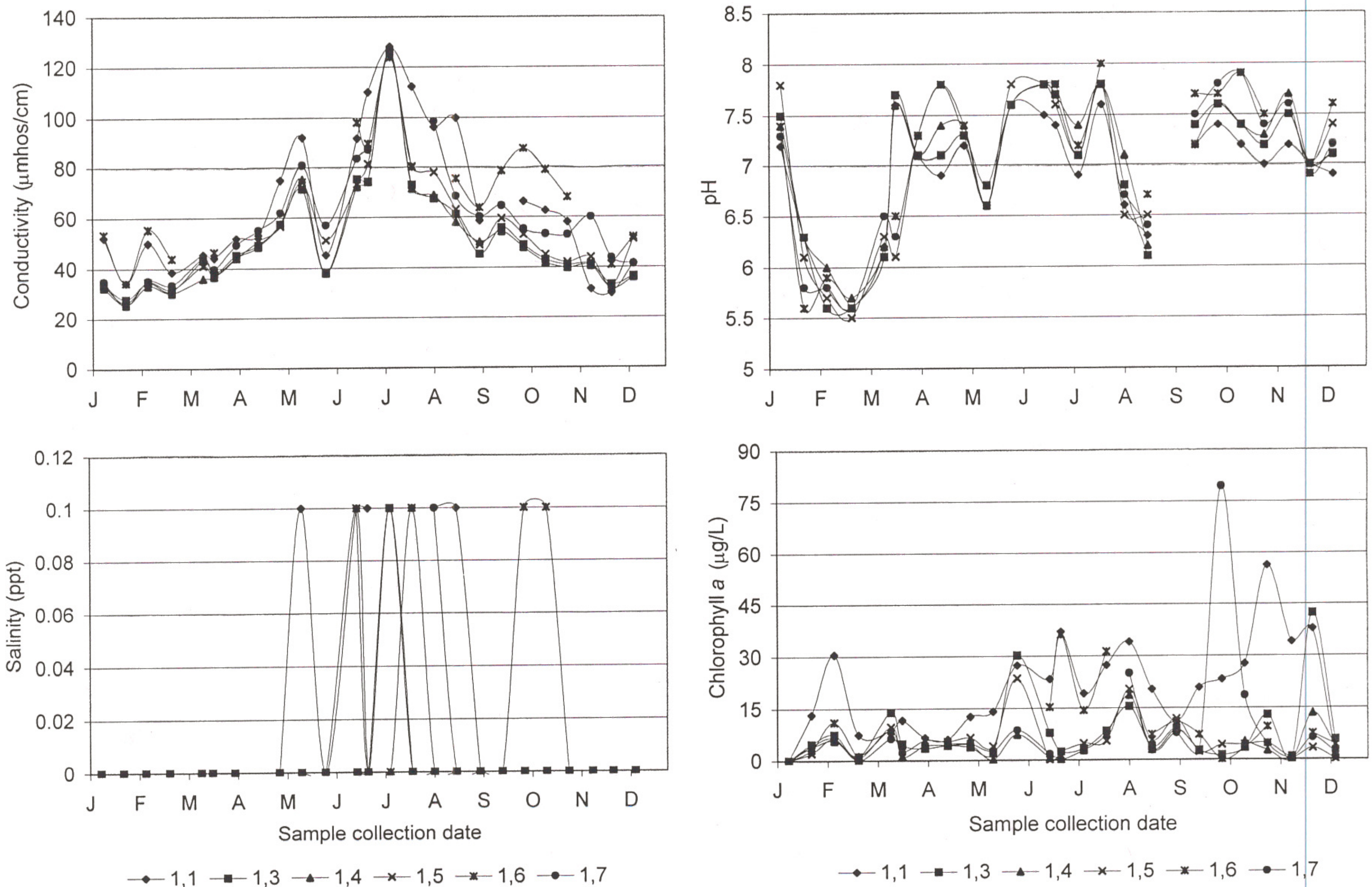


Fig. 1-3. 2001 turbidity and total, dissolved and suspended solids measurements for Otoucalofa Creek.

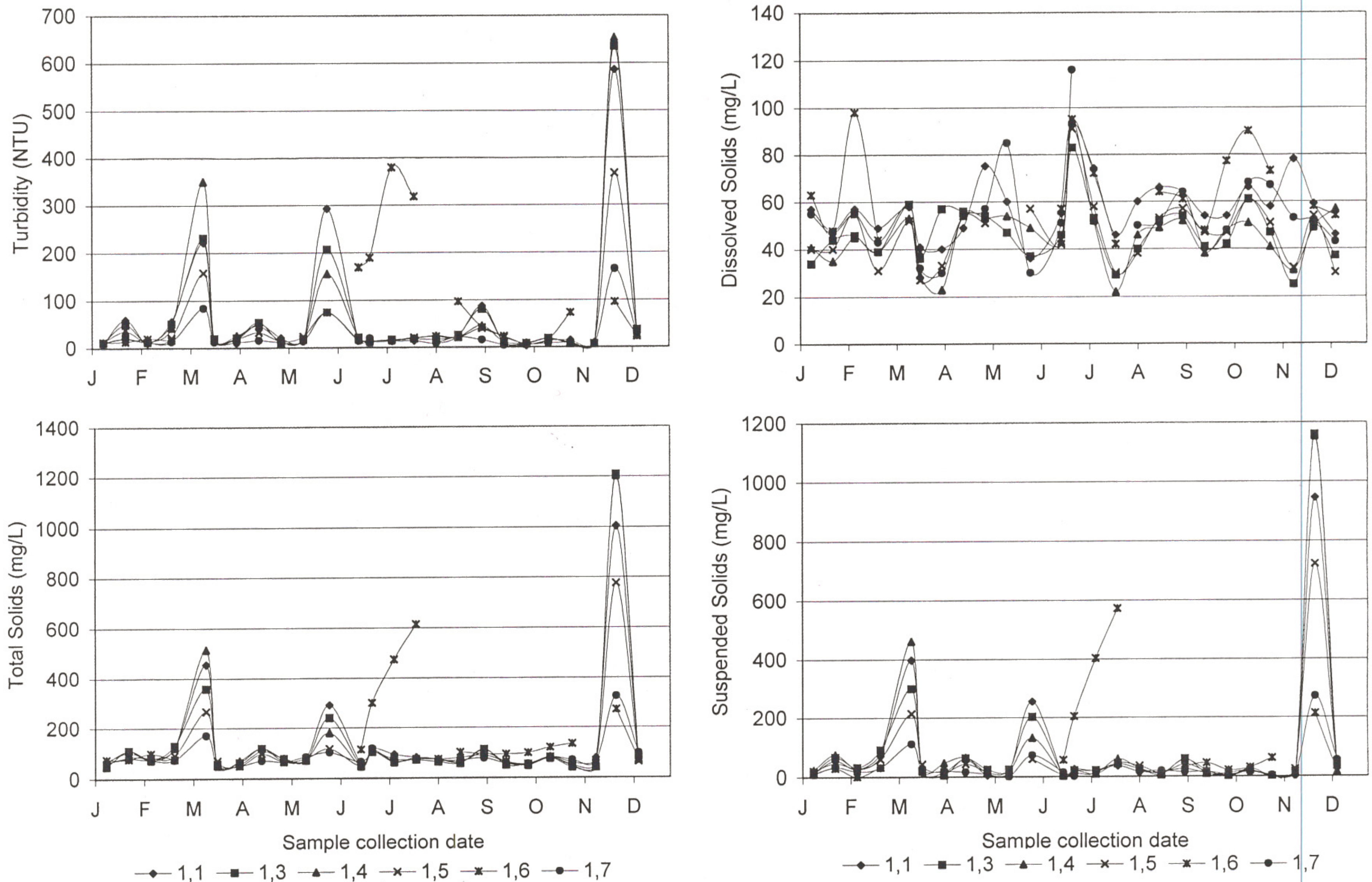


Fig. 1-4. 2001 hardness, alkalinity, filtered orthophosphate, and total orthophosphate measurements for Otoucalofa Creek.

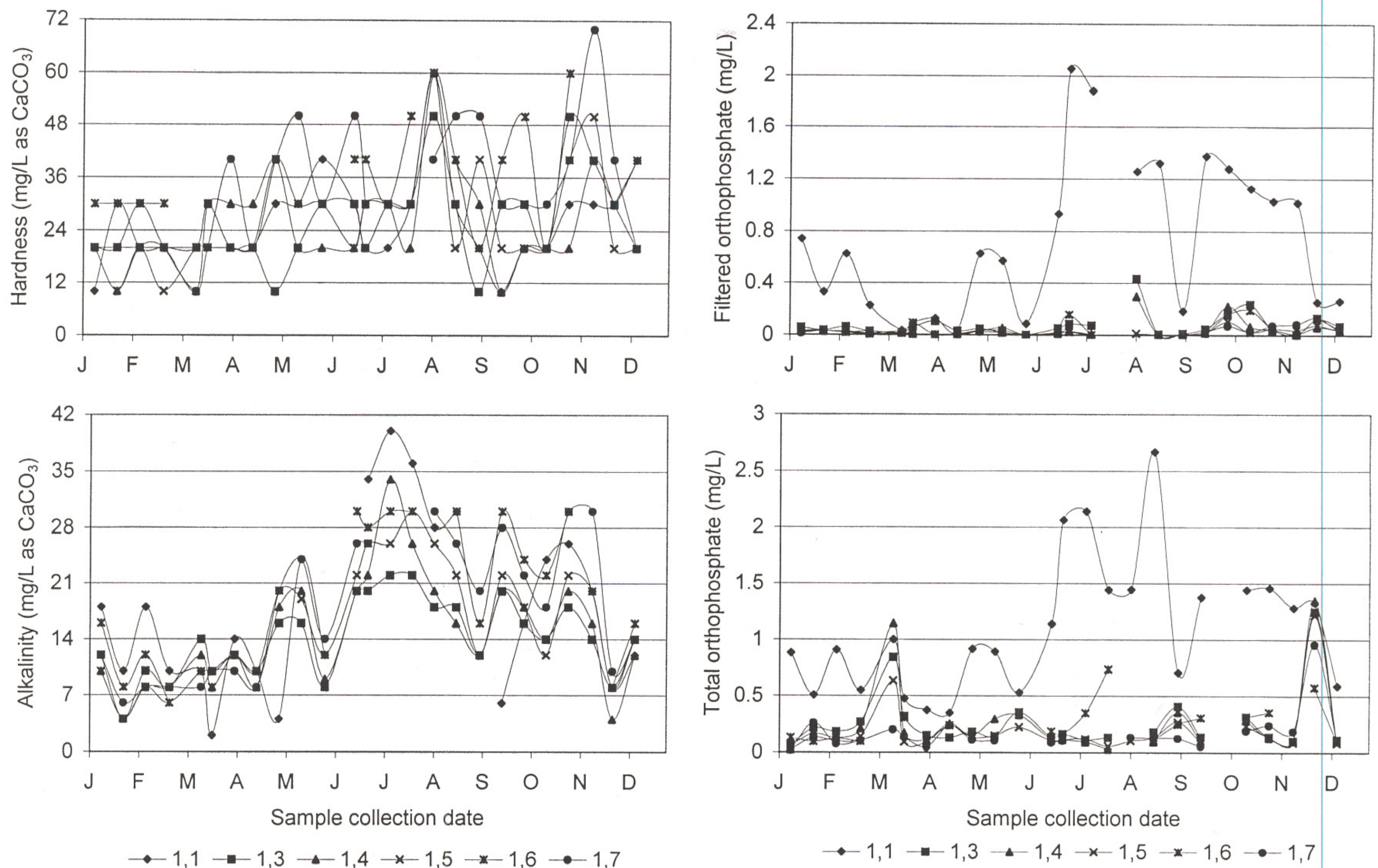


Fig. 1-5. 2001 ammonia, nitrate, nitrite, and total nitrogen measurements for Otoucalofa Creek.

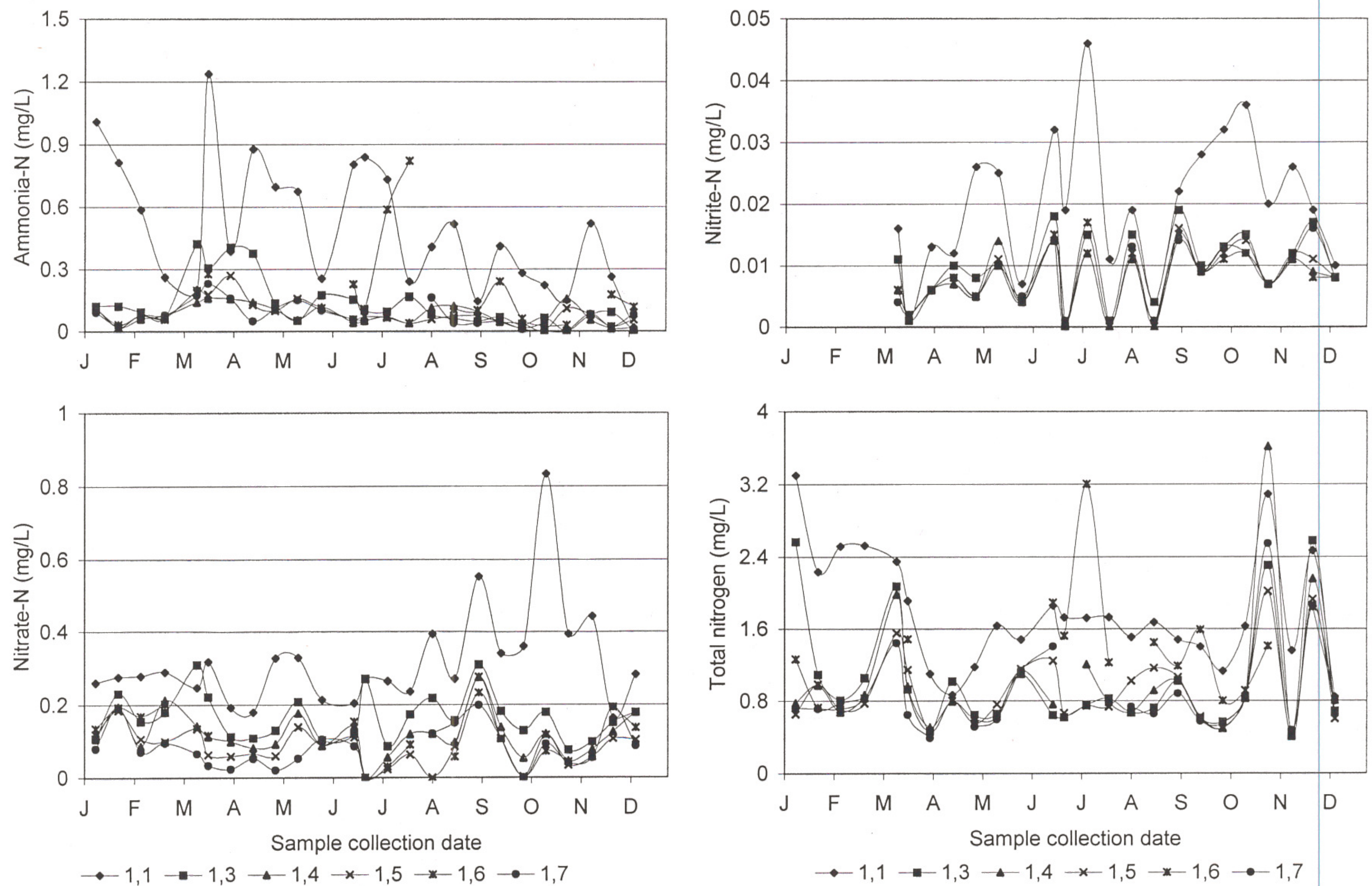


Fig. 1-6. 2001 fecal coliform and enterococci measurements for Otoucalofa Creek

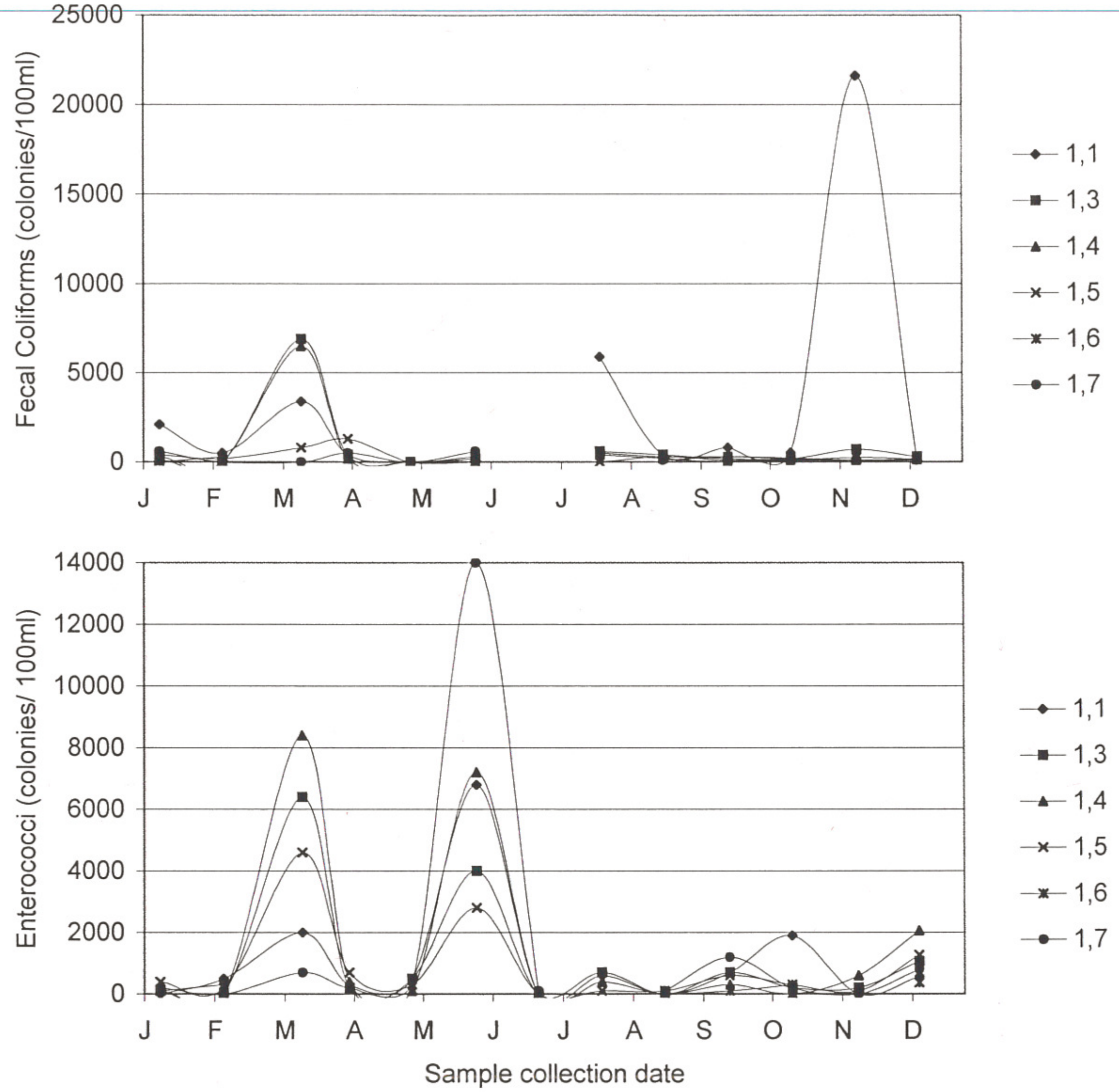


Fig. 1-7. Box plots of 2001 turbidity, chlorophyll *a*, total orthophosphate, total nitrogen, winter (January-April and November-December 2001) fecal coliform, and summer (May-October 2001) fecal coliform measurements by site for Otoucalofa Creek. Box = 25th-75th percentiles; whiskers = 10th-90th percentiles; points = 5th-95th percentiles; solid line = median value.

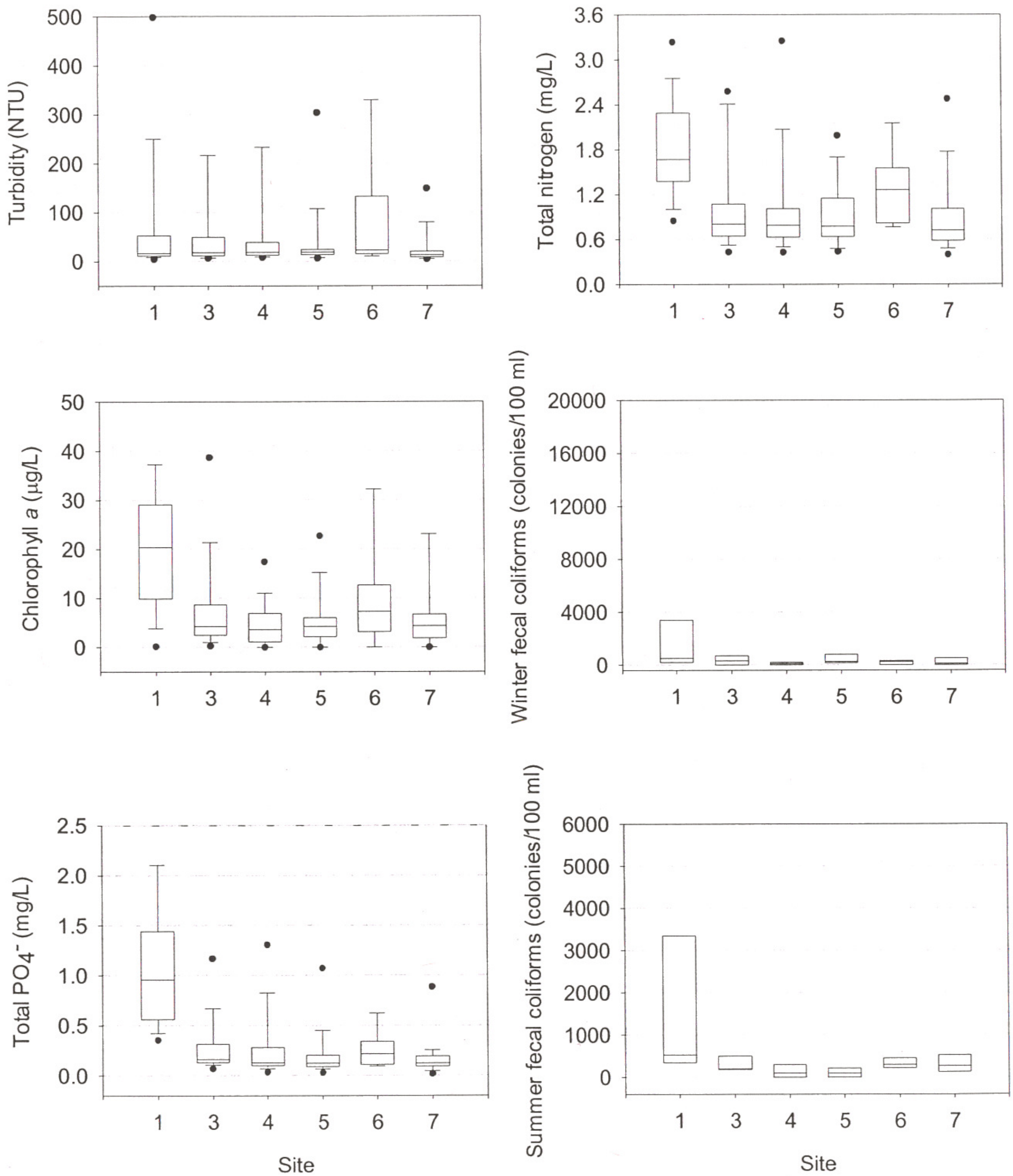


Fig. 1-8. Suspended solids concentrations in Otoucalofa Creek 1985-2001.

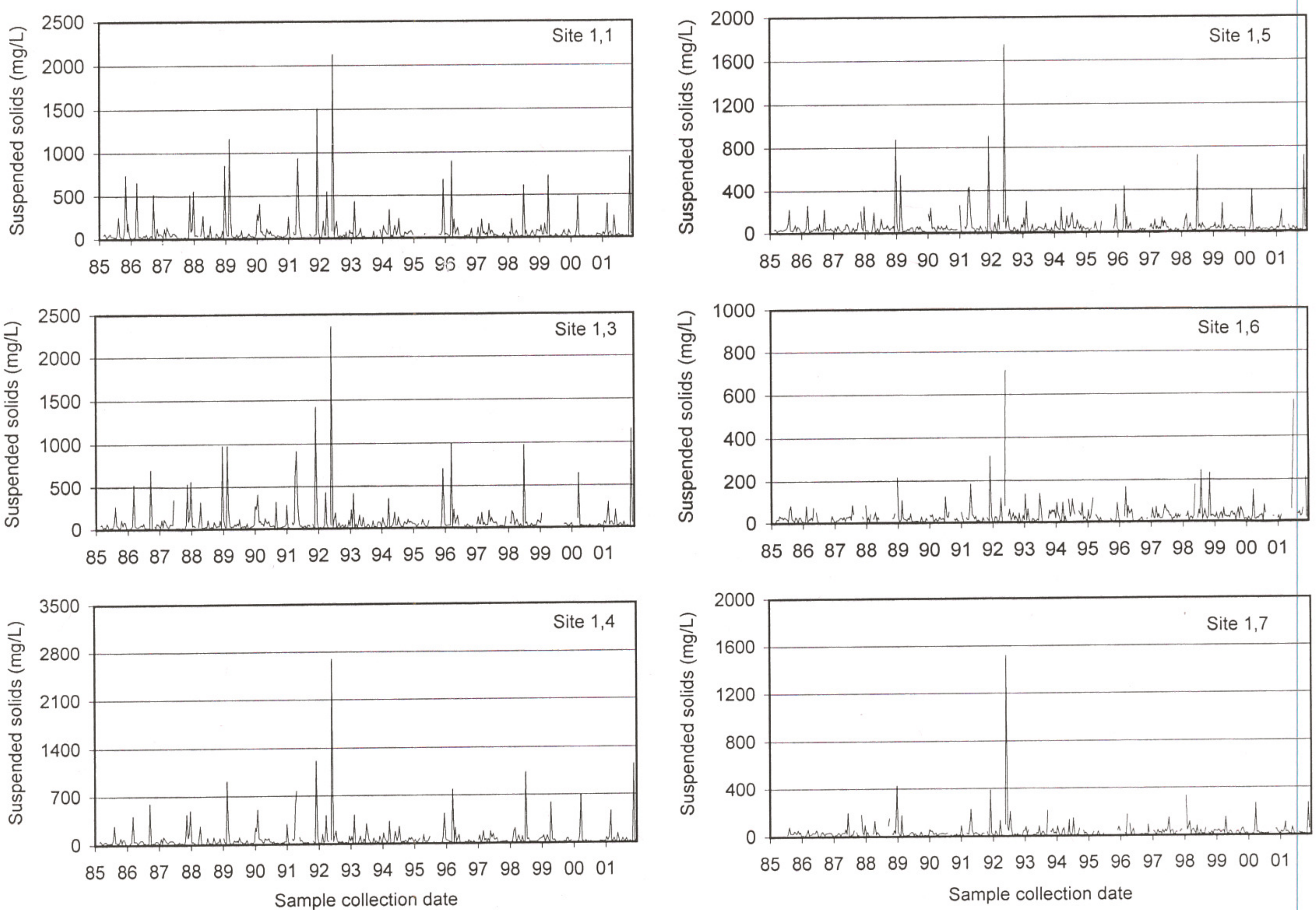


Fig. 1-9. Total phosphorus concentrations in Otoucalofa Creek 1985-2001.

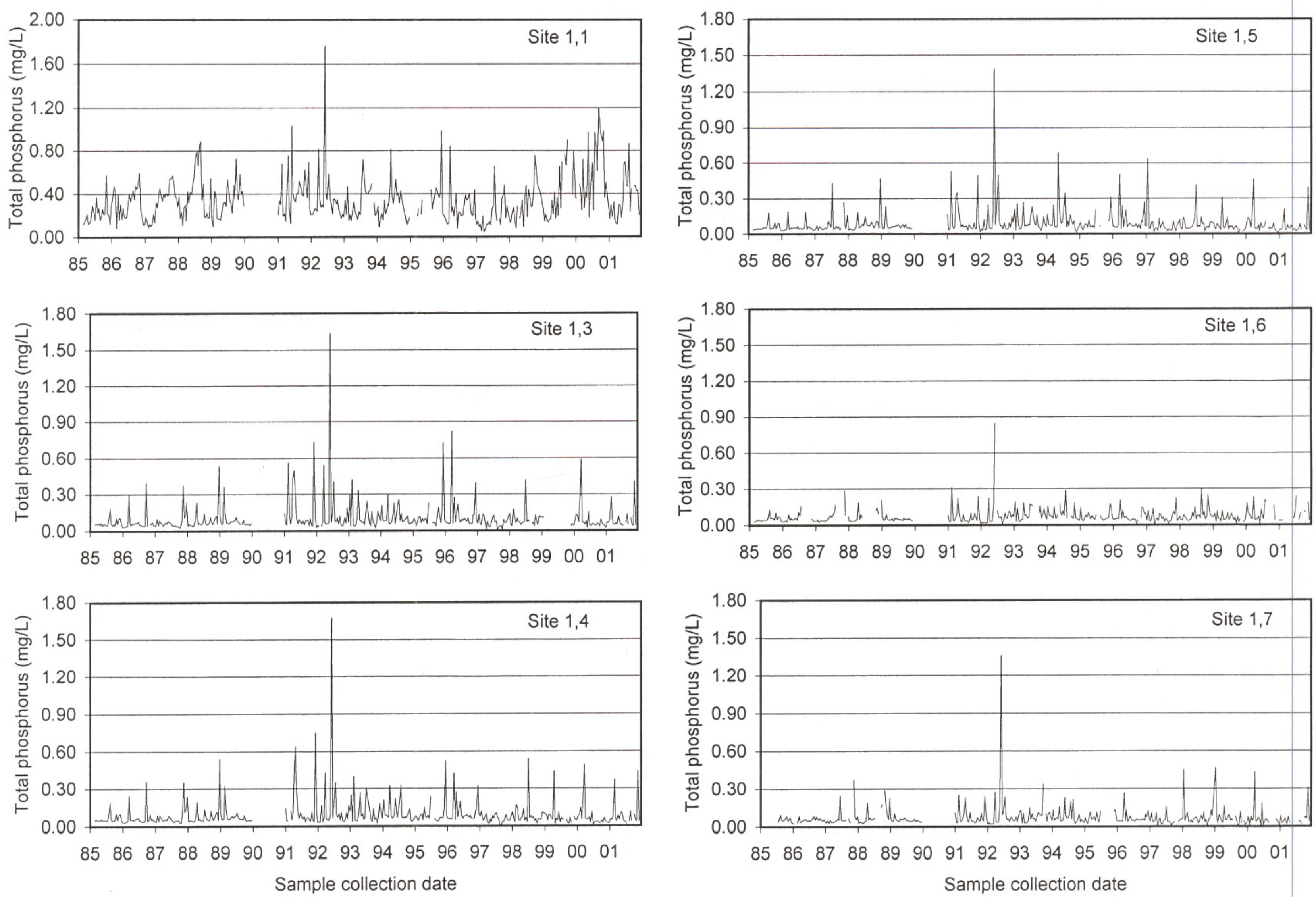


Figure B. Severe erosion observed in the Demonstration Erosion Control (DEC) Project in A) Hotophia Creek watershed (DEC 4) and B) Yalobusha River watershed (DEC 17).

A

B

Fig. 2-1. 2001 depth to water, water depth, temperature, and dissolved oxygen measurements for Long Creek.

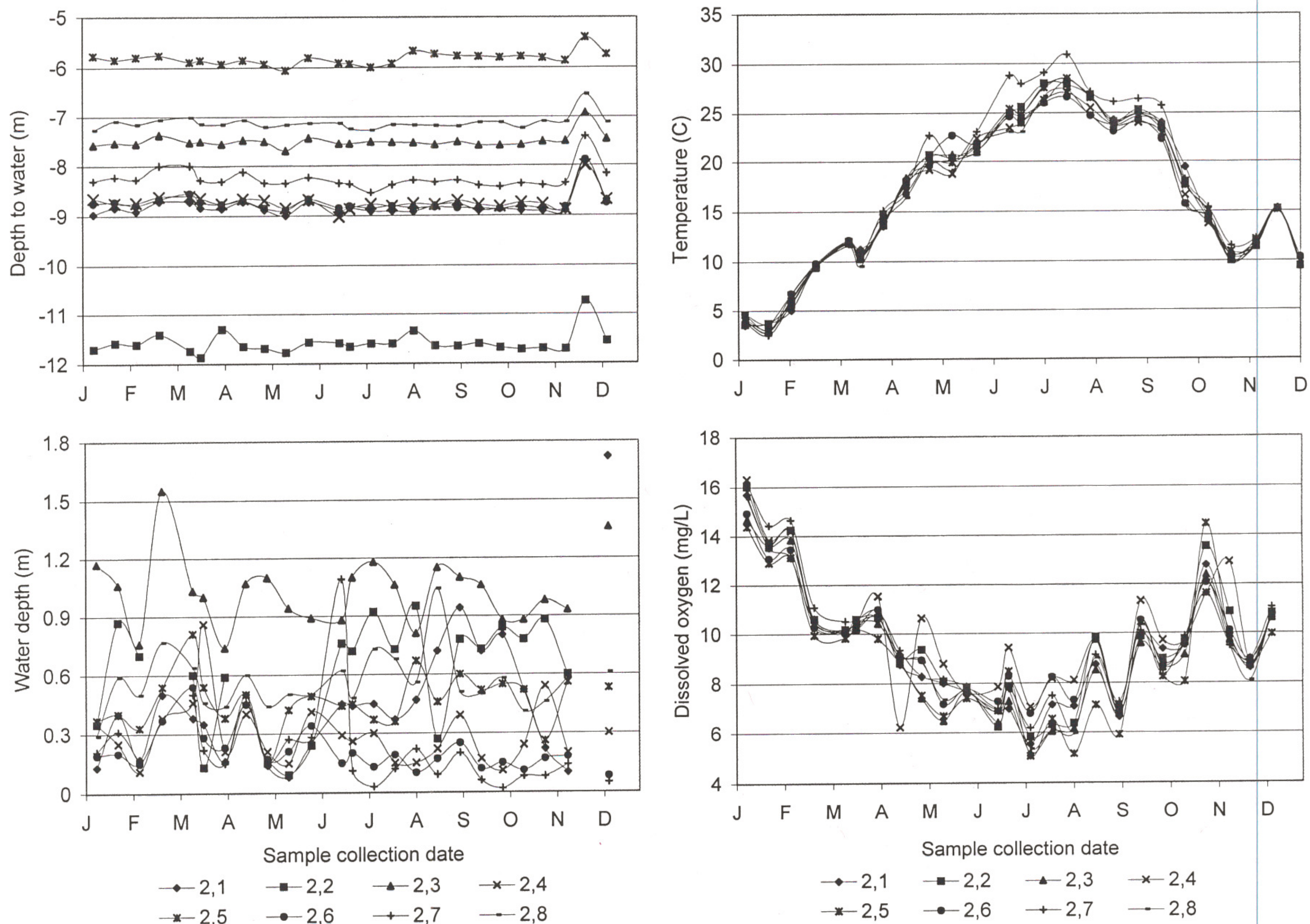


Fig. 2-2. 2001 conductivity, salinity, pH, and chlorphyll *a* measurements for Long Creek.

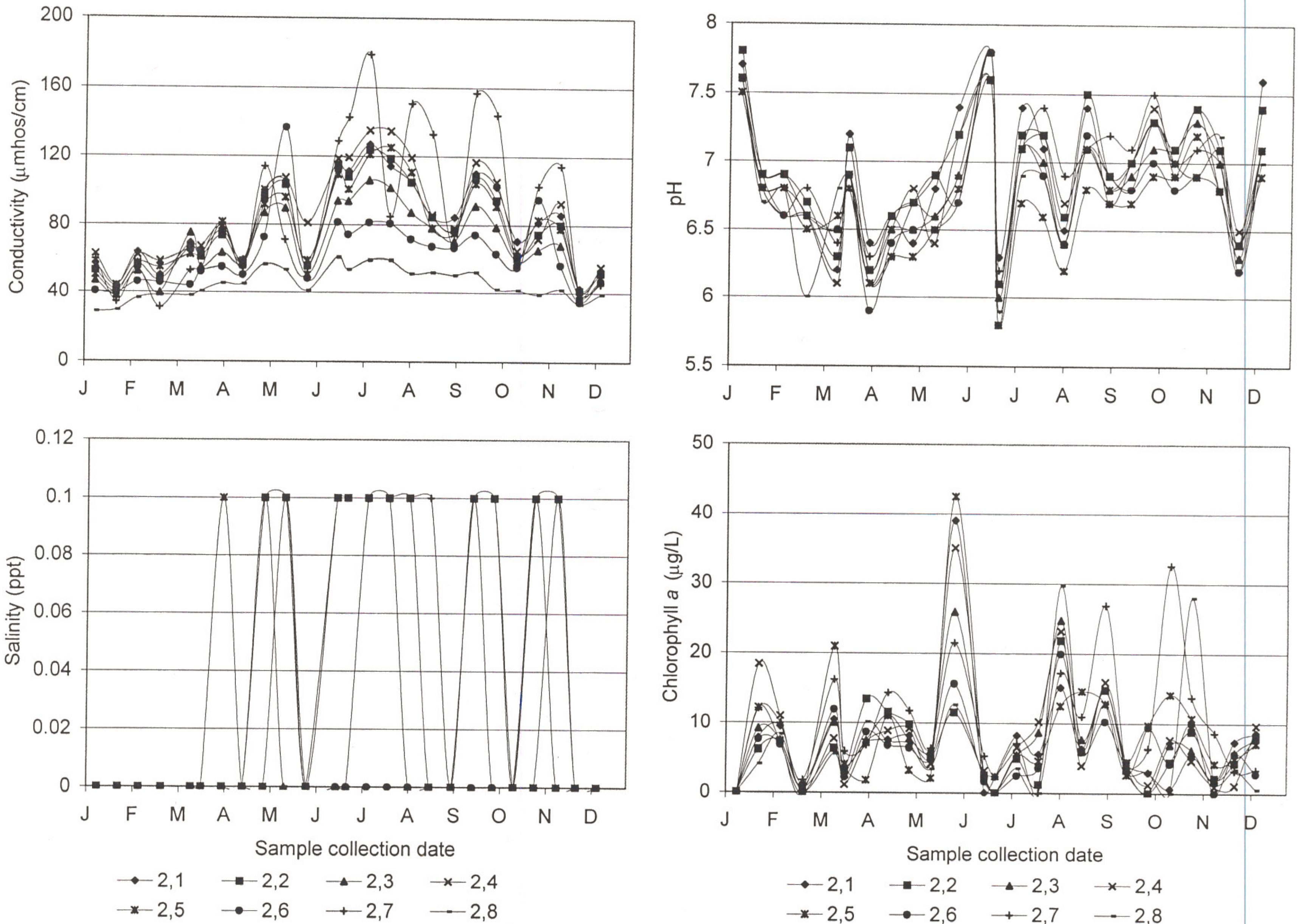


Fig. 2-3. 2001 turbidity, and total, dissolved and suspended solids measurements for Long Creek.

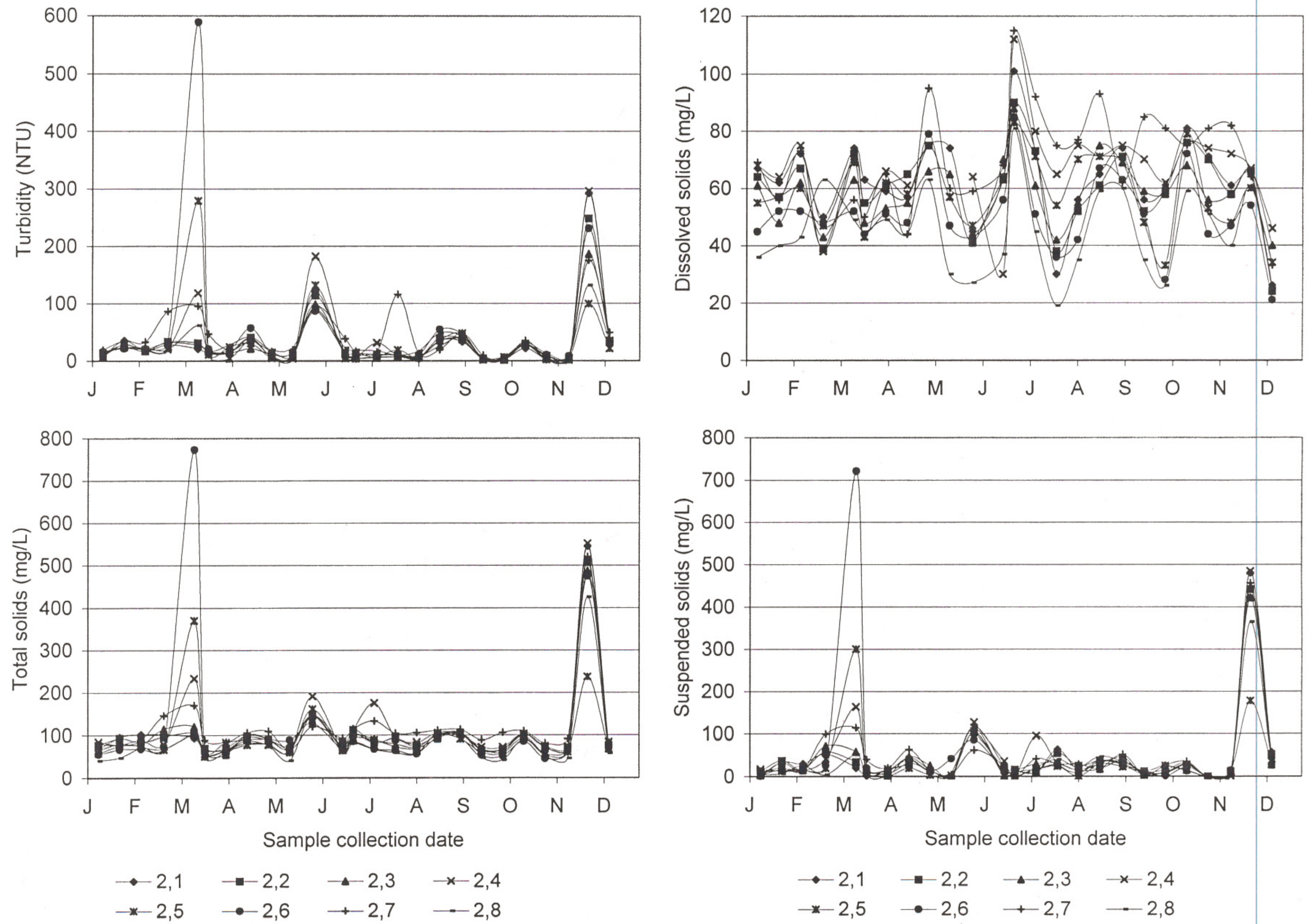


Fig. 2-4. 2001 hardness, alkalinity, filtered orthophosphate, and total orthophosphate measurements for Long Creek.

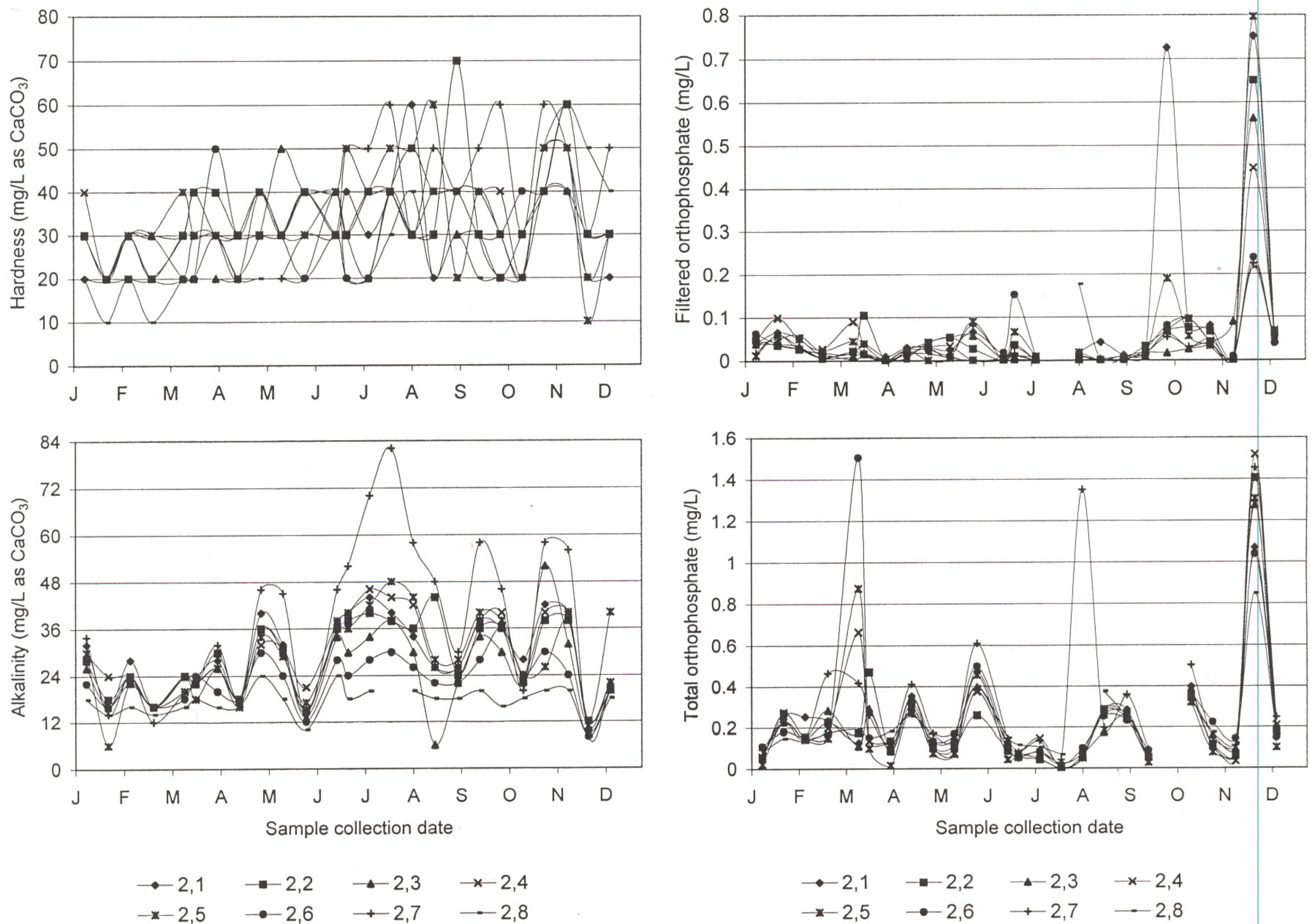


Fig. 2-5. 2001 ammonia, nitrate, nitrite, and total nitrogen measurements for Long Creek.

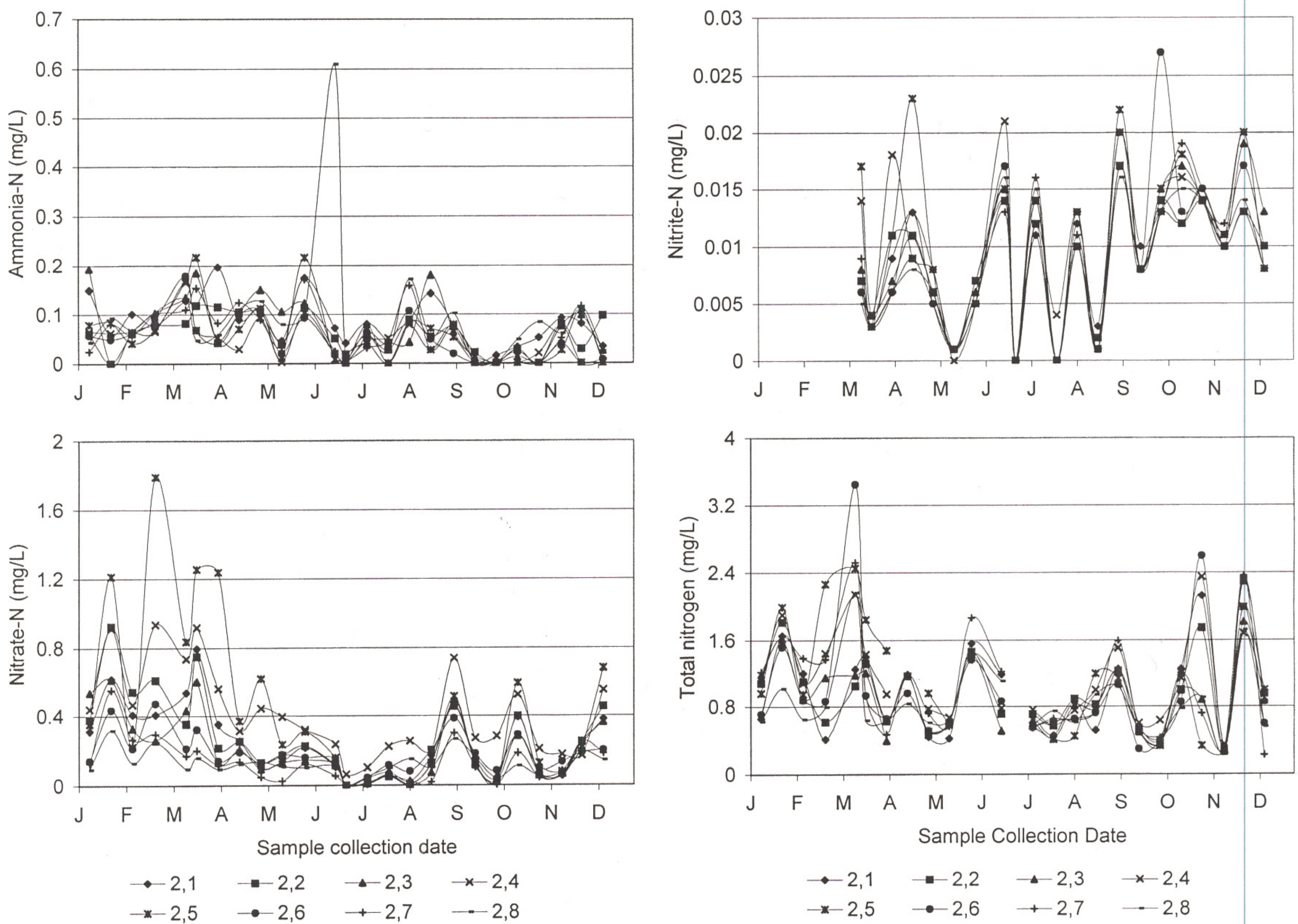


Fig. 2-6. 2001 fecal coliform and enterococci measurements for Long Creek.

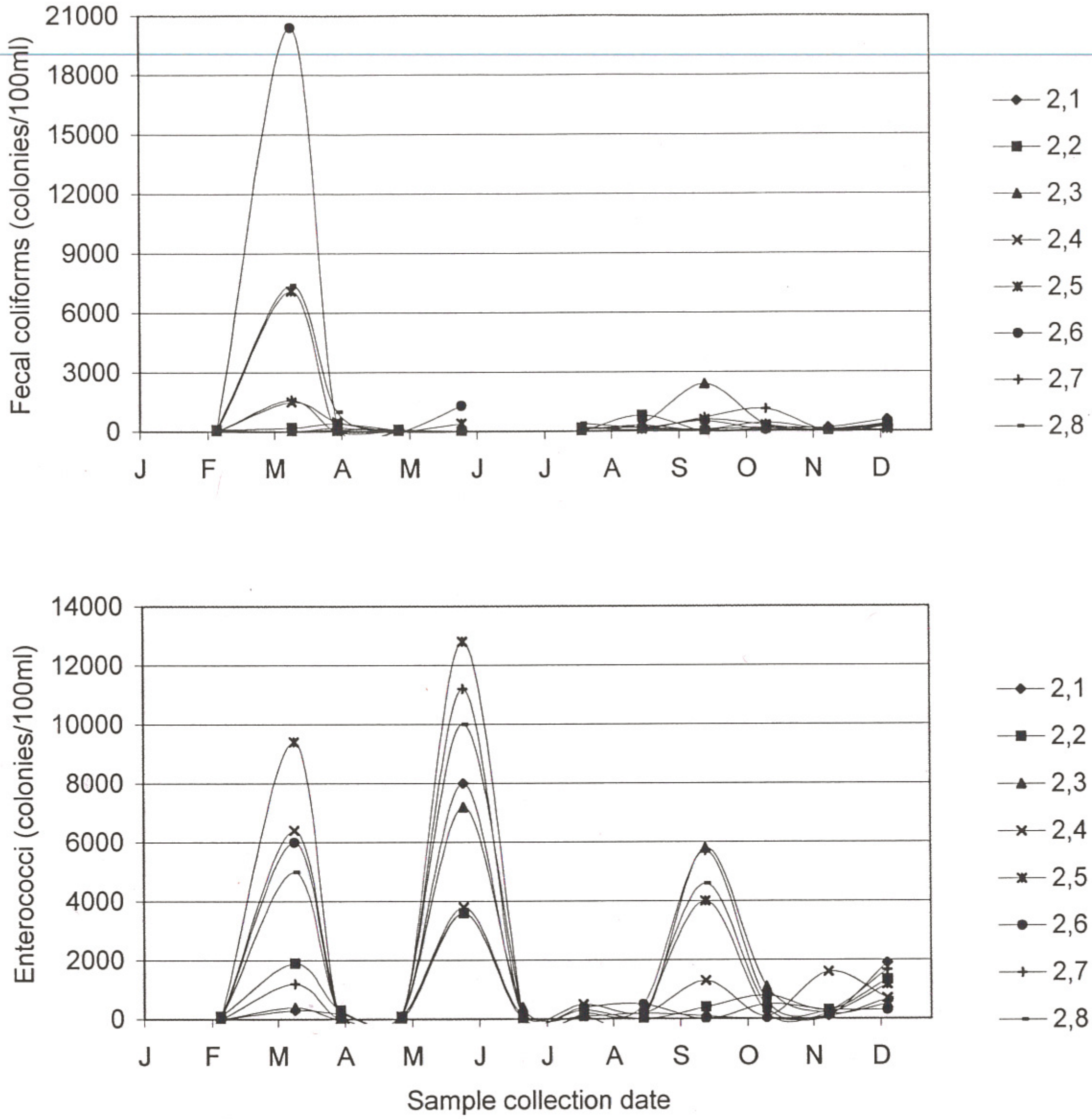


Fig. 2-7. Box plots of 2001 turbidity, chlorophyll *a*, total orthophosphate, total nitrogen, winter (January-April and November-December 2001) fecal coliform, and summer (May-October 2001) fecal coliform measurements by site for Long Creek. Box = 25th-75th percentiles; whiskers = 10th-90th percentiles; points = 5th-95th percentiles; solid line = median value.

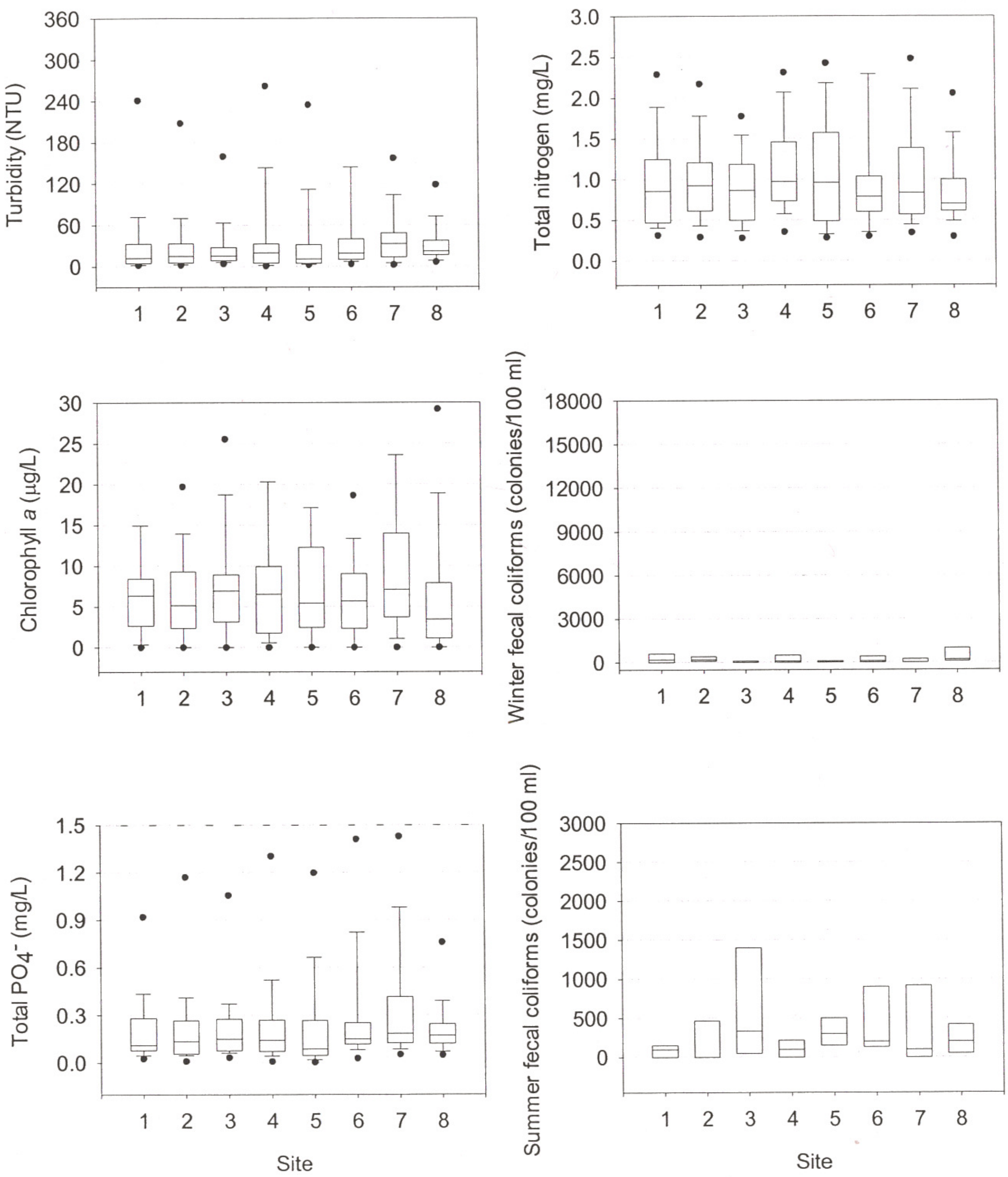


Figure C. Erosion control structures utilized in the Demonstration Erosion Control (DEC) Project; A) rip-rap in Long Creek watershed (DEC 2) and B) drop-pipe structure.

A

B

Fig. 4-1. 2001 depth to water, water depth, temperature, and dissolved oxygen measurements for Hotophia Creek.

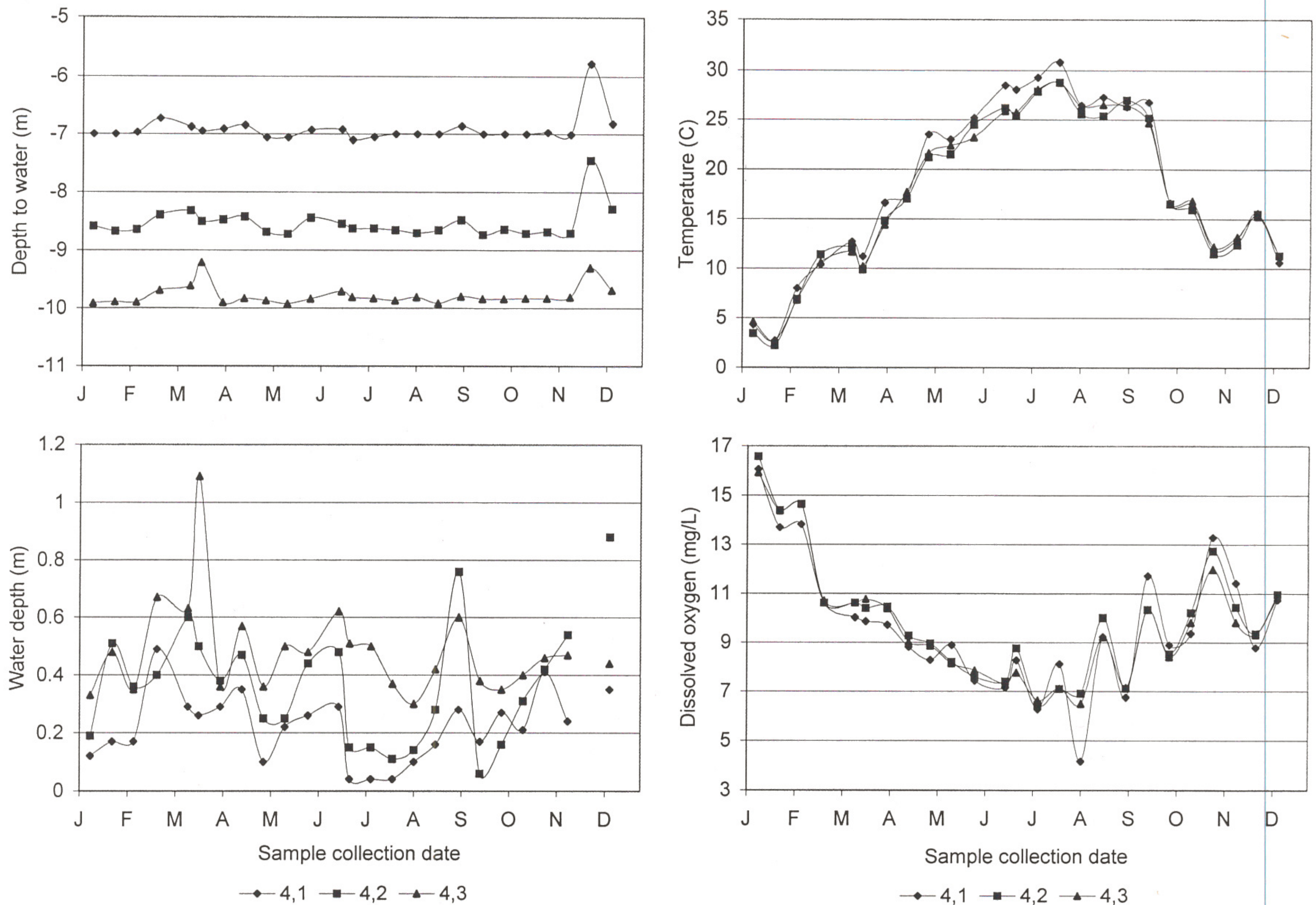


Fig. 4-2. 2001 conductivity, salinity, pH, and chlorophyll *a* measurements for Hotophia Creek.

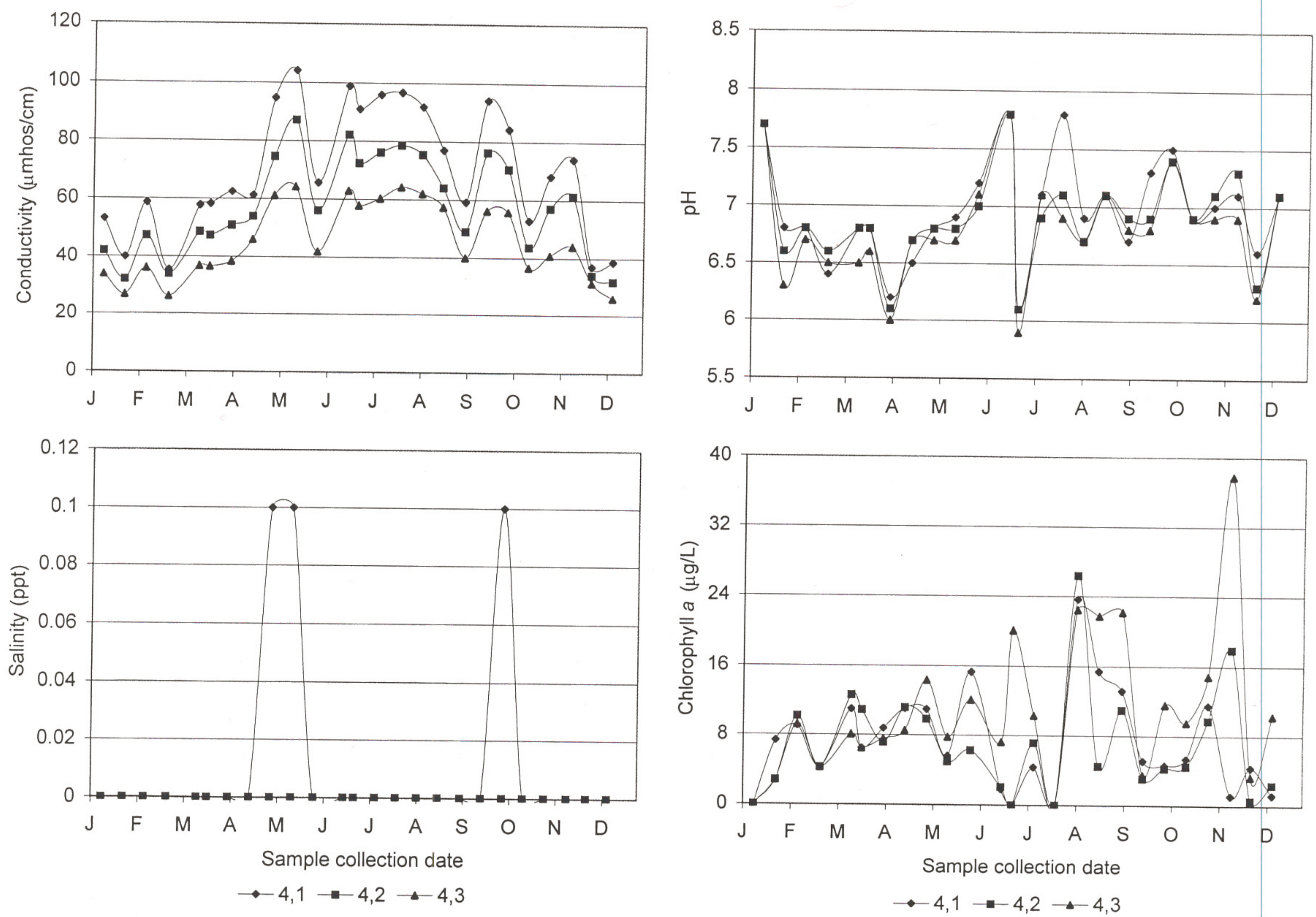


Fig. 4-3. 2001 turbidity, and total, dissolved and suspended solids measurements for Hotophia Creek.

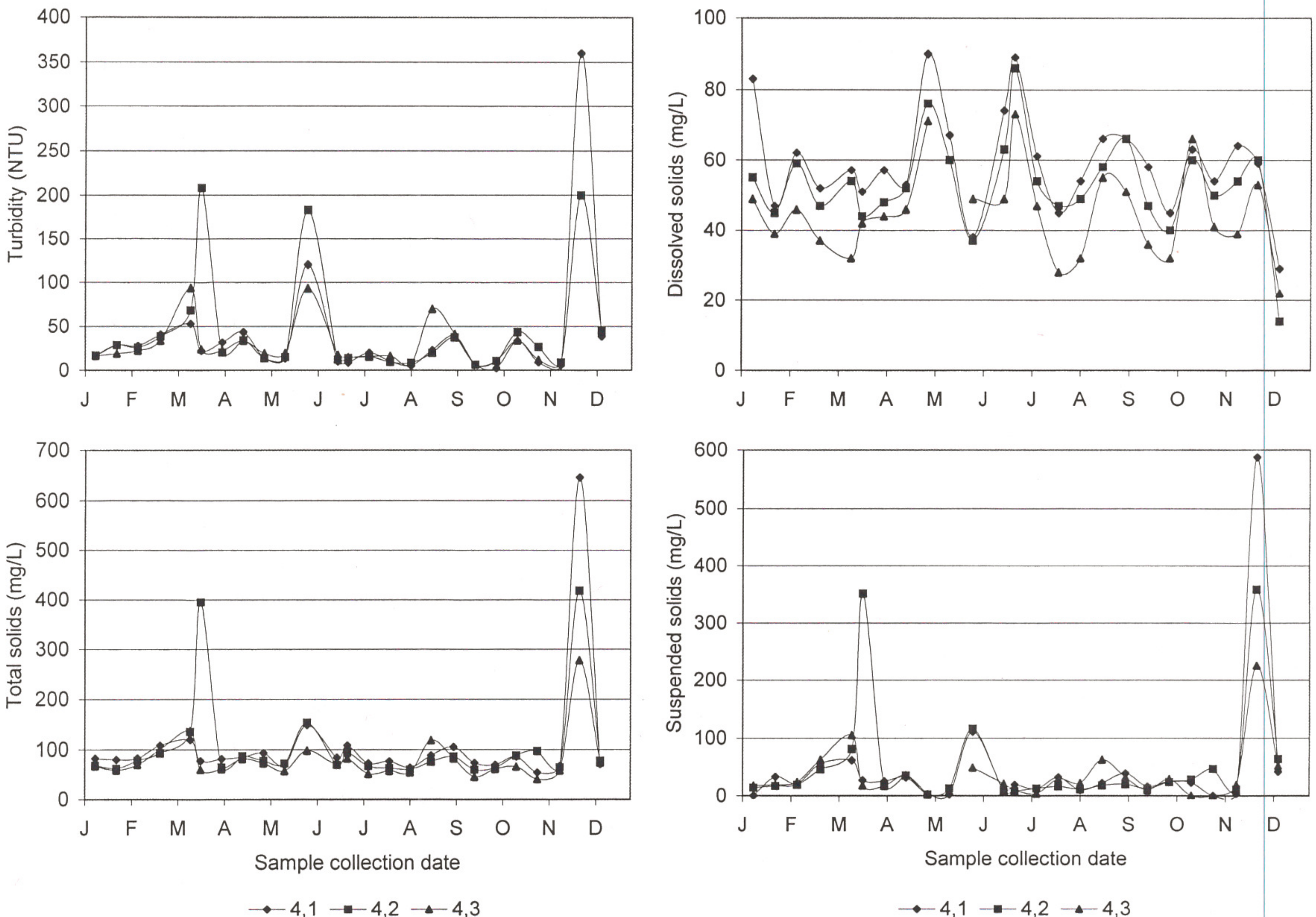


Fig. 4-4. 2001 hardness, alkalinity, filtered orthophosphate, and total orthophosphate measurements for Hotophia Creek.

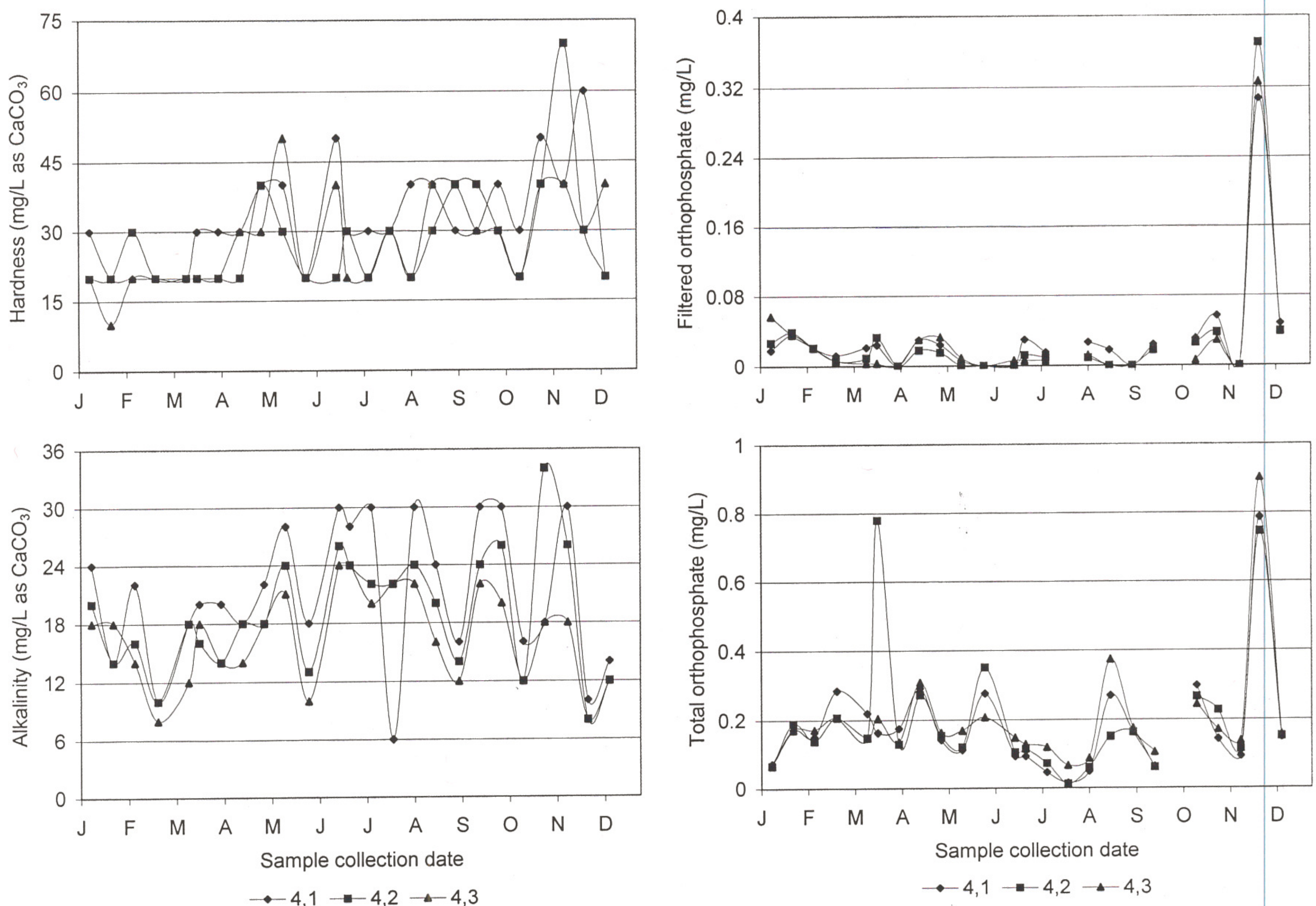


Fig. 4-5. 2001 ammonia, nitrate, nitrite, and total nitrogen measurements for Hotophia Creek.

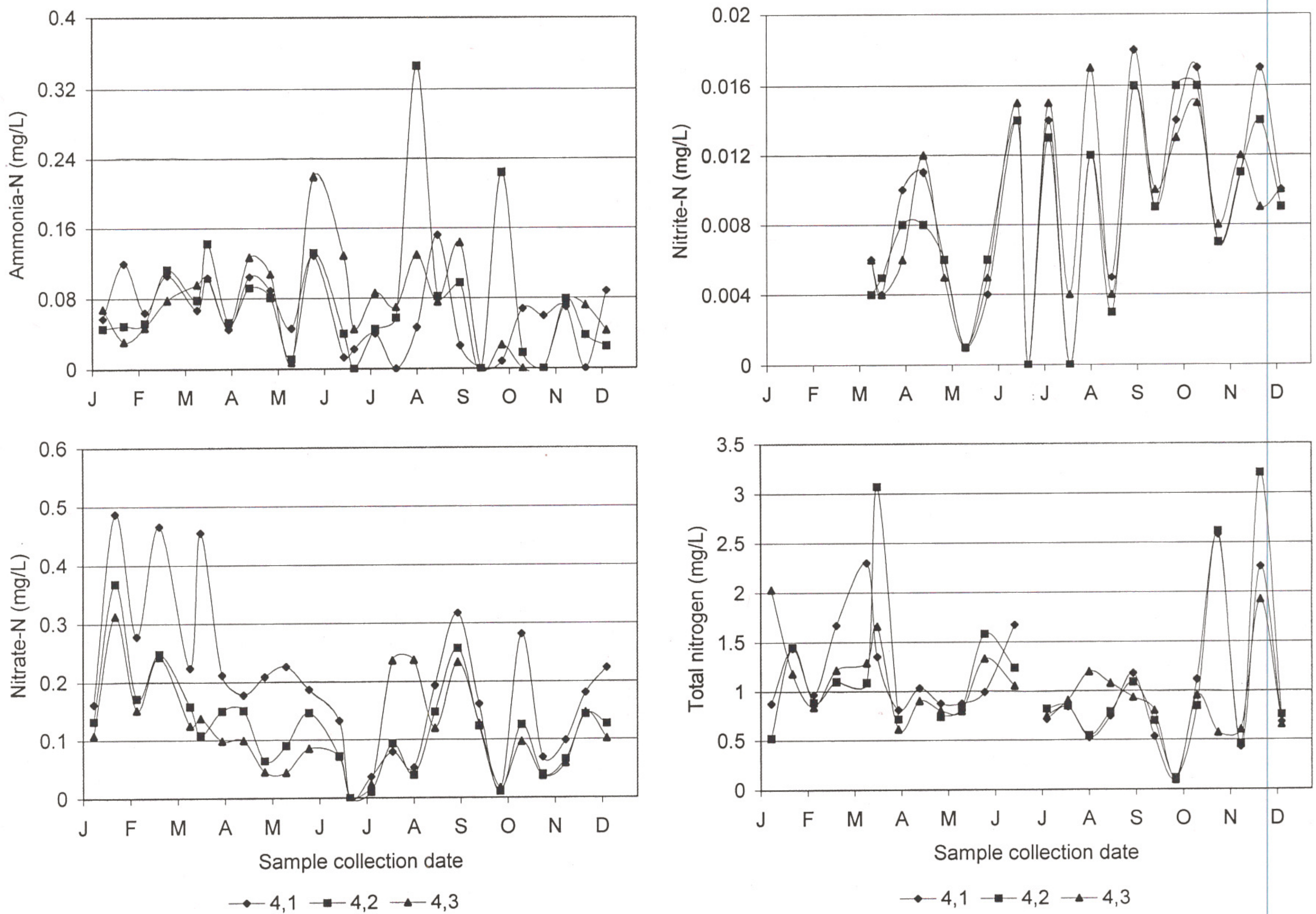
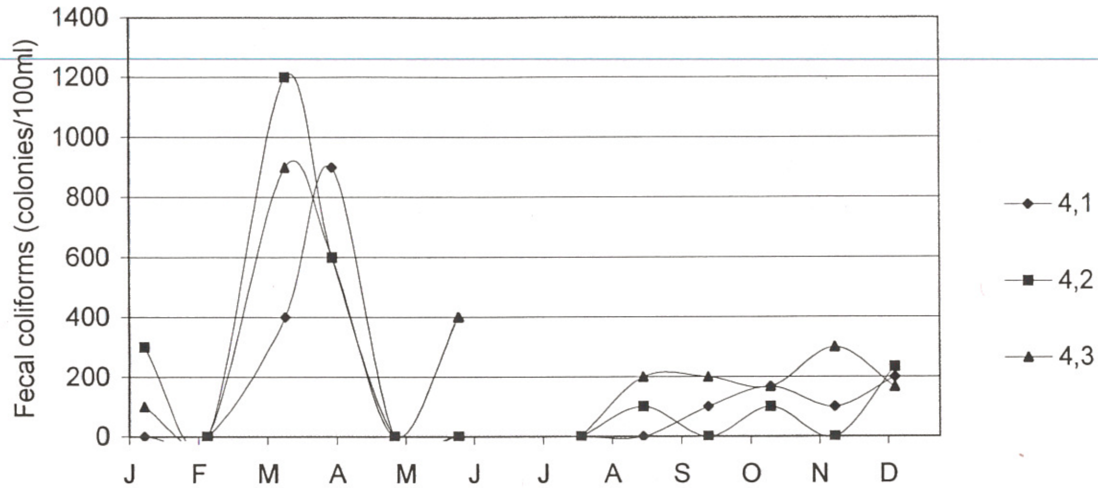


Fig. 4-6. 2001 fecal coliform and enterococci measurements for Hotophia Creek.



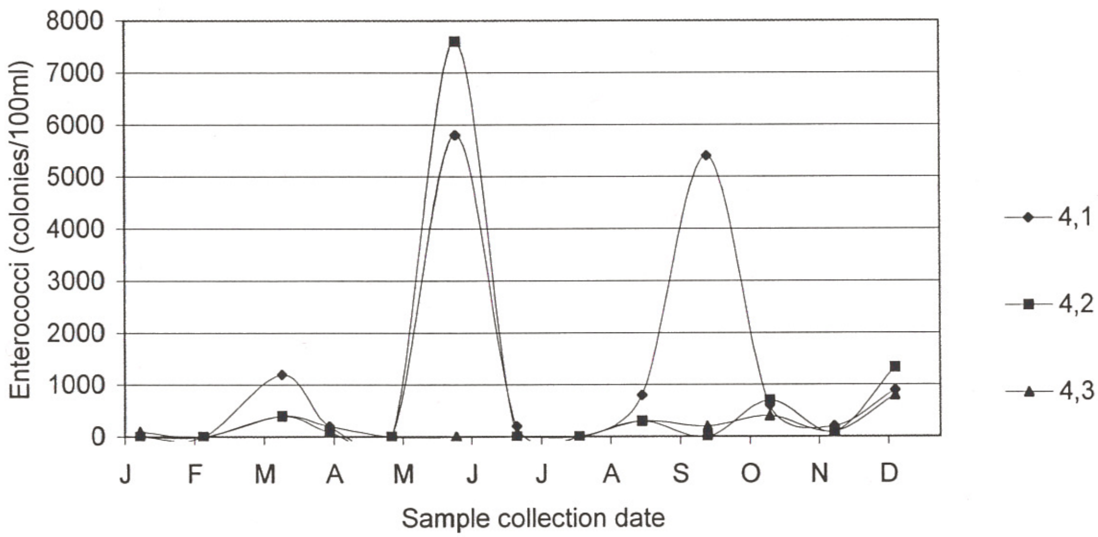


Fig. 4-7. Box plots of 2001 turbidity, chlorophyll *a*, total orthophosphate, total nitrogen, winter (January-April and November-December 2001) fecal coliform, and summer (May-October 2001) fecal coliform measurements by site for Hotophia Creek. Box = 25th-75th percentiles; whiskers = 10th-90th percentiles; points = 5th-95th percentiles; solid line = median value.

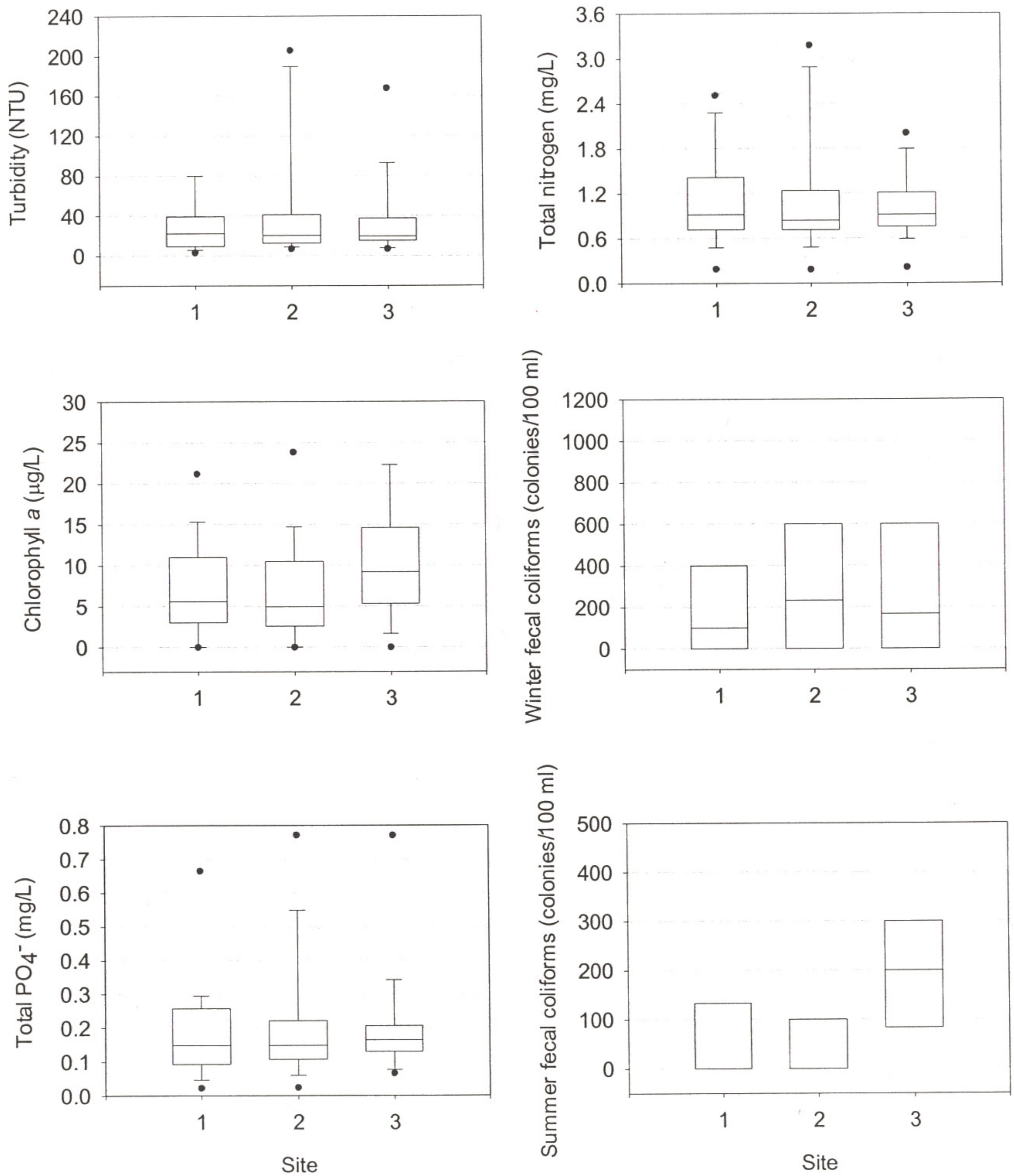


Fig. 8-1. 2001 depth to water, water depth, temperature and dissolved oxygen measurements for Abiaca Creek.

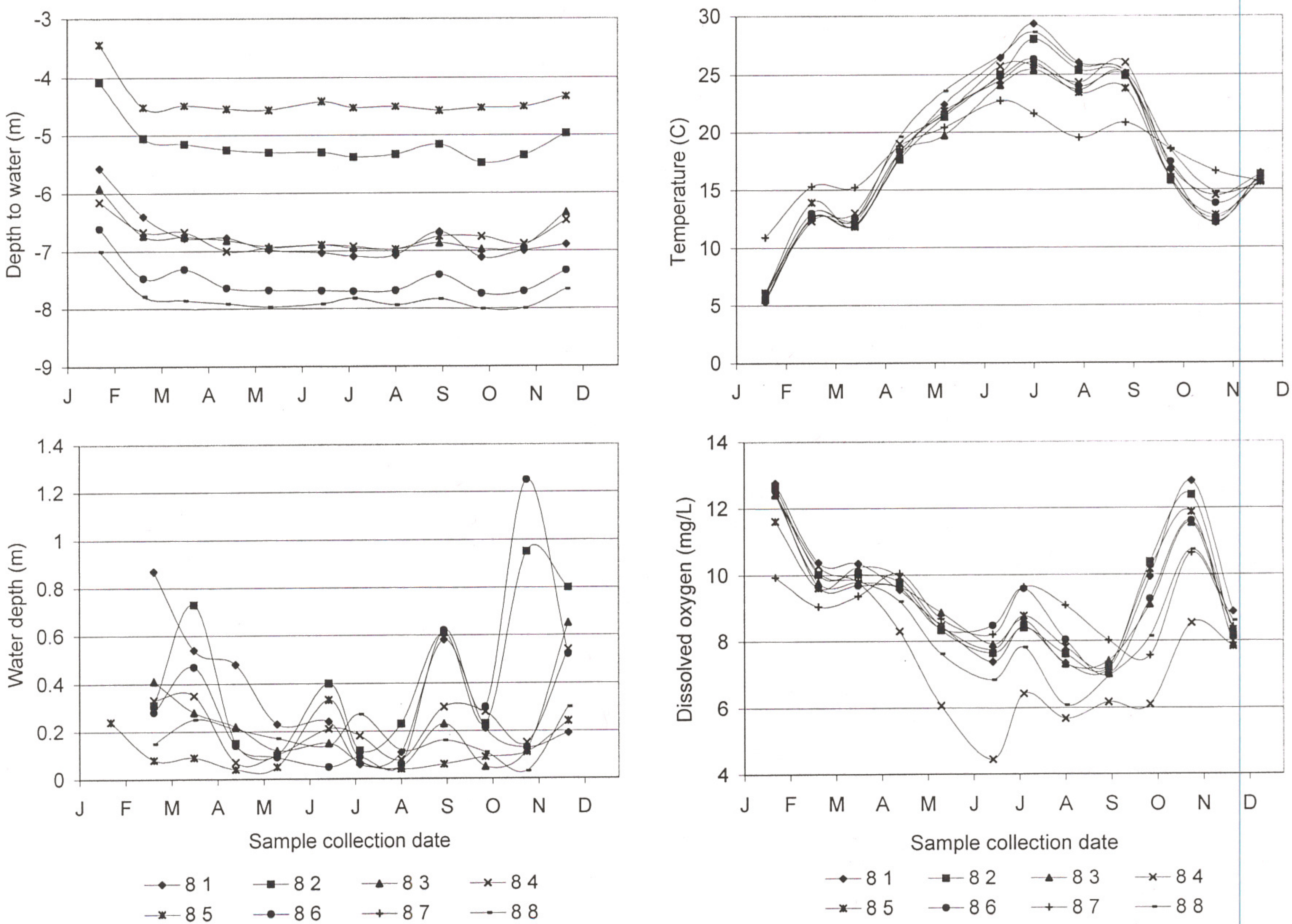


Fig. 8-2. 2001 conductivity, salinity, pH, and chlorphyll *a* measurements for Abiaca Creek.

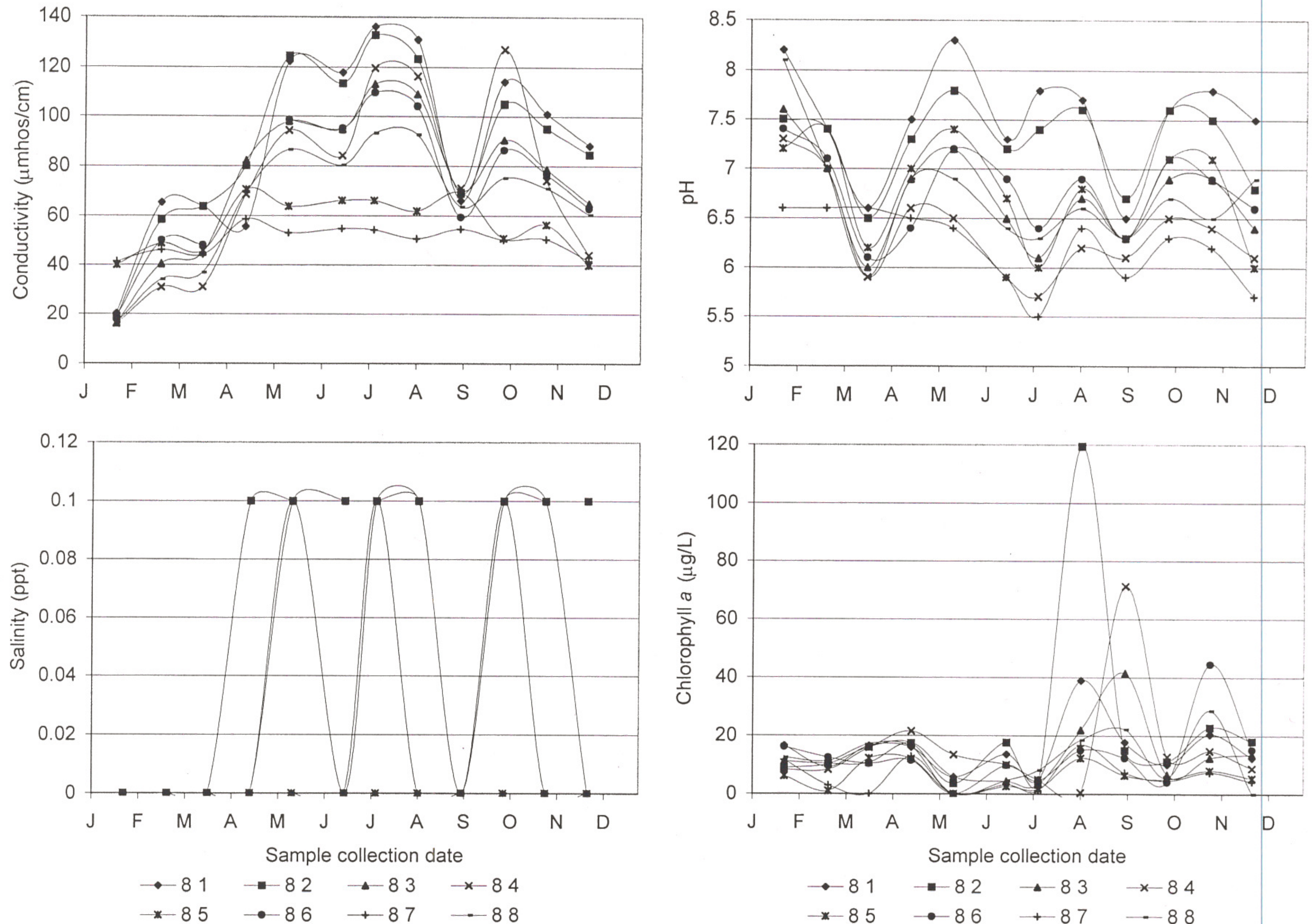


Fig. 8-3. 2001 turbidity, and total, dissolved and suspended solids measurements for Abiaca Creek.

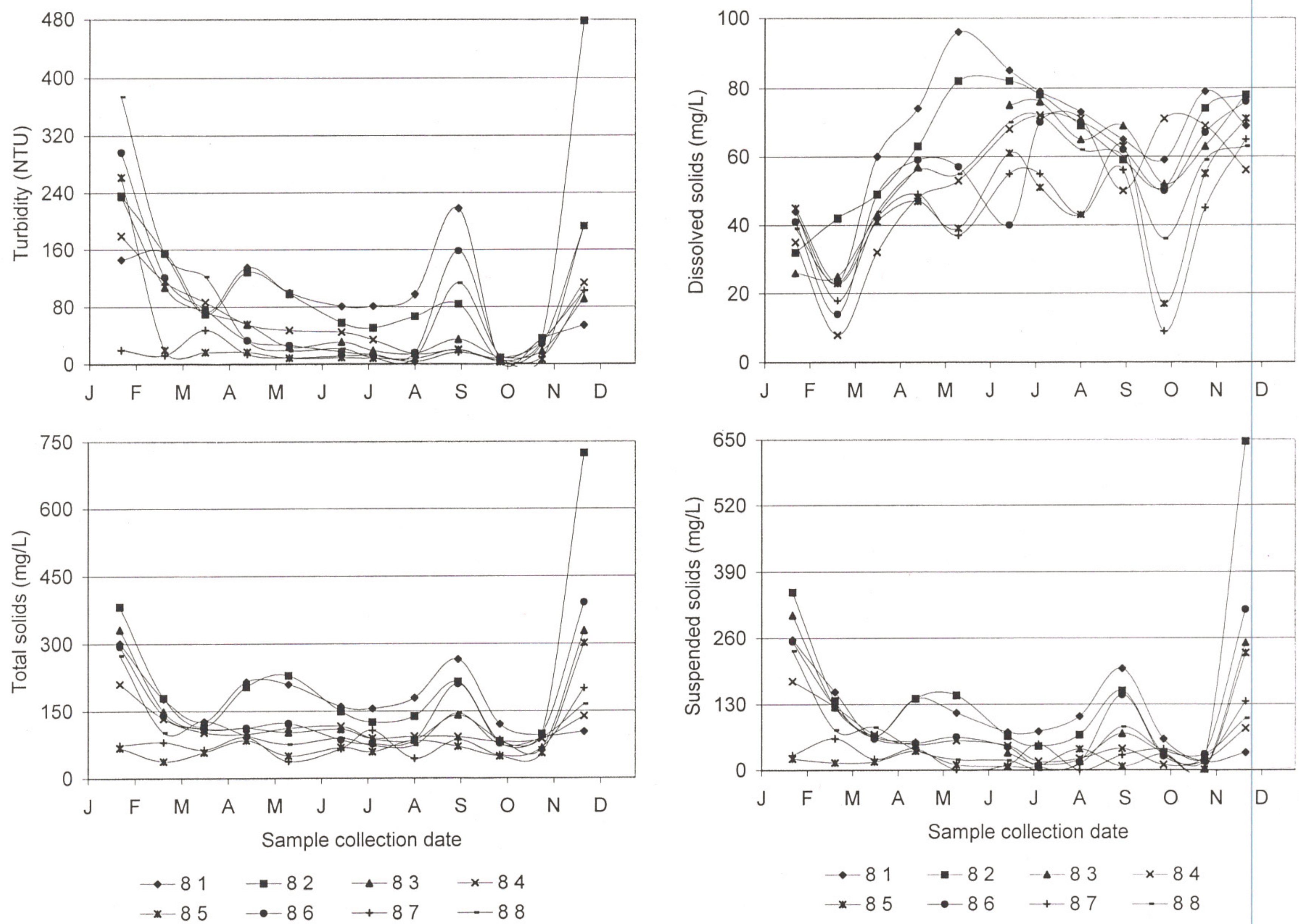


Fig. 8-4. 2001 hardness, alkalinity, filtered orthophosphate, and total orthophosphate measurements for Abiaca Creek.

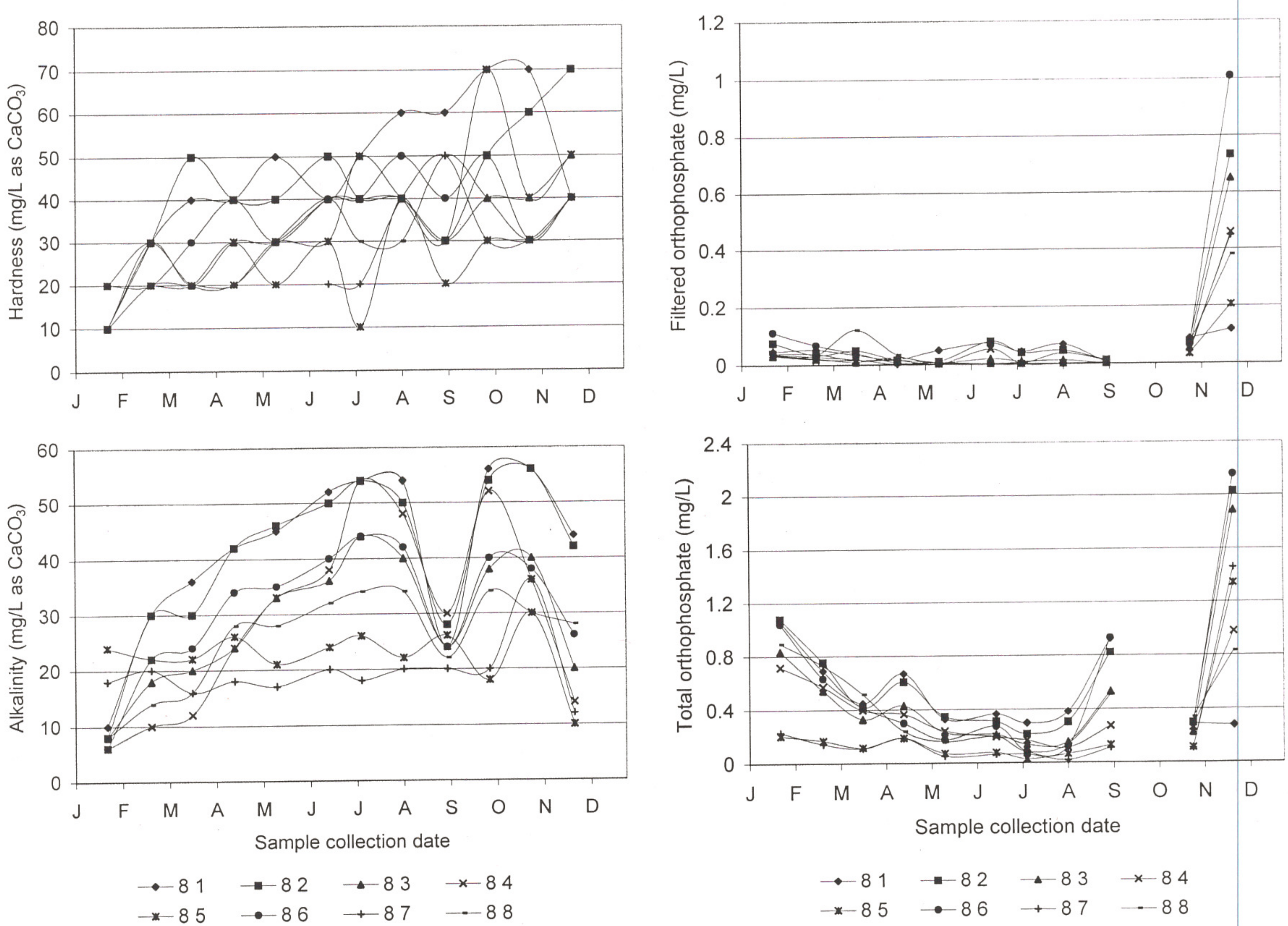


Fig. 8-5. 2001 ammonia, nitrate, nitrite, and total nitrogen measurements for Abiaca Creek.

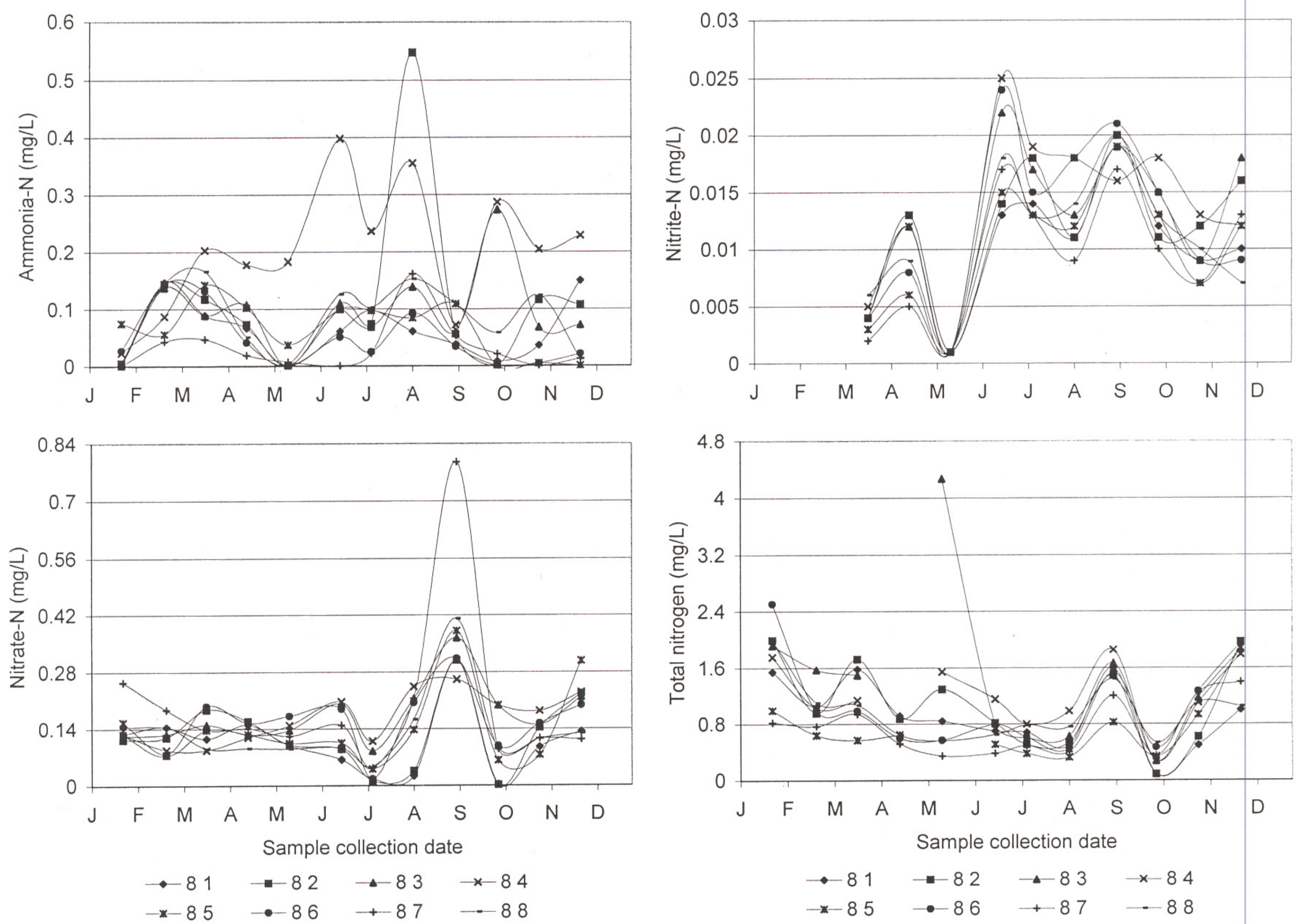
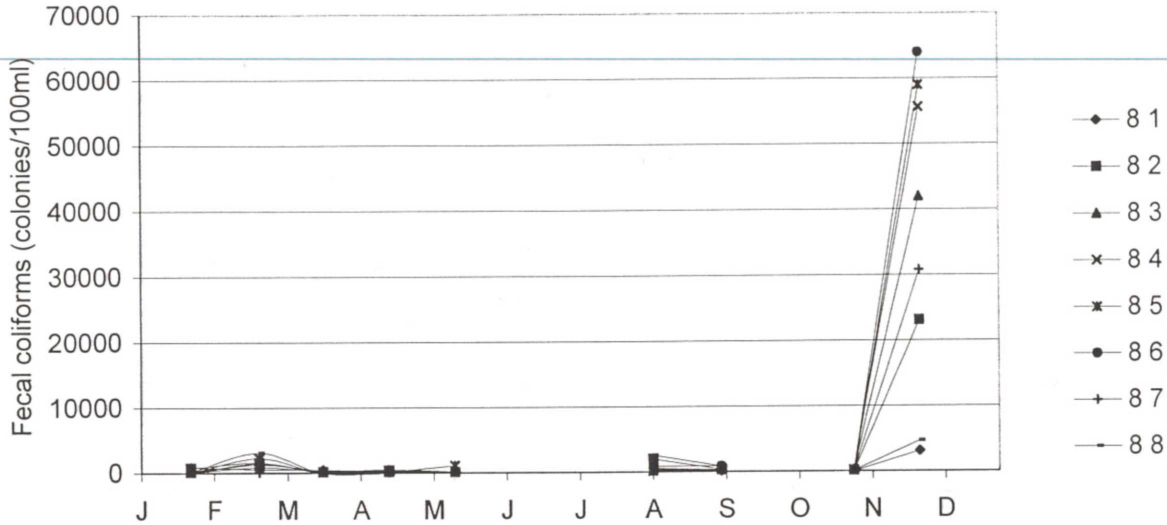


Fig. 8-6. 2001 fecal coliform and enterococci measurements for Abiaca Creek.



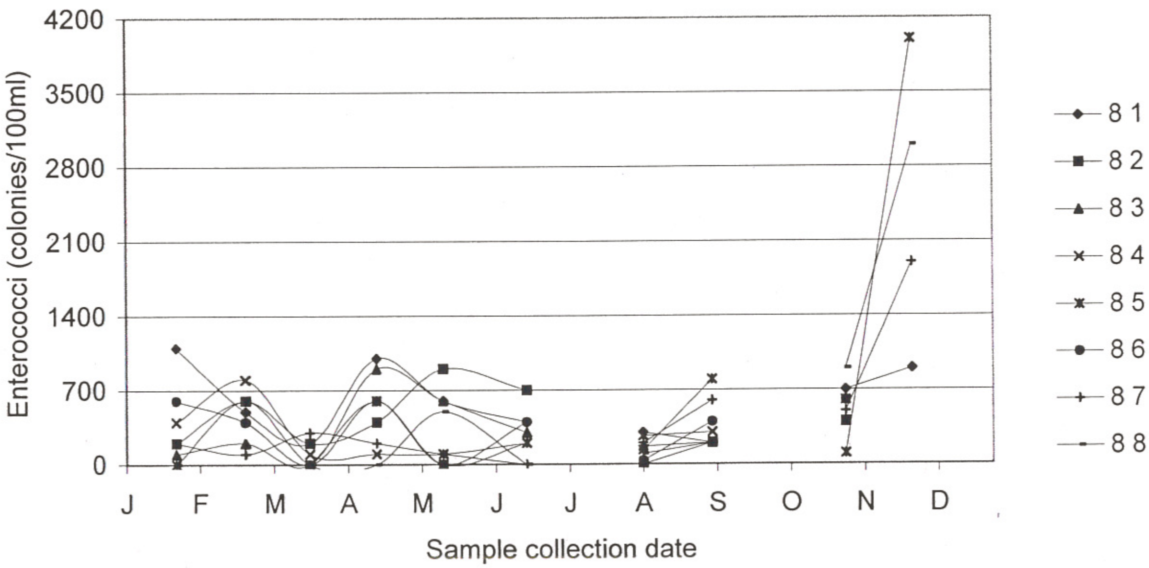


Fig. 8-7. Box plots of 2001 turbidity, chlorophyll *a*, total orthophosphate, total nitrogen, winter (January-April and November-December 2001) fecal coliform, and summer (May-October 2001) fecal coliform measurements by site for Abiaca Creek. Box = 25th-75th percentiles; whiskers = 10th-90th percentiles; points = 5th-95th percentiles; solid line = median value.

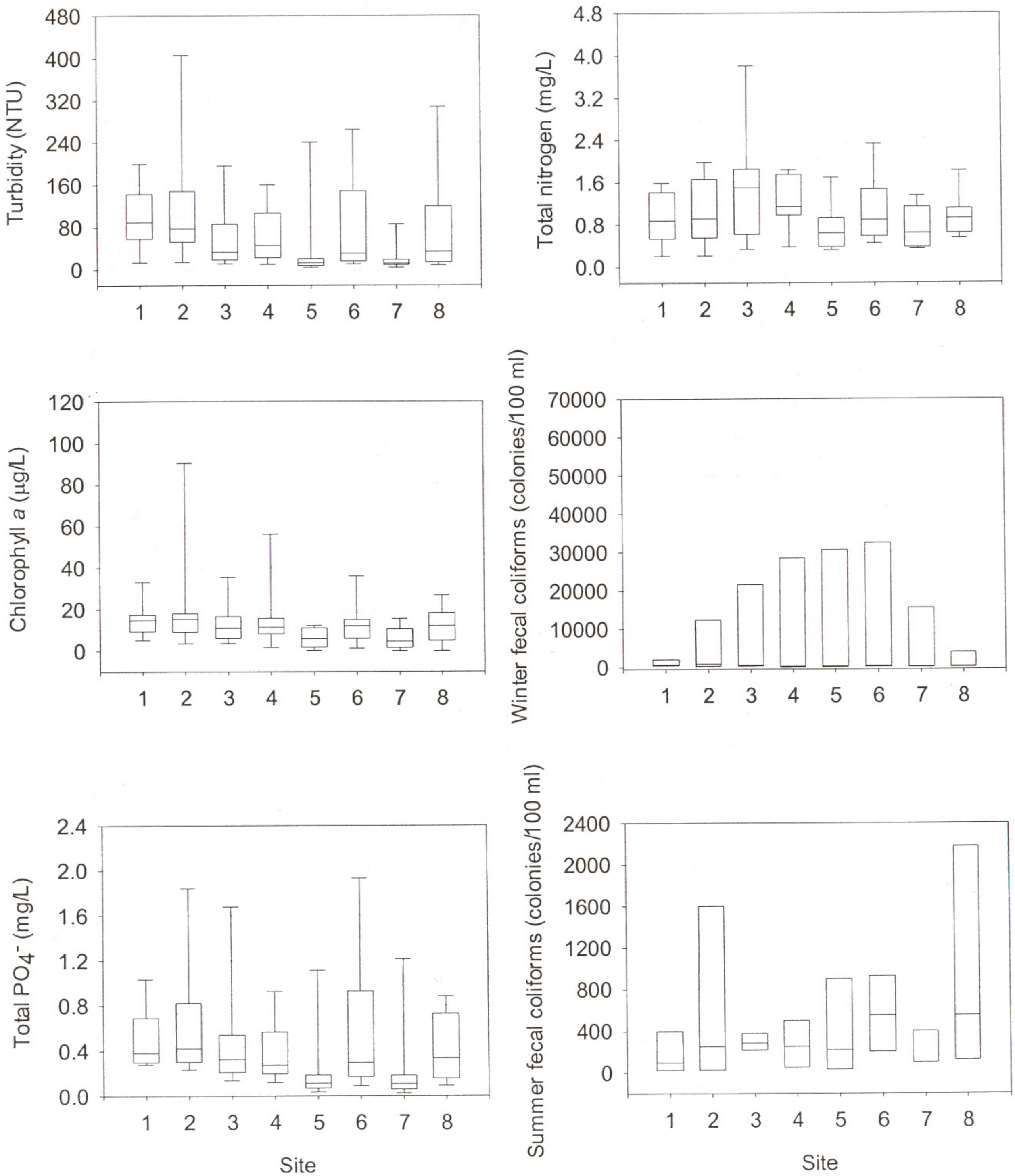


Fig. 9-1. 2001 depth to water, water depth, temperature, and dissolved oxygen measurements for Toby Tubby Creek.

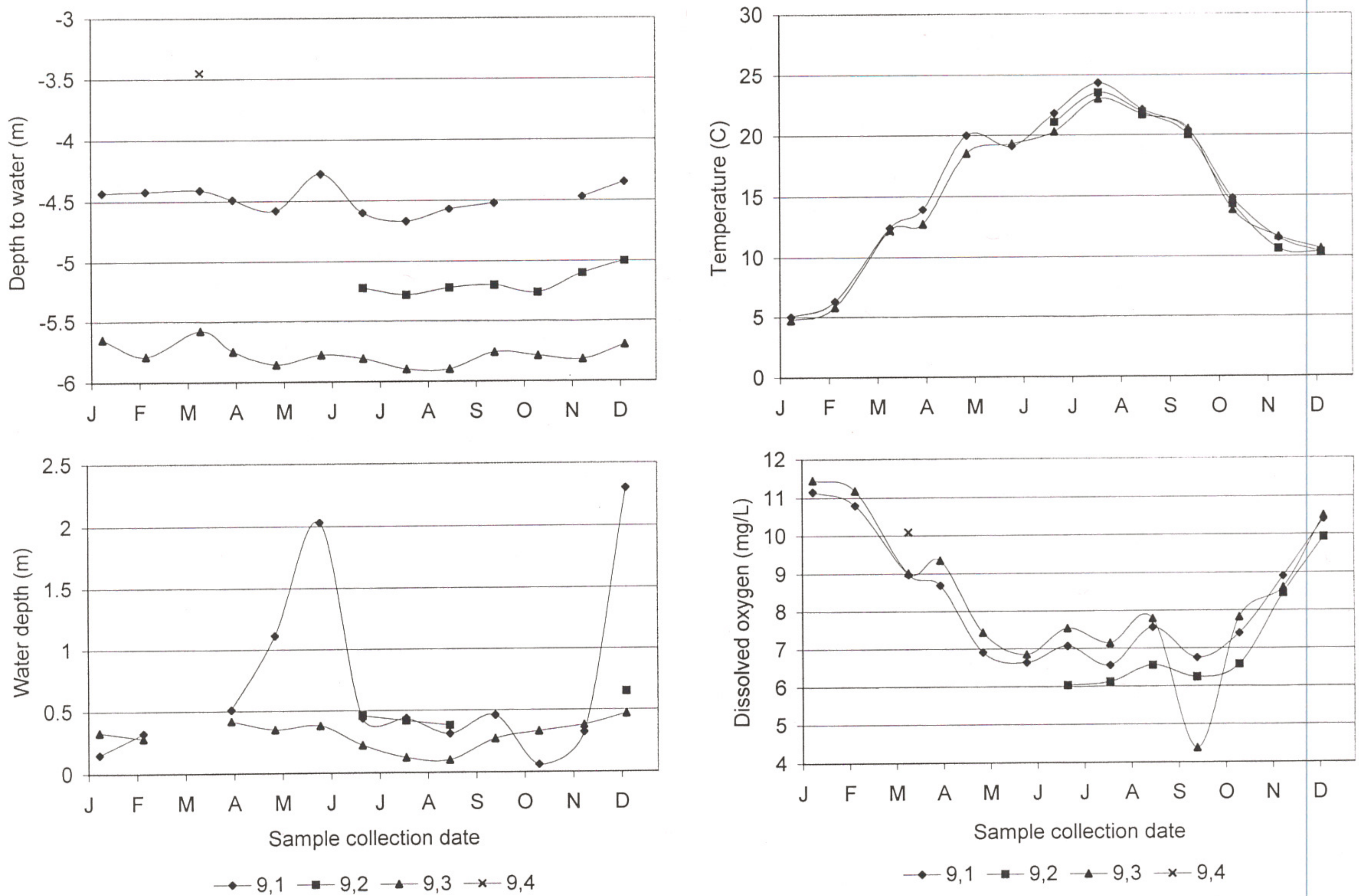


Fig. 9-2. 2001 conductivity, salinity, pH, and chlorophyll *a* measurements for Toby Tubby Creek.

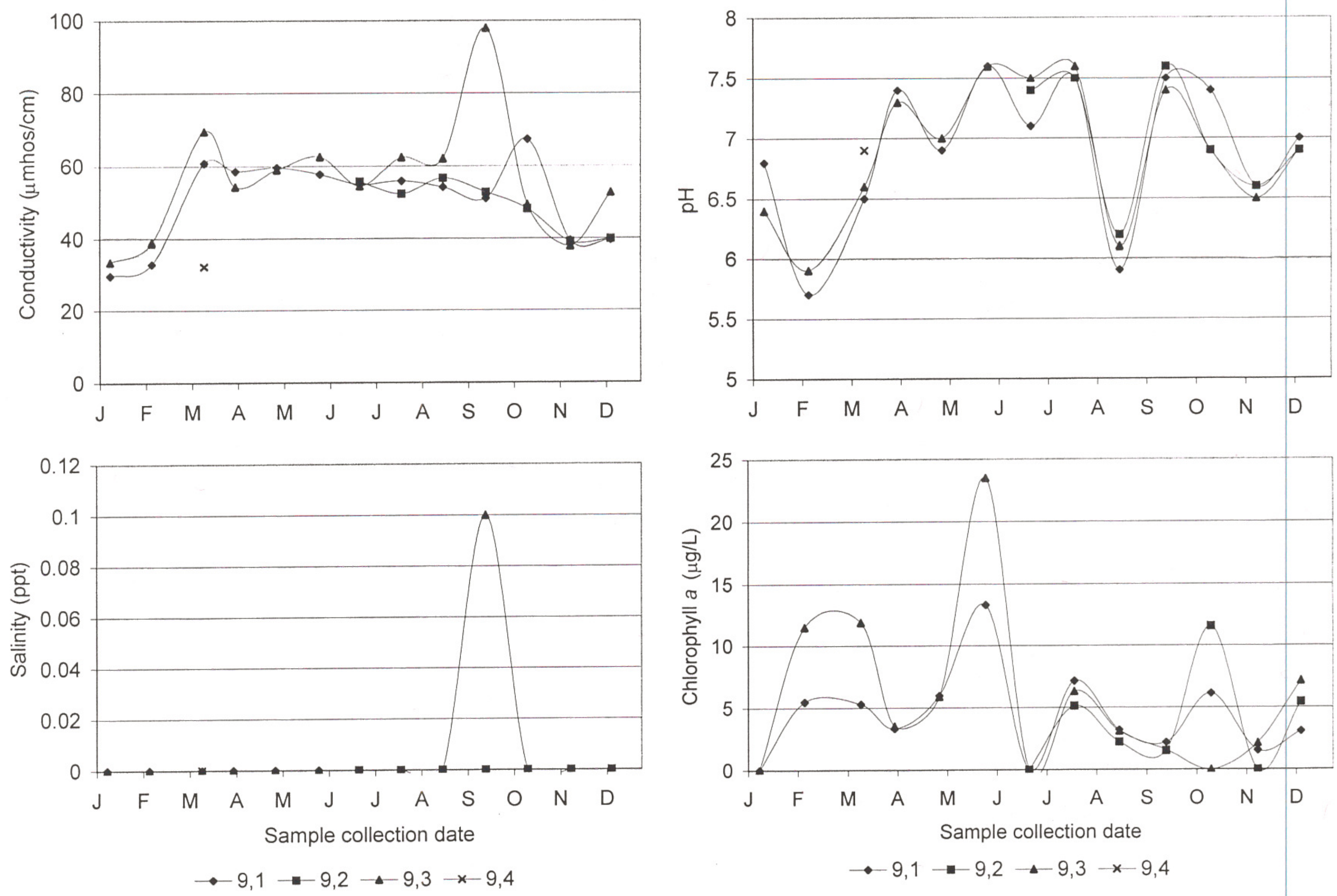


Fig. 9-3. 2001 turbidity, and total, dissolved and suspended solids measurements for Toby Tubby Creek.

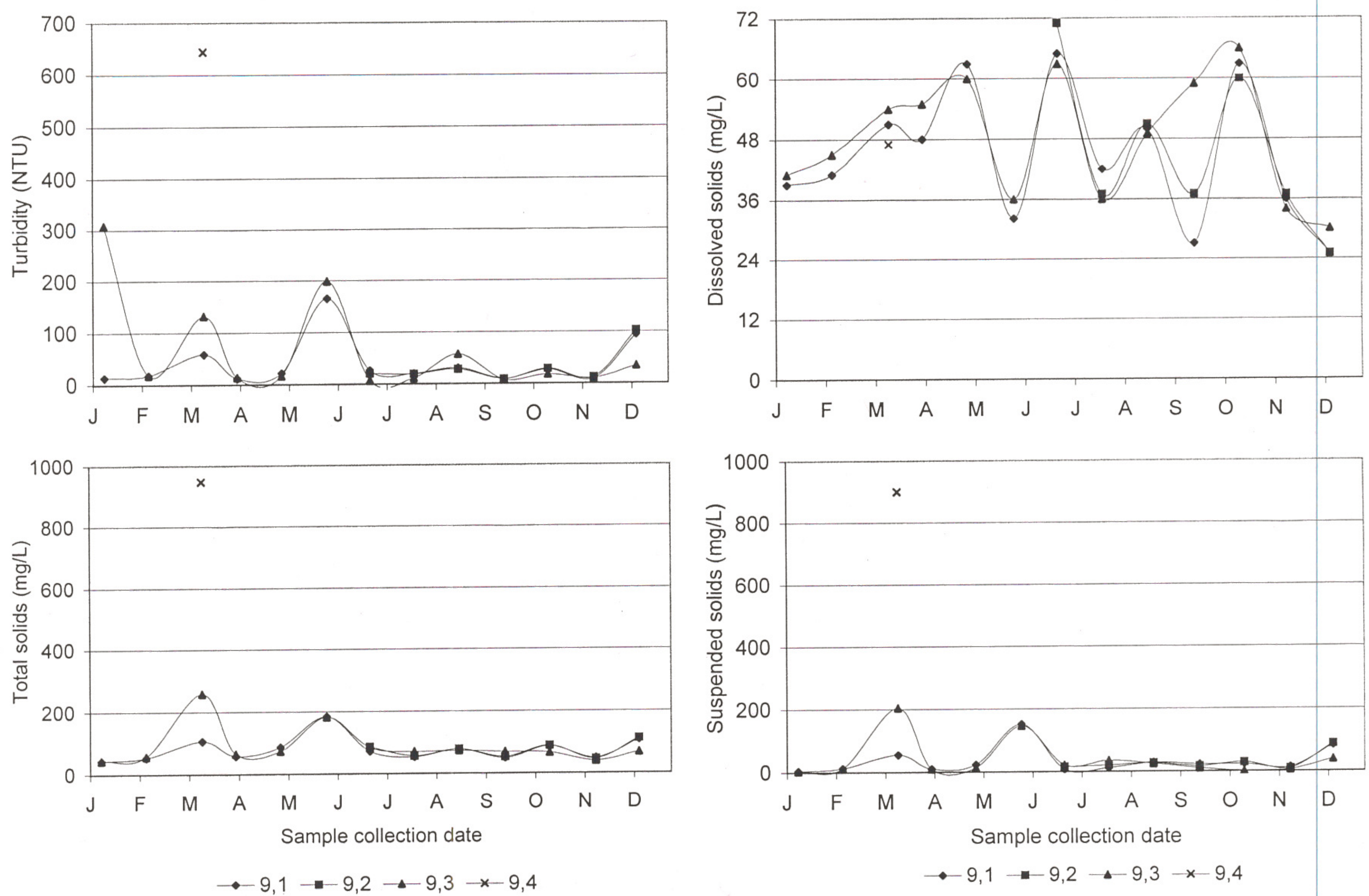


Fig. 9-4. 2001 hardness, alkalinity, filtered orthophosphate, and total orthophosphate measurements for Toby Tubby Creek.

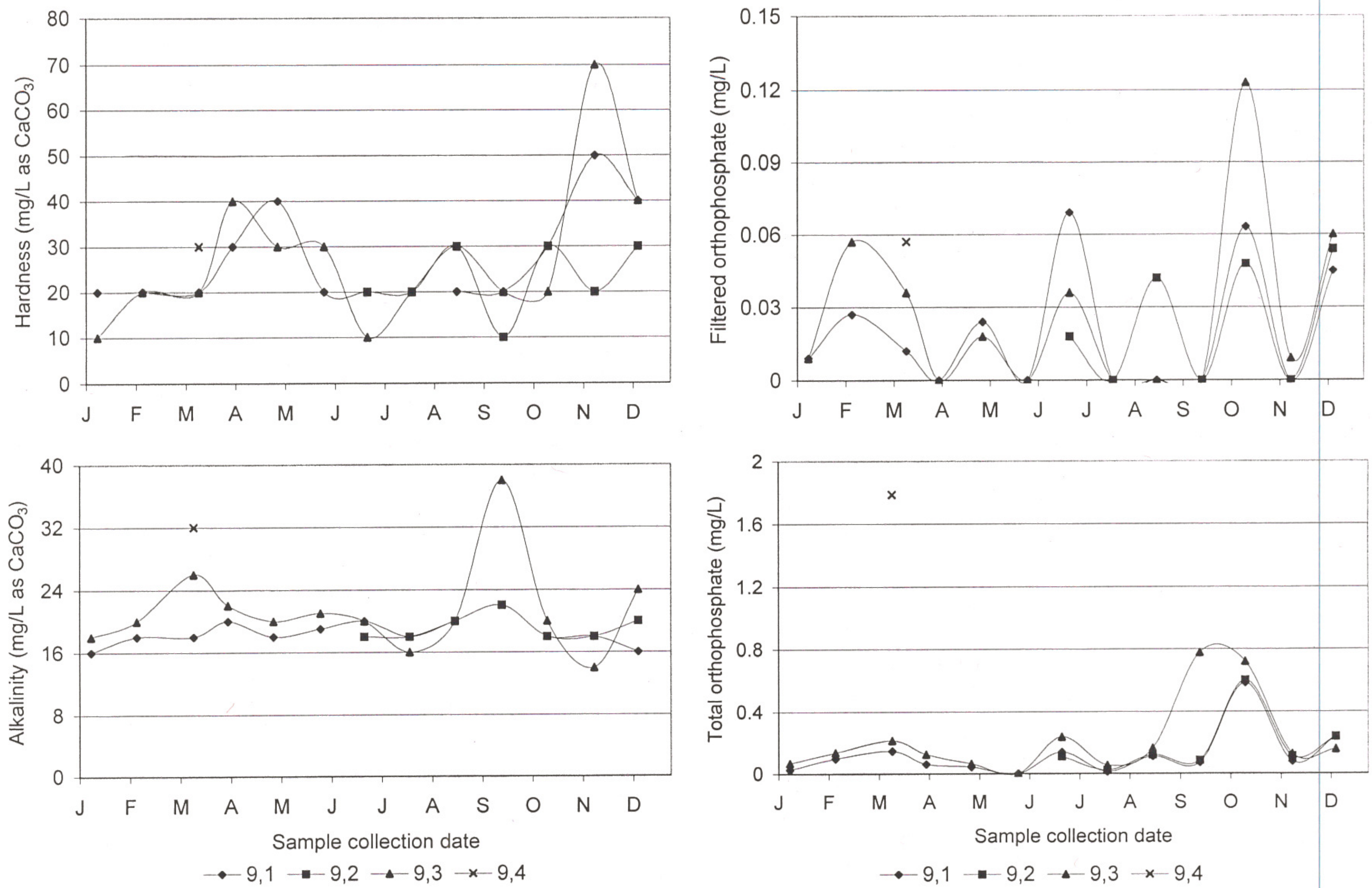


Fig. 9-5. 2001 ammonia, nitrate, nitrite, and total nitrogen measurements for Toby Tubby Creek.

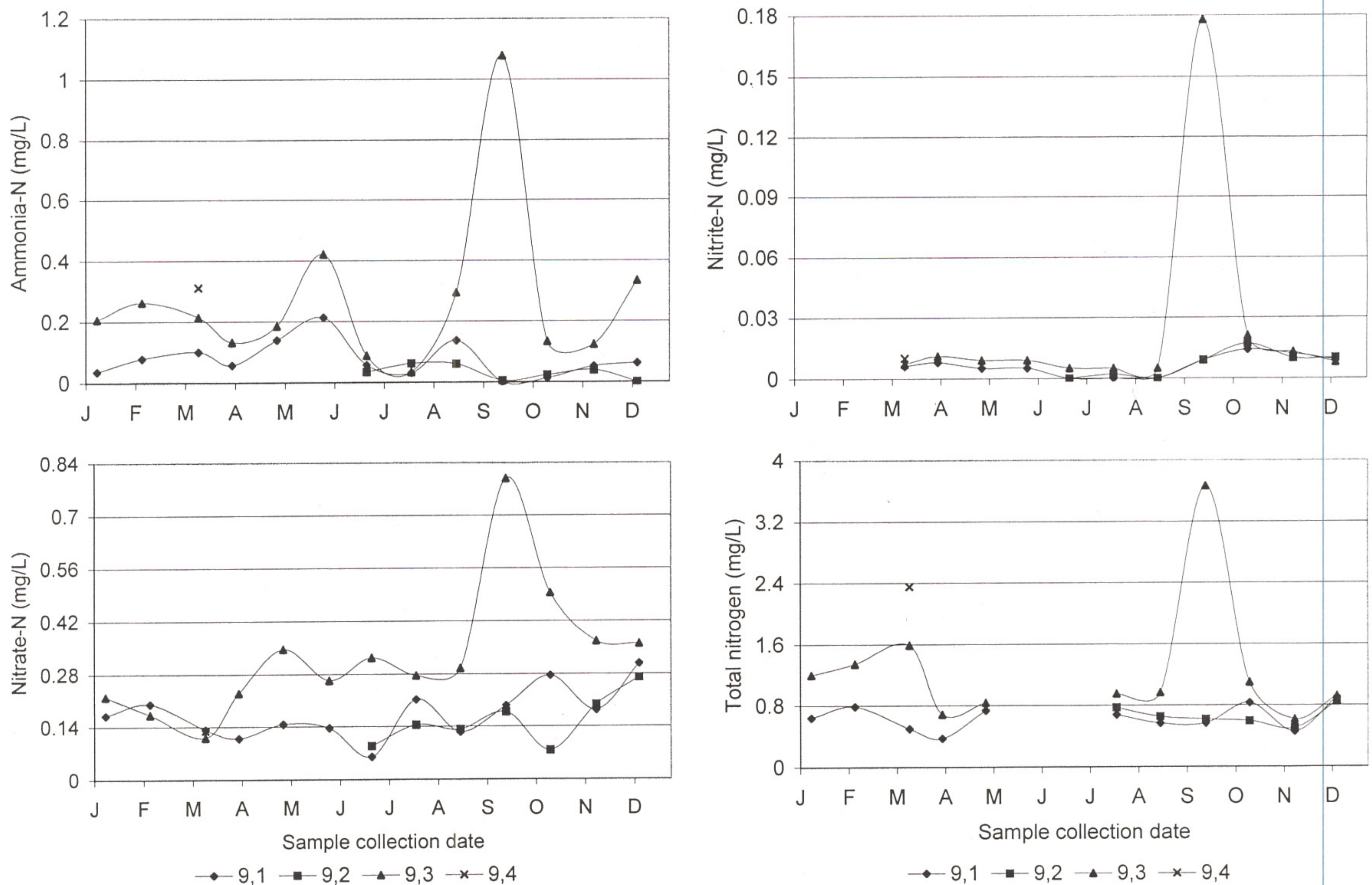


Fig. 9-6. 2001 fecal coliform and enterococci measurements for Toby Tubby Creek.

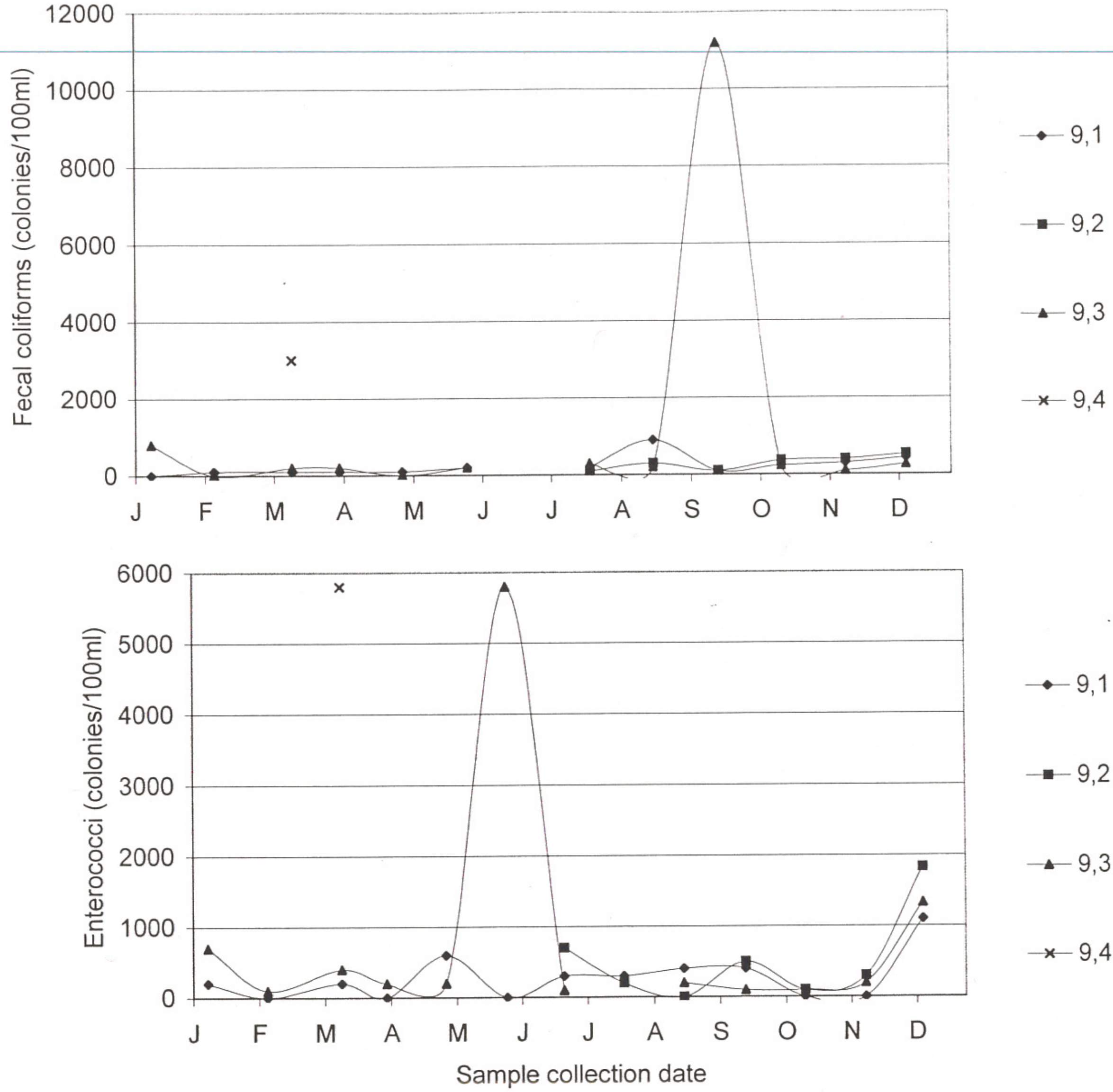


Fig. 9-7. Box plots of 2001 turbidity, chlorophyll *a*, total orthophosphate, total nitrogen, winter (January-April and November-December 2001) fecal coliform, and summer (May-October 2001) fecal coliform measurements by site for Toby Tubby Creek. Box = 25th-75th percentiles; whiskers = 10th-90th percentiles; points = 5th-95th percentiles; solid line = median value.

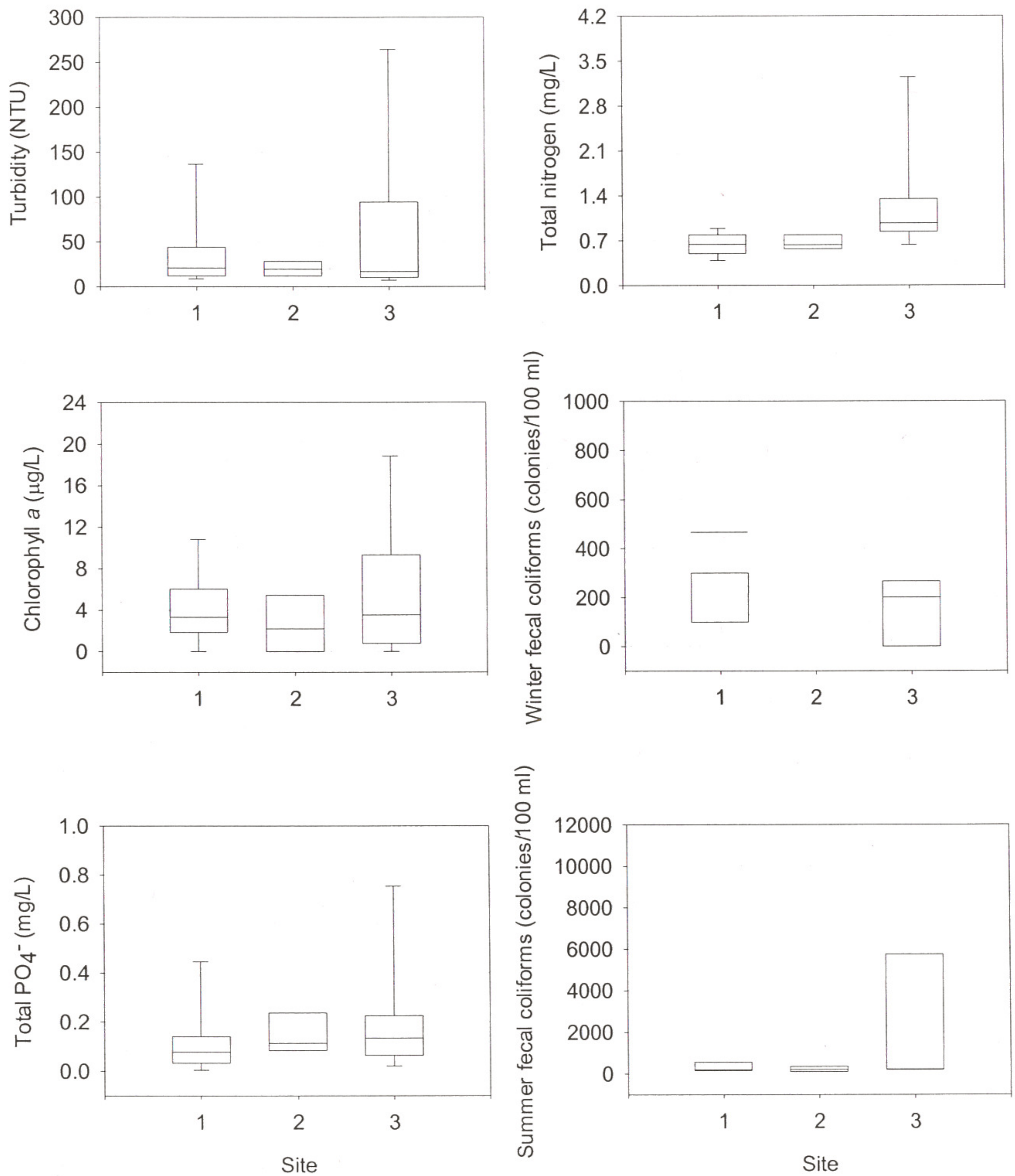


Fig. 13-1. 2001 depth to water, water depth, temperature, and dissolved oxygen measurements for Burney Branch Creek.

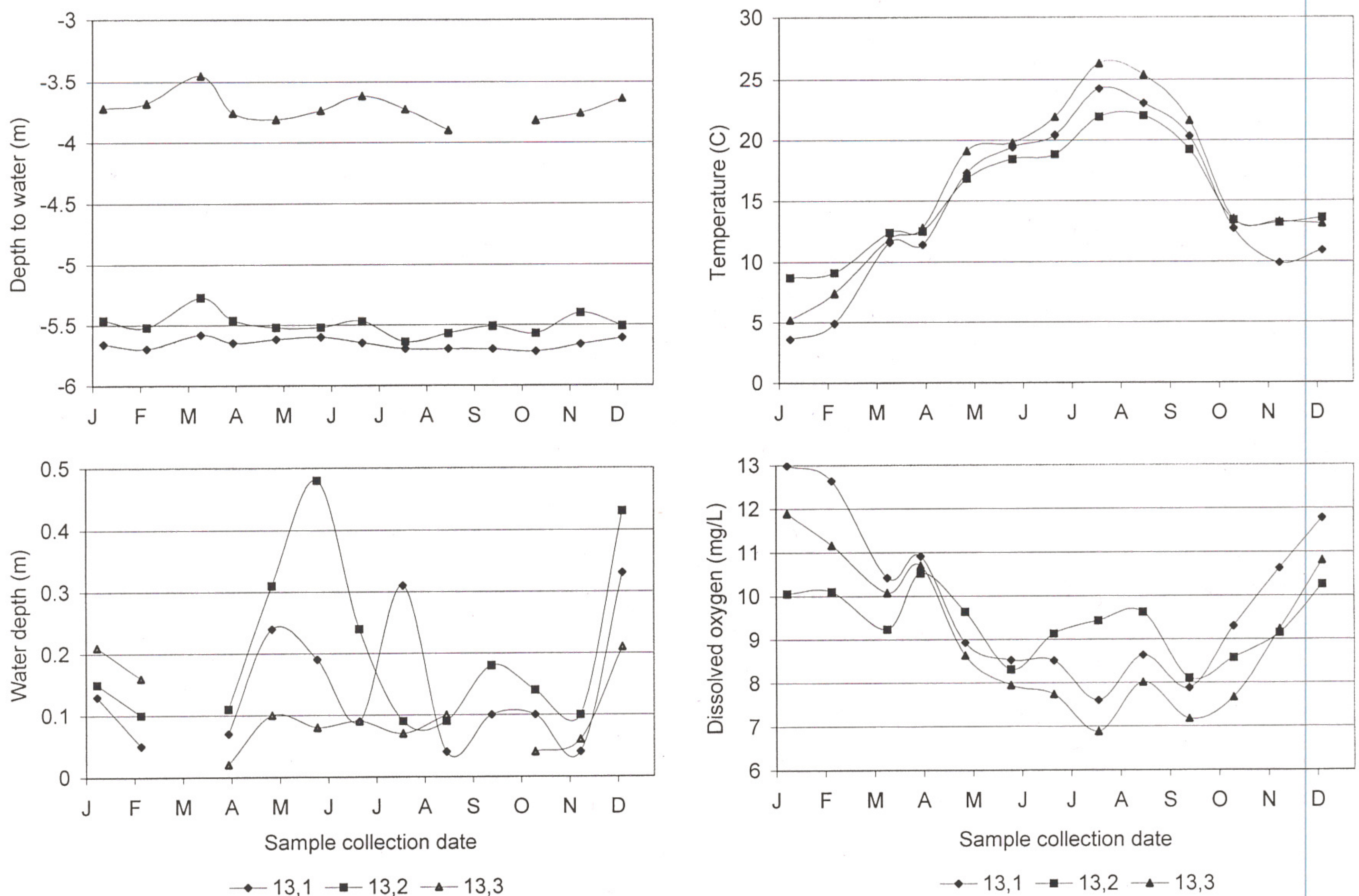


Fig. 13-2. 2001 conductivity, salinity, pH, and chlorophyll *a* measurements for Burney Branch Creek.

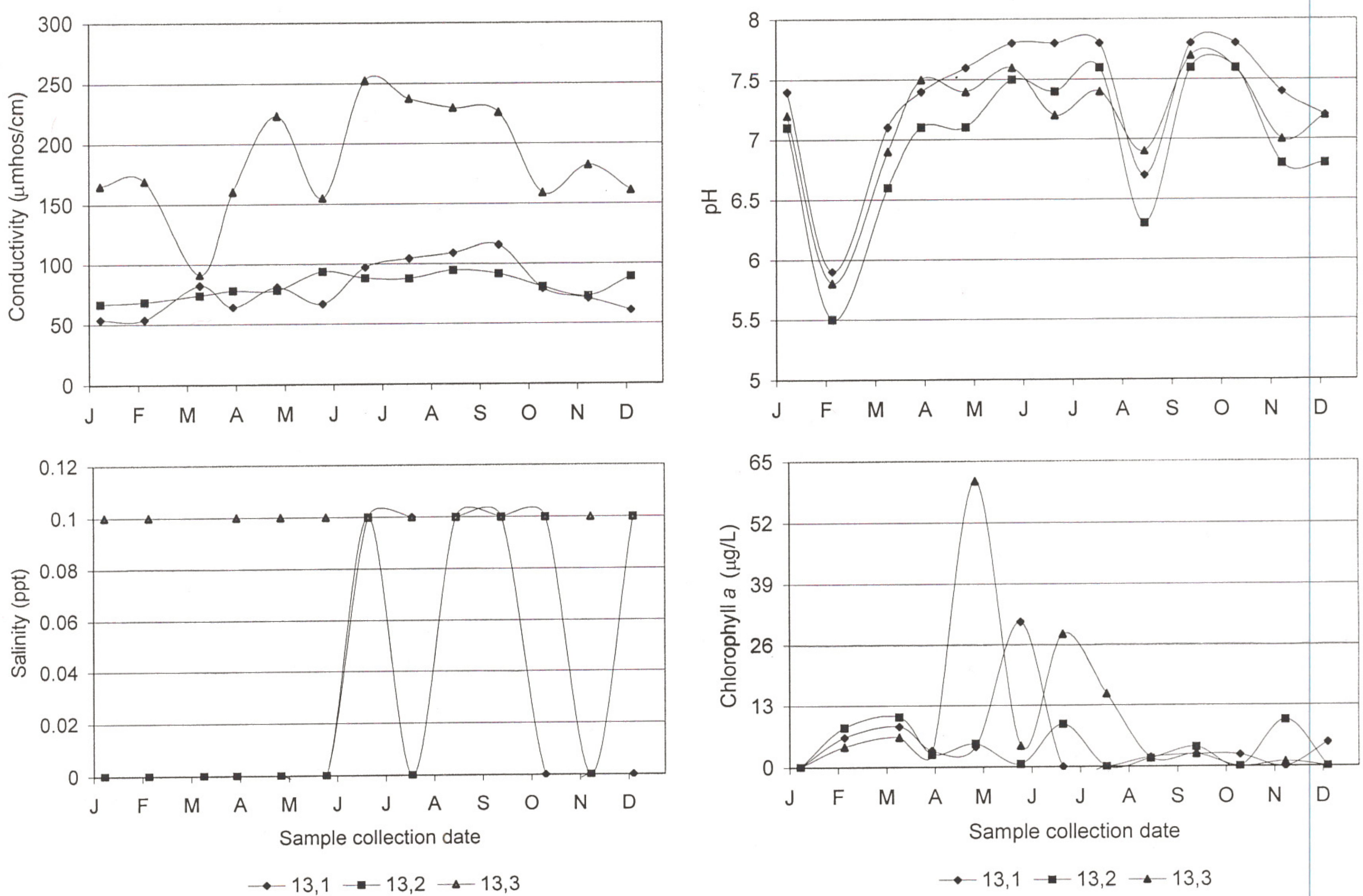


Fig. 13-3. 2001 turbidity, and total, dissolved and suspended solids measurements for Burney Branch Creek.

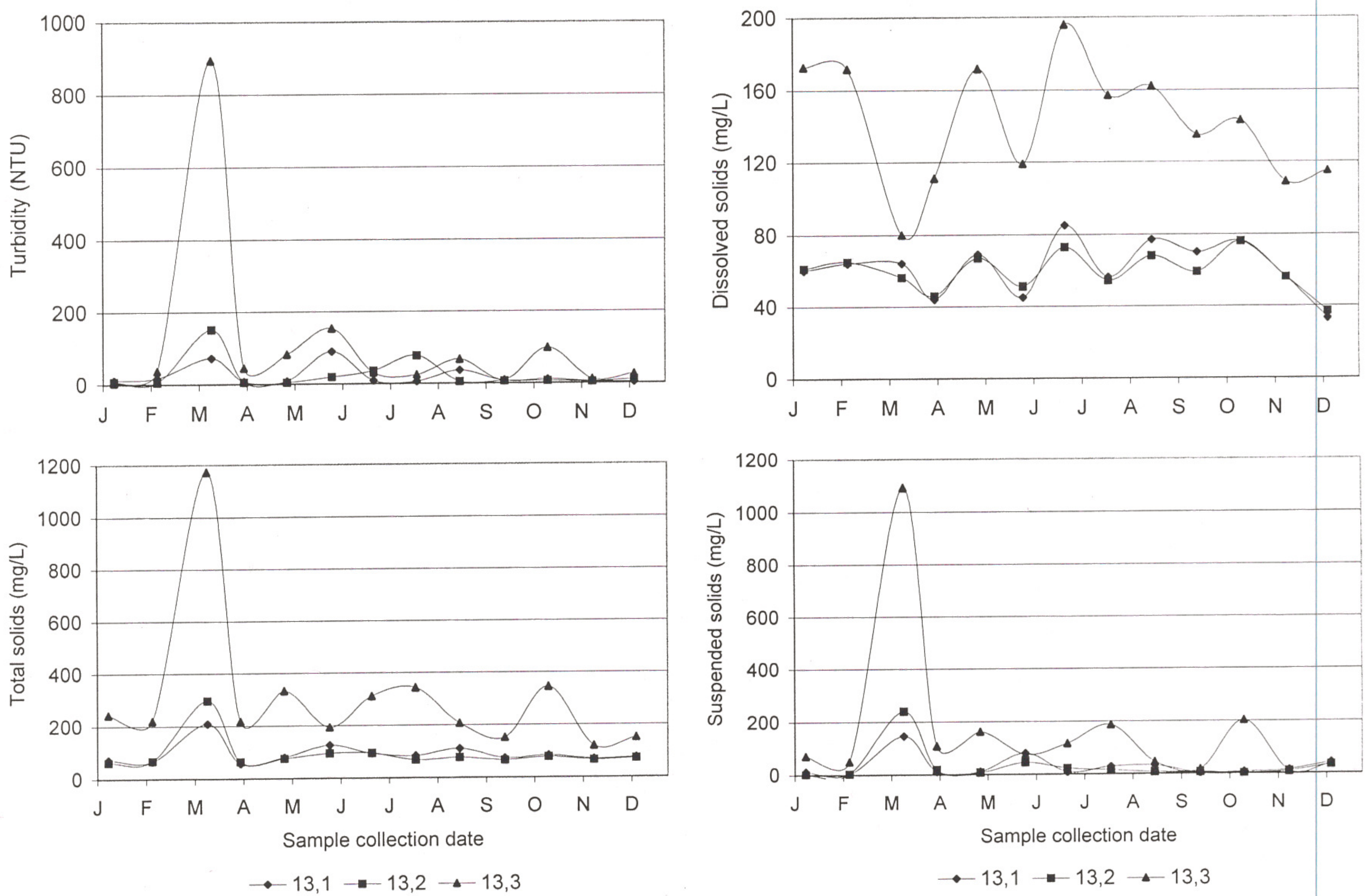


Fig. 13-4. 2001 hardness, alkalinity, filtered orthophosphate, and total orthophosphate measurements for Burney Branch Creek.

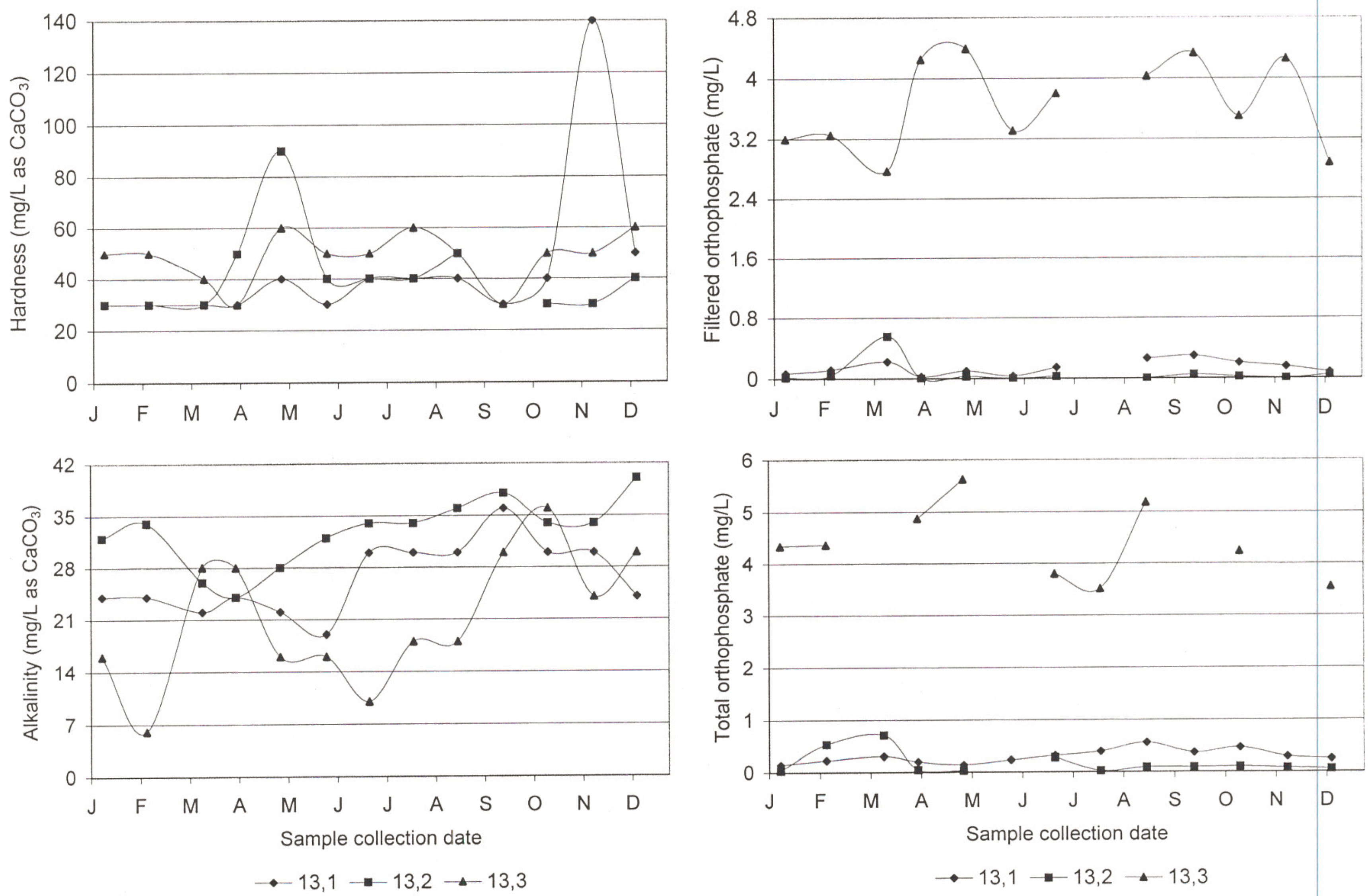


Fig. 13-5. 2001 ammonia, nitrate, nitrite, and total nitrogen measurements for Burney Branch Creek.

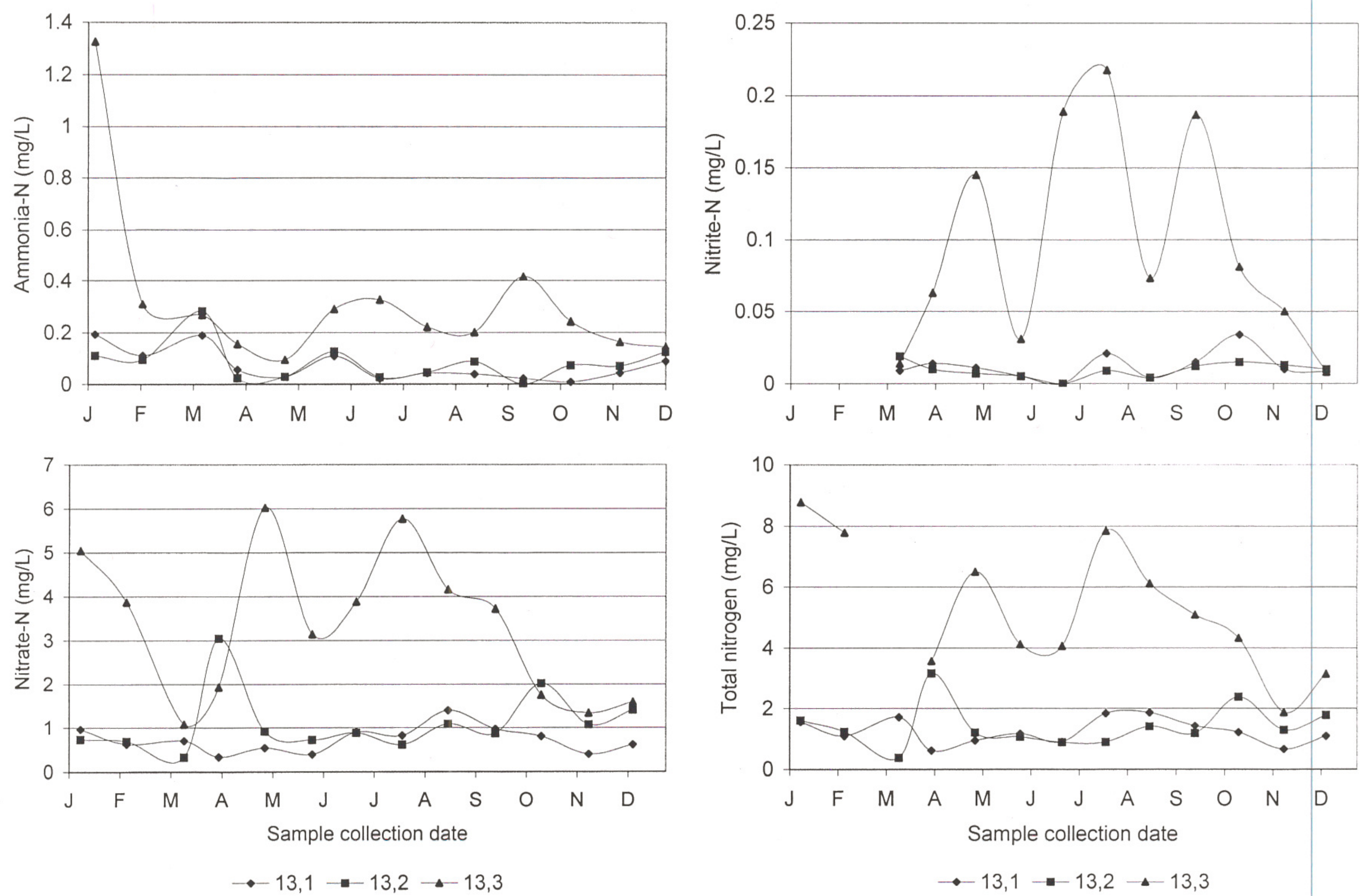


Fig. 13-6. 2001 fecal coliform and enterococci measurements for Burney Branch Creek.

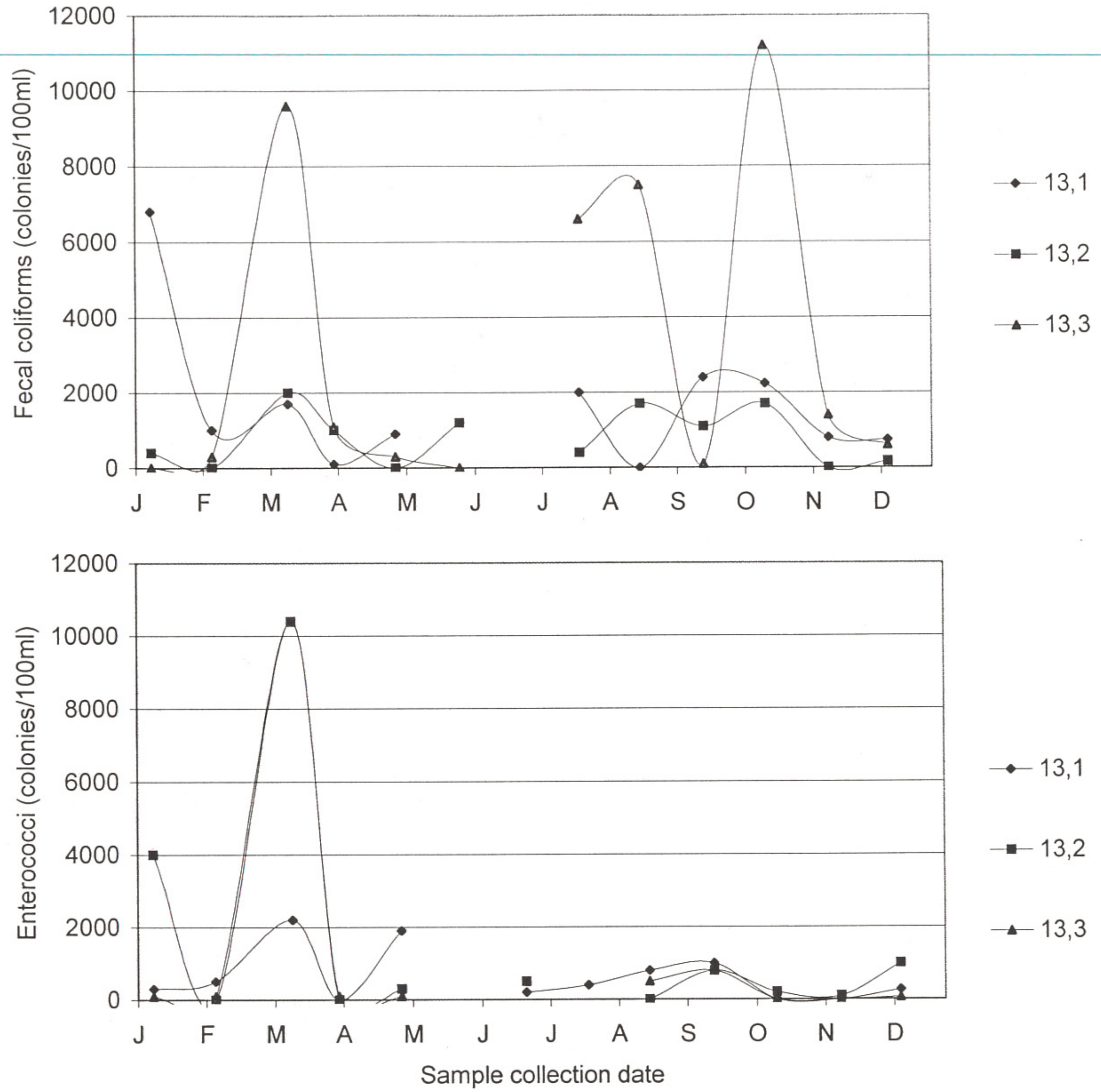


Fig. 13-7. Box plots of 2001 turbidity, chlorophyll *a*, total orthophosphate, total nitrogen, winter (January-April and November-December 2001) fecal coliform, and summer (May-October 2001) fecal coliform measurements by site for Burney Branch Creek. Box = 25th-75th percentiles; whiskers = 10th-90th percentiles; points=5th-95th percentiles; solid line = median value.

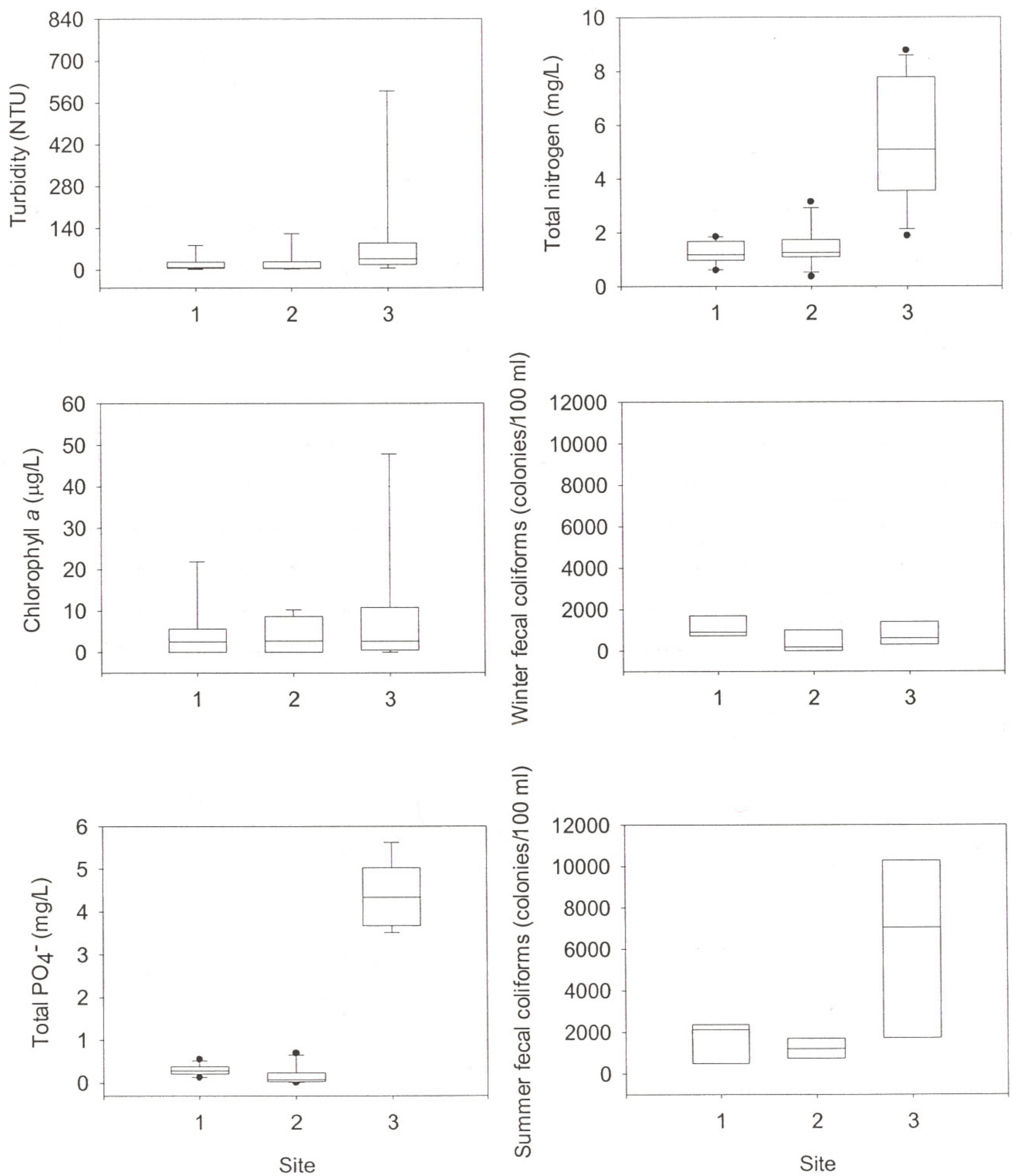


Fig. 17-1. 2001 depth to water, water depth, temperature, and dissolved oxygen measurements for Yalobusha River.

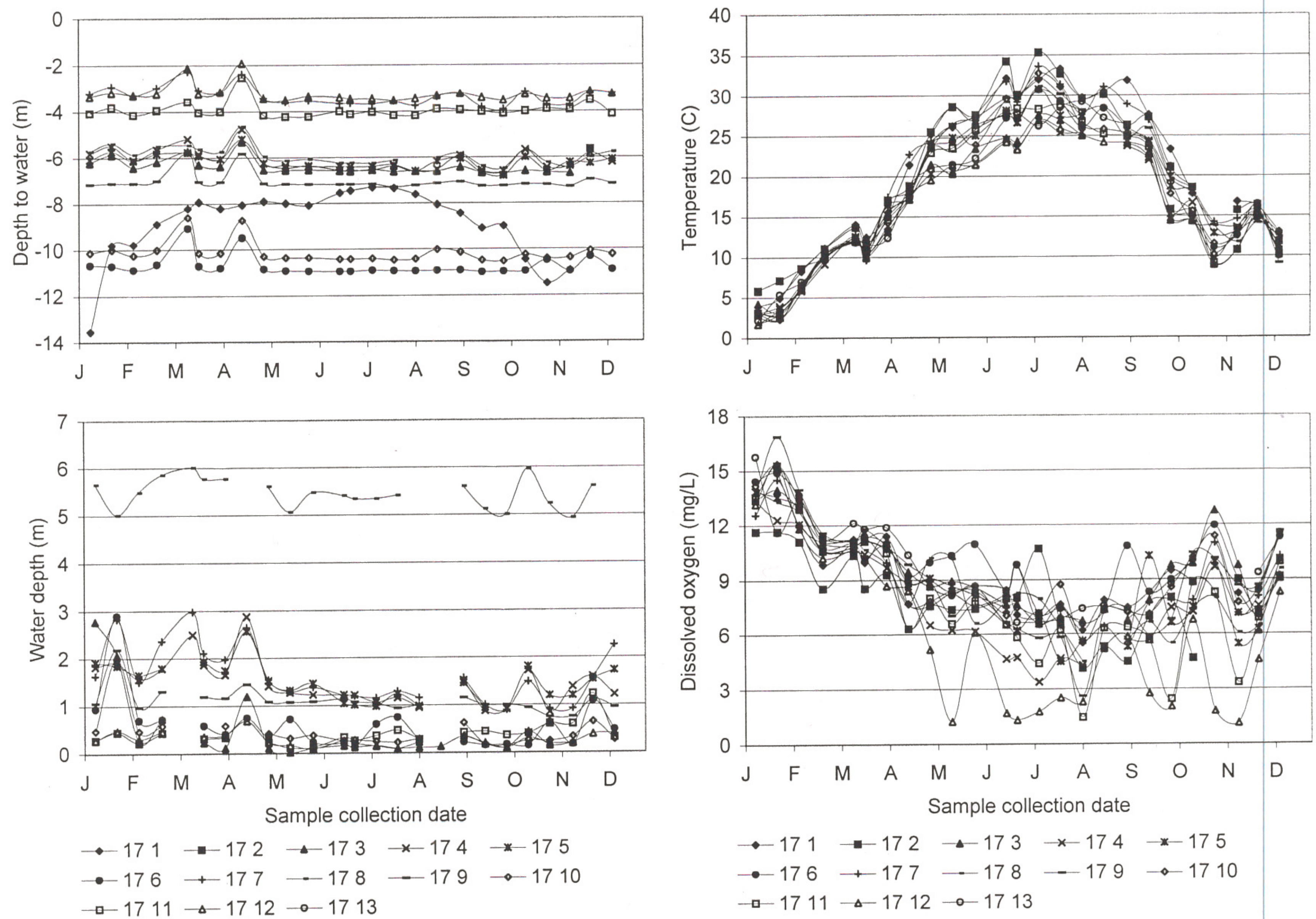


Fig. 17-2. 2001 conductivity, salinity, pH, and chlorophyll *a* measurements for Yalobusha River.

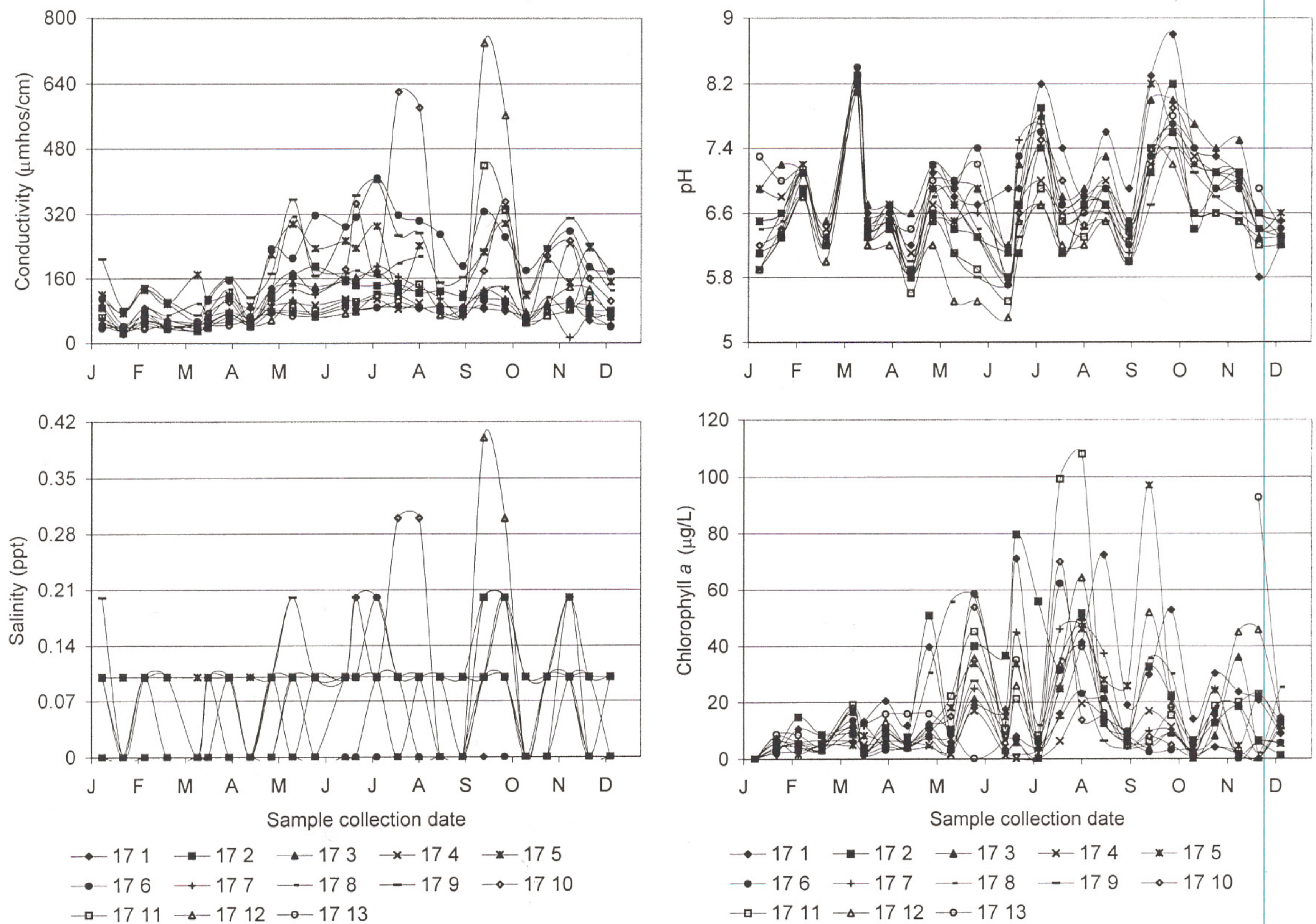


Fig. 17-3. 2001 turbidity, and total, dissolved and suspended solids measurements for Yalobusha River.

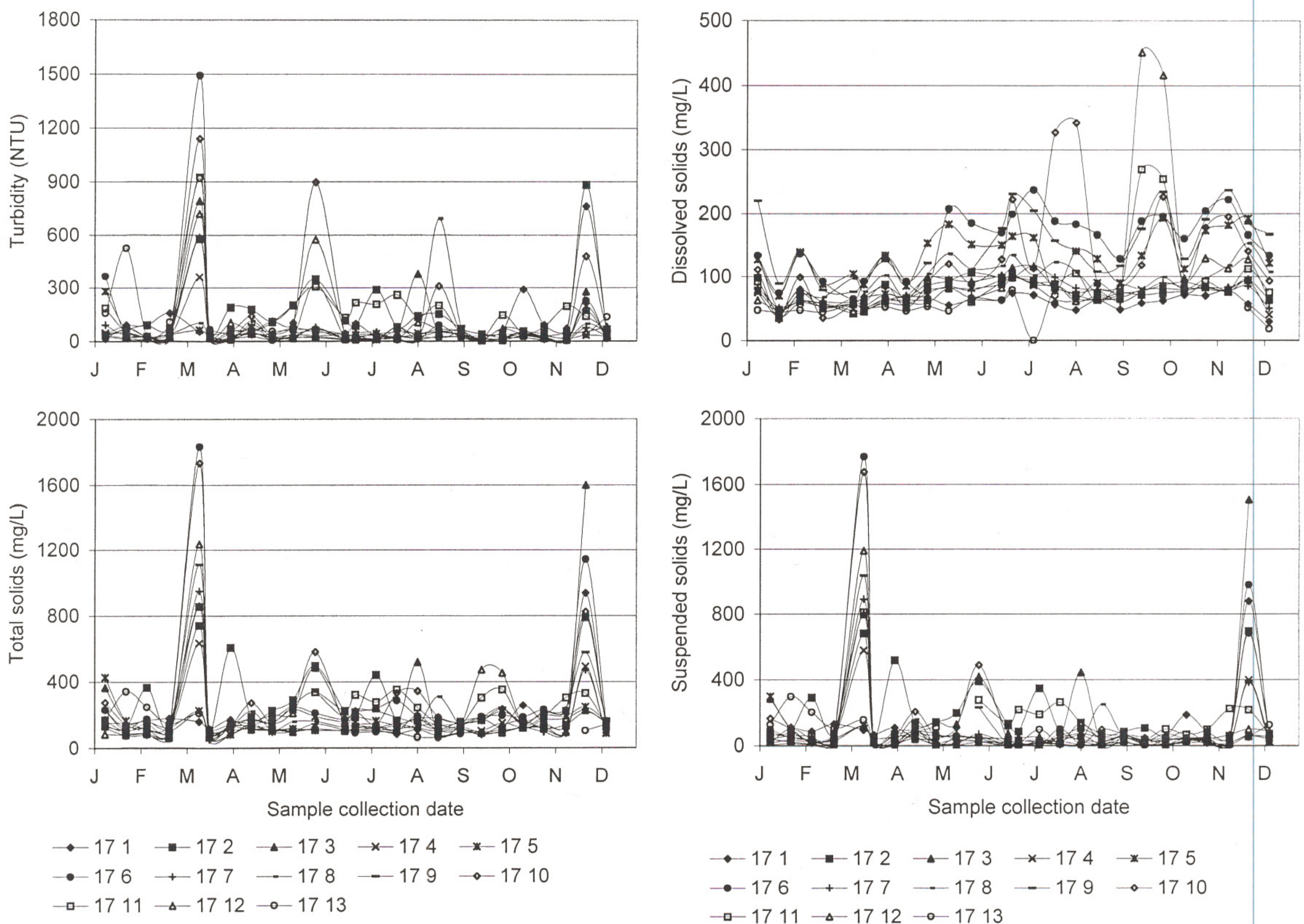


Fig. 17-4. 2001 hardness, alkalinity, filtered orthophosphate, and total orthophosphate measurements for Yalobusha River.

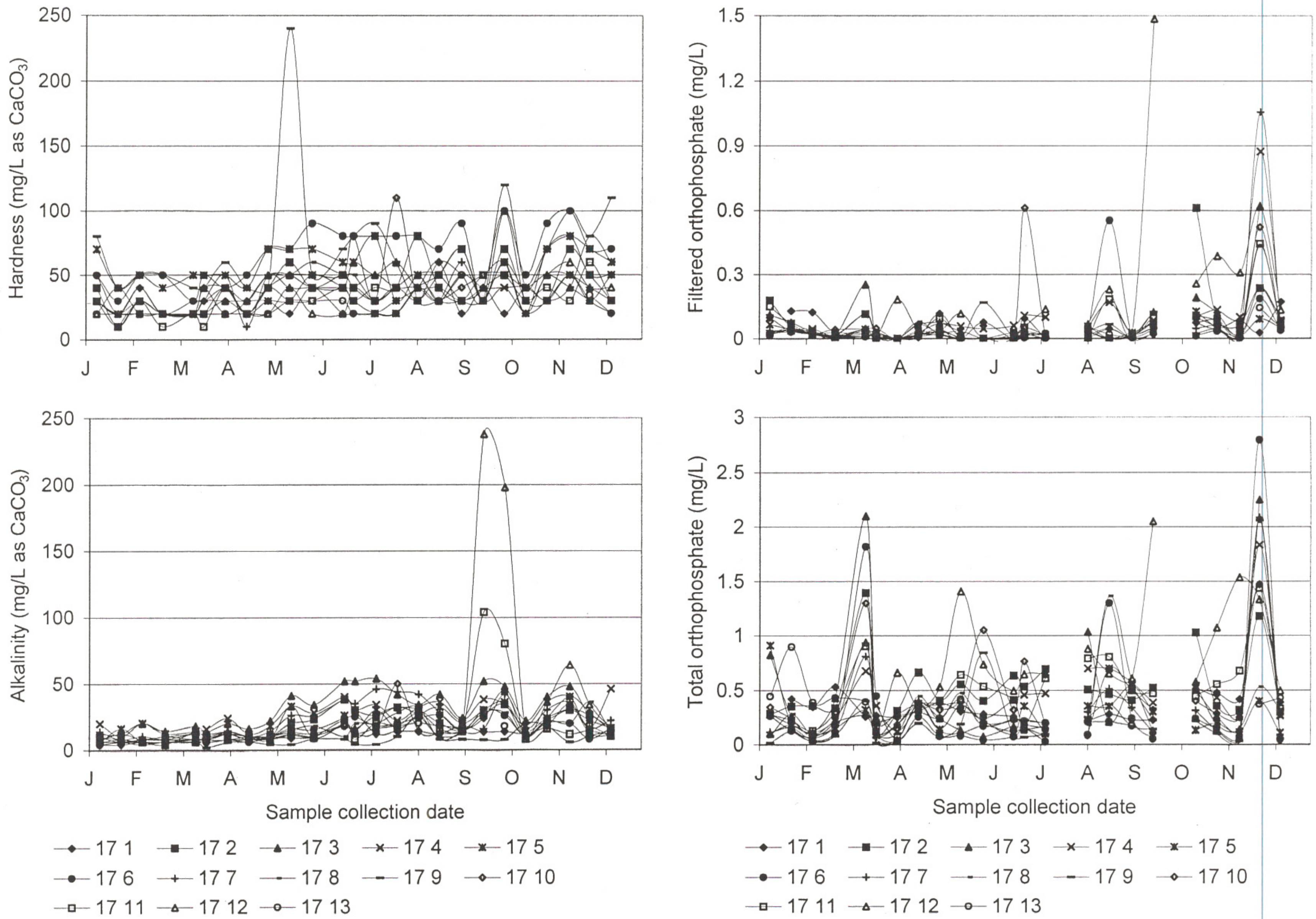


Fig. 17-5. 2001 ammonia, nitrate, nitrite, and total nitrogen measurements for Yalobusha River.

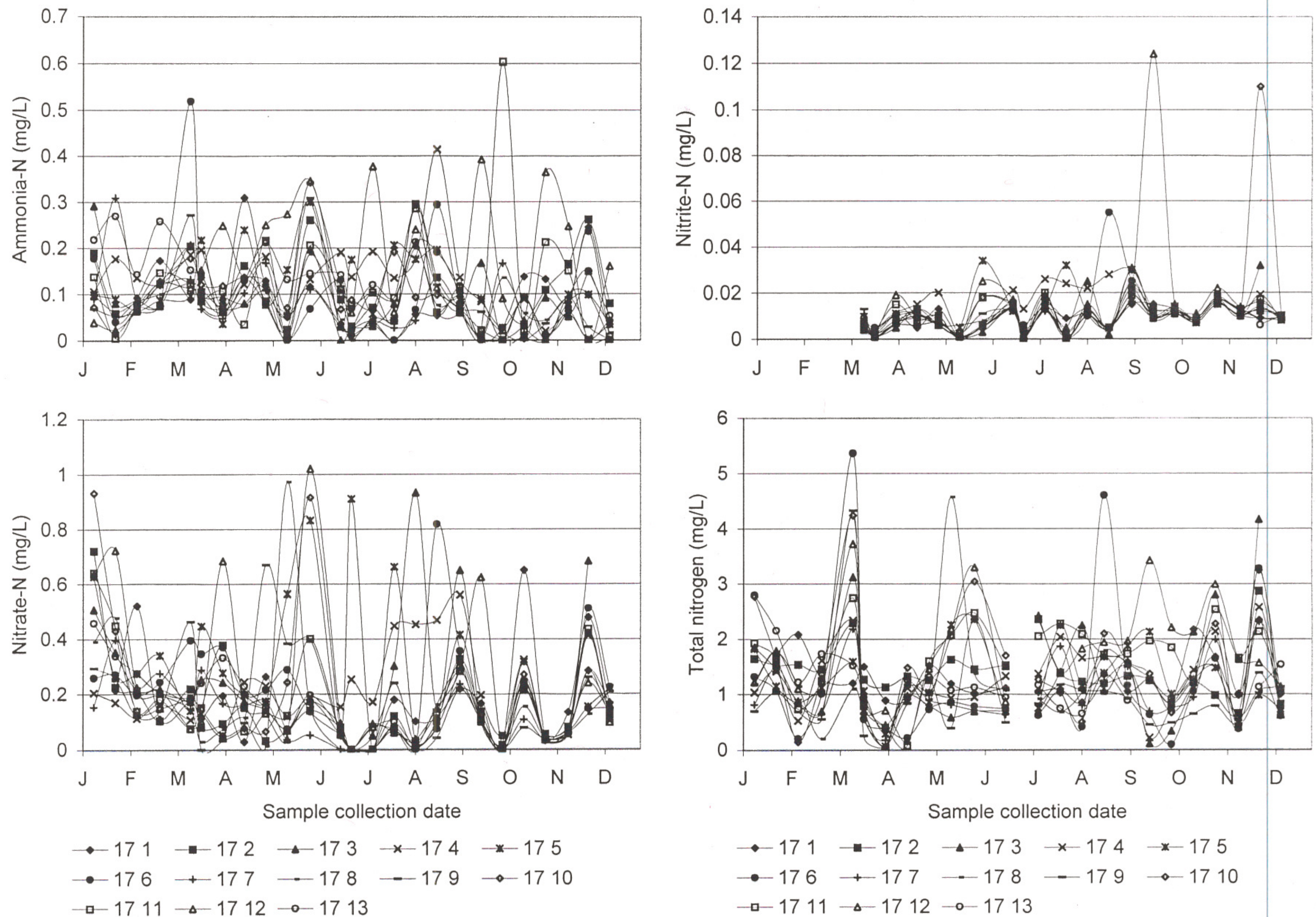


Fig. 17-6. 2001 fecal coliform and enterococci measurements for Yalobusha River.

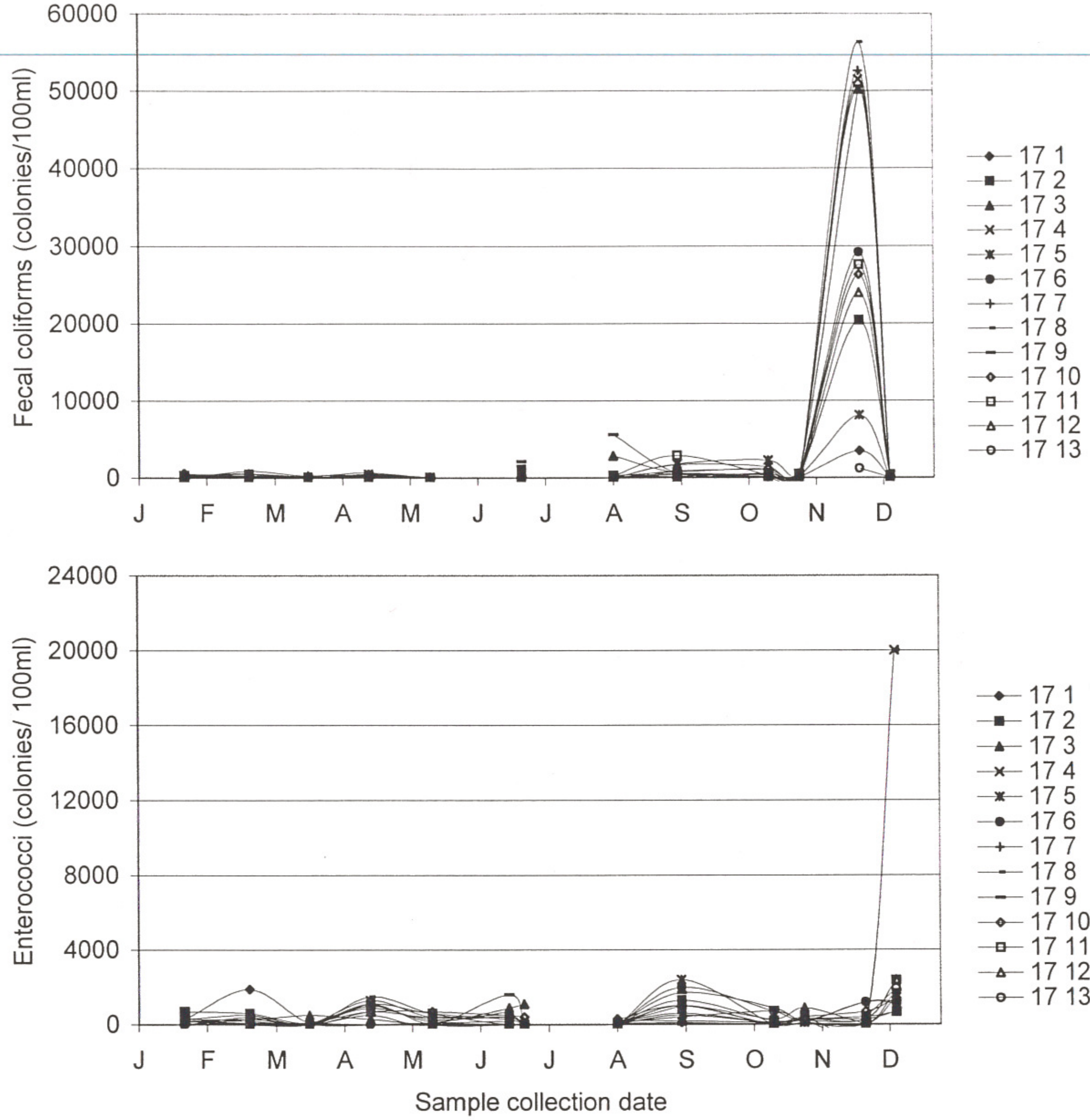


Fig. 17-7. Box plots of 2001 turbidity, chlorophyll *a*, total orthophosphate, total nitrogen, winter (January-April and November-December 2001) fecal coliform, and summer (May-October 2001) fecal coliform measurements by site for Yalobusha River. Box = 25th-75th percentiles; whiskers = 10th-90th percentiles; points = 5th-95th percentiles; solid line = median value.

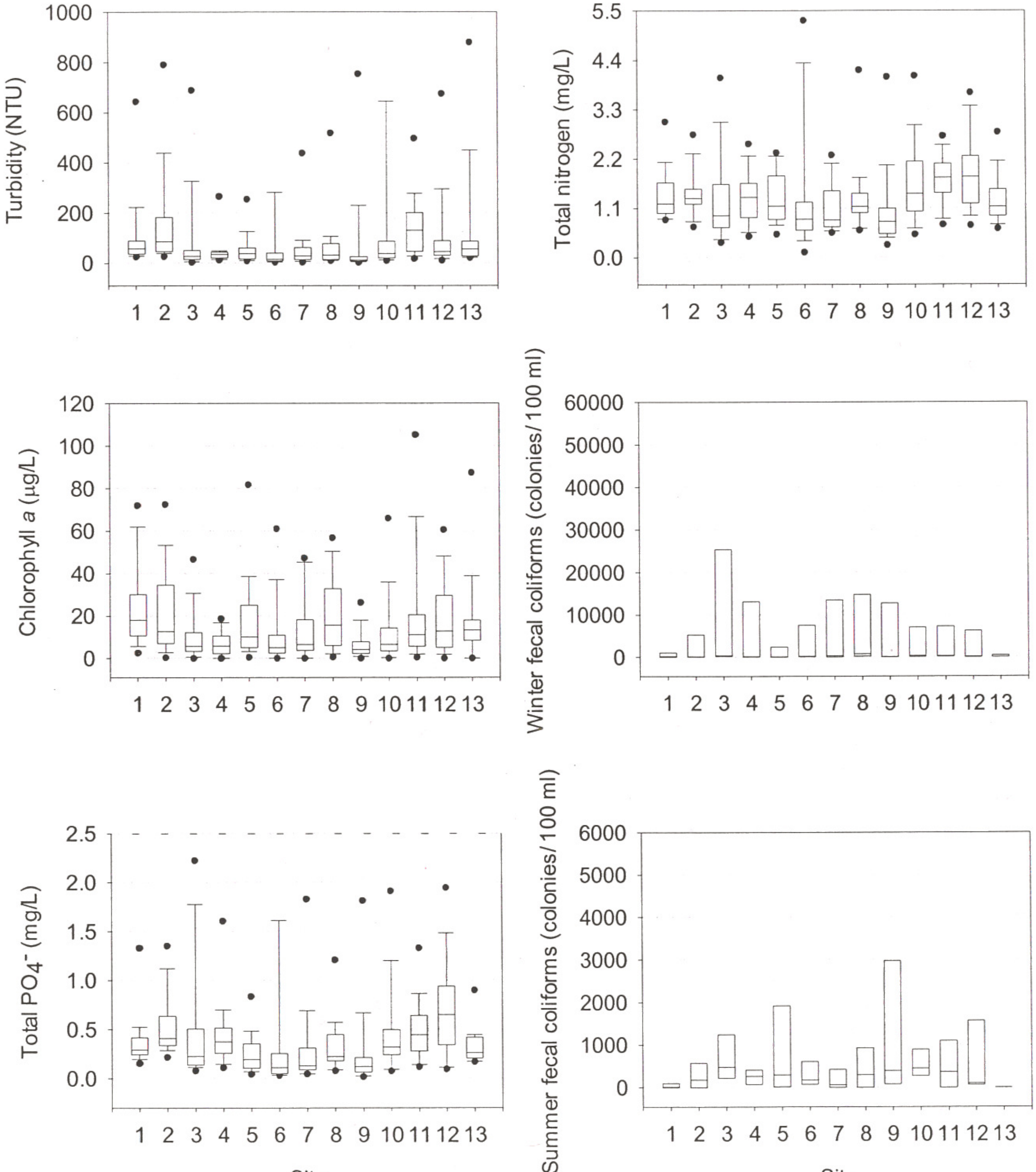
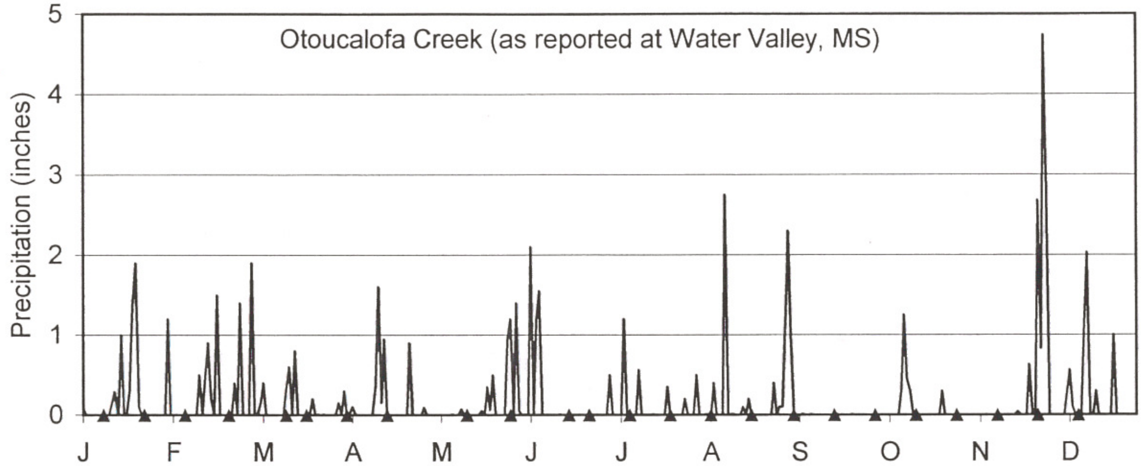
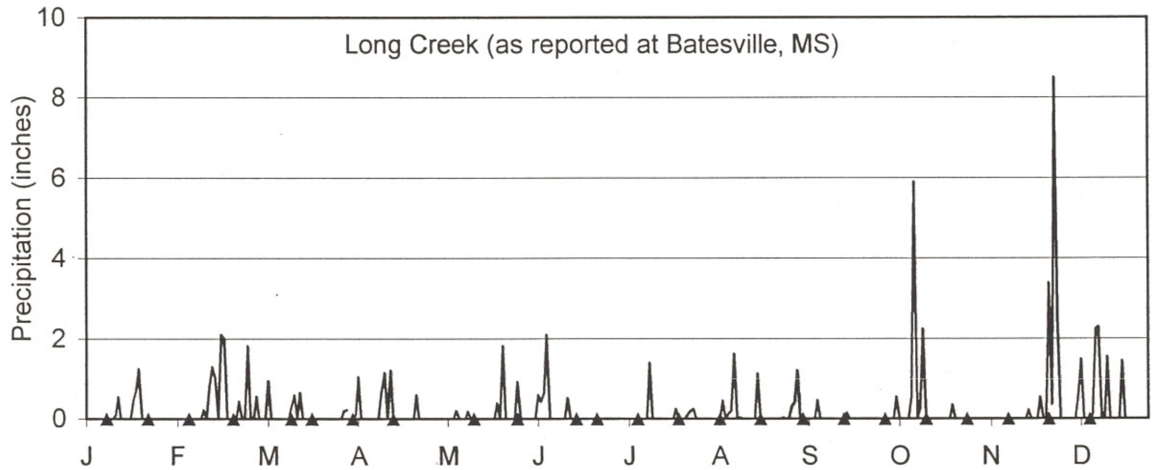


Fig. D. 2001 precipitation amounts for Otoucalofa, Long, and Hotophia Creeks. Closed triangles represent sample collection date. Climatological data from USDC, NOAA (USDC 2001a-l)





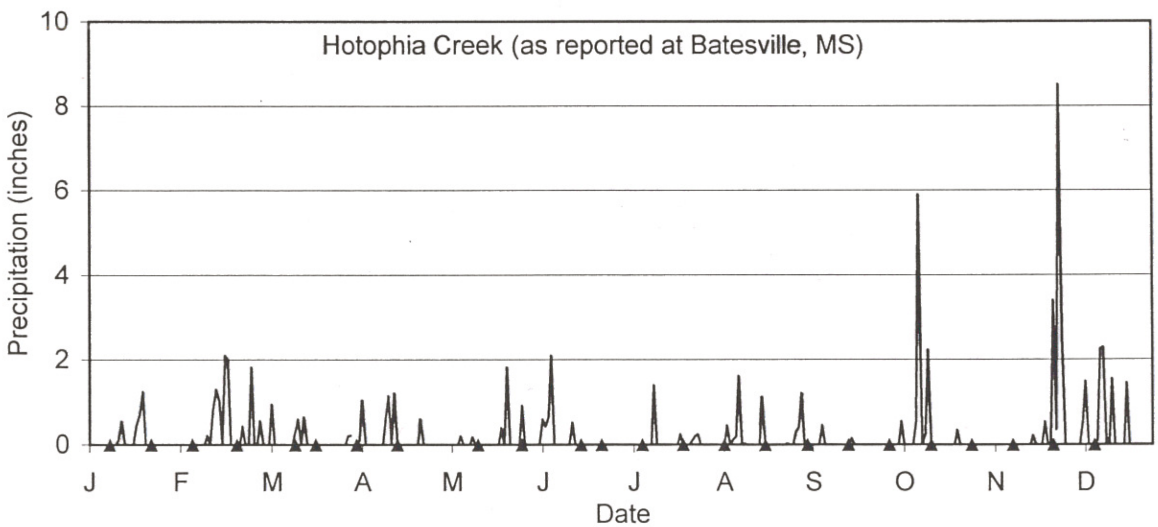


Fig. E. 2001 precipitation amounts for Abiaca, Toby Tubby, Burney Branch Creeks, and Yalobusha River. Closed triangles represent sample collection date. Climatological data from USDC, NOAA (USDC 2001a-l)

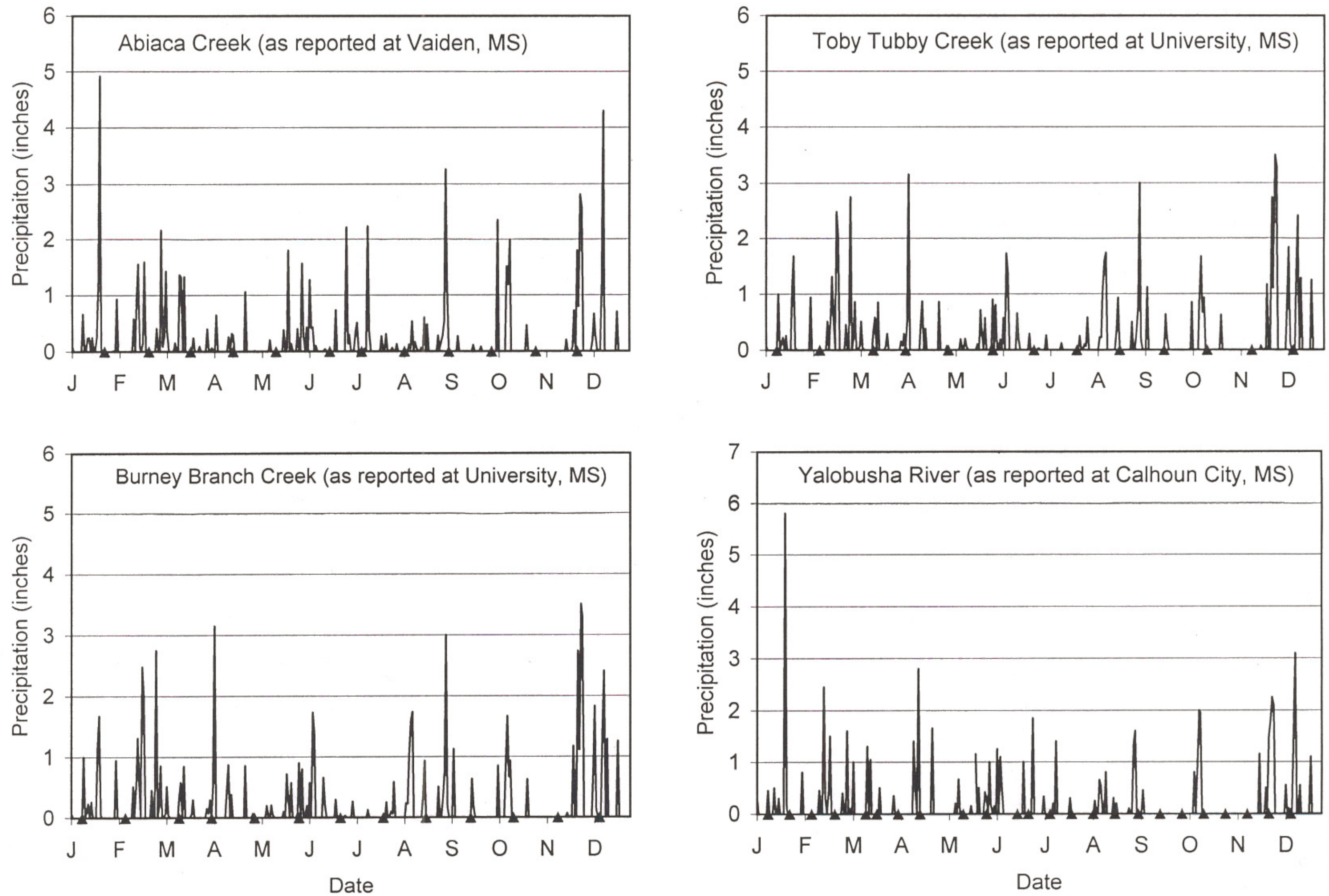


Fig. F. 2001 mean daily discharge or gauge height for Abiaca Creek, Toby Tubby Creek, Burney Branch Creek, and Yalobusha River. Data from USGS, Water Resources (USGS 2002).

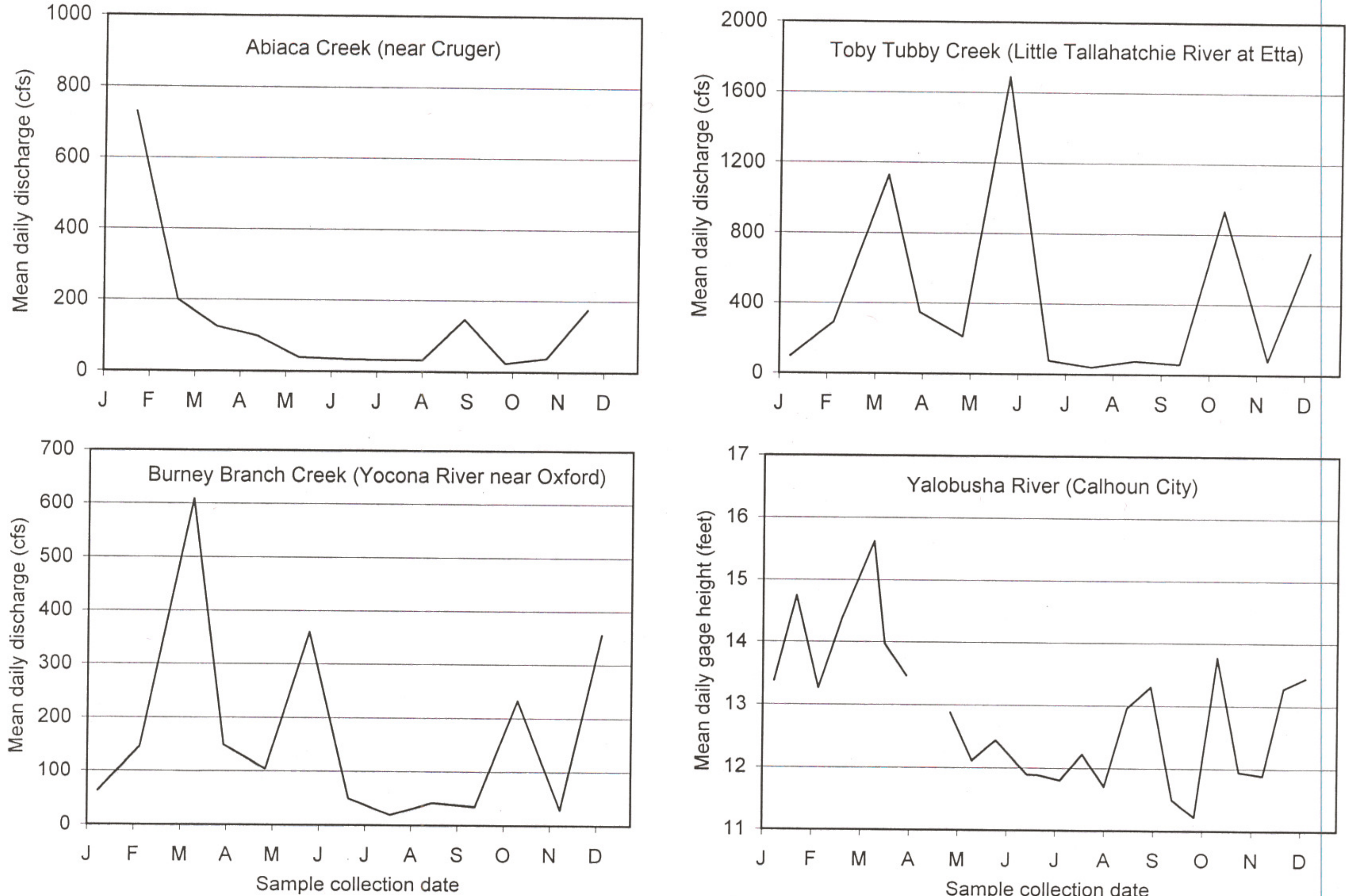


Fig. G. Box plots of 2001 pH, suspended solids, turbidity, and chlorophyll *a* measurements for DEC streams. Box = 25th-75th percentiles; whiskers = 10th-90th percentiles; points = 5th-95th percentiles; solid line = median value; broken line = mean value. Dotted line = water quality criteria value.

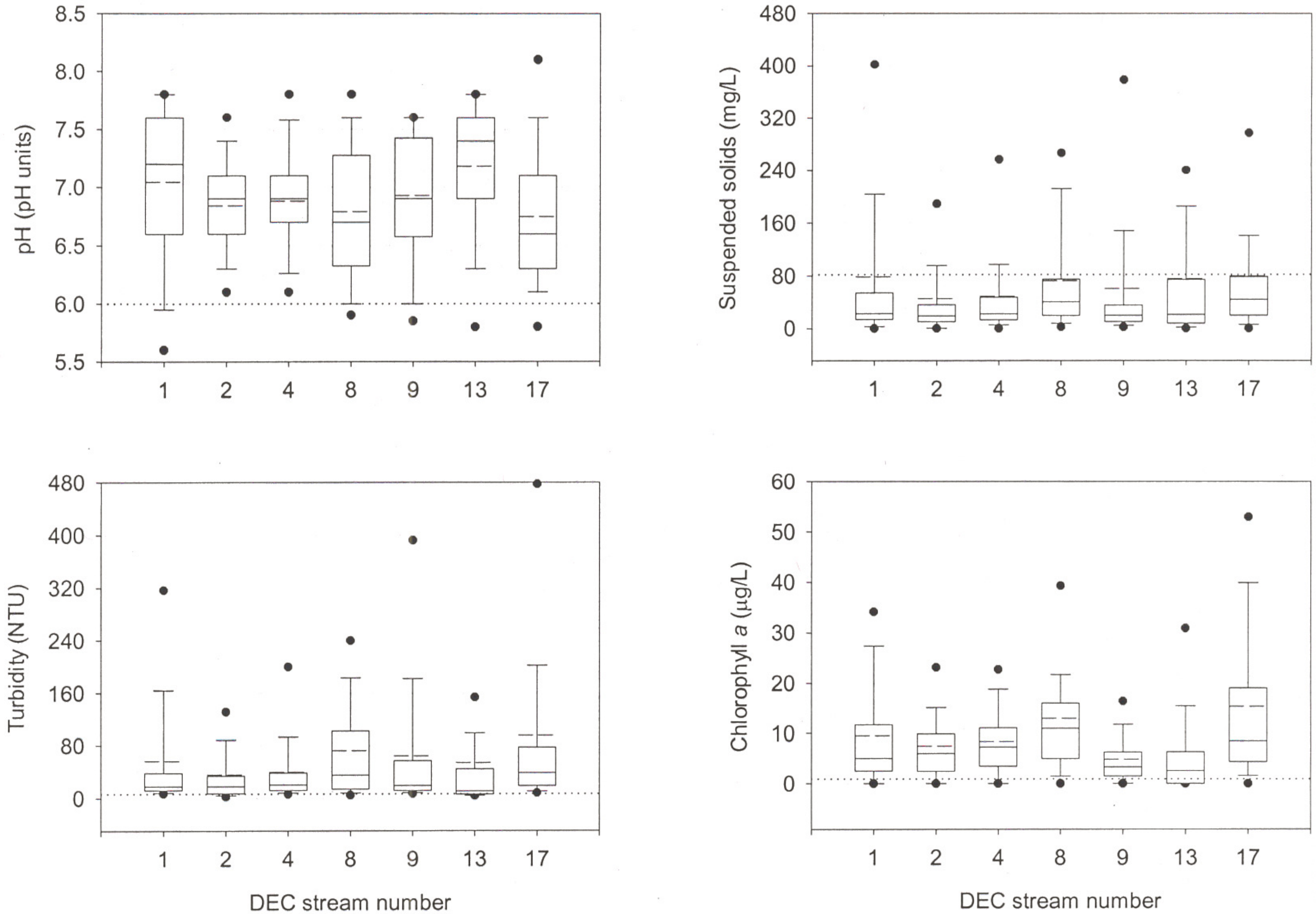


Fig. H. Box plots of 2001 total orthophosphate, total nitrogen, winter (January-April and November-December 2001) fecal coliform, and summer (May-October 2001) fecal coliform measurements for DEC streams. Box = 25th-75th percentiles; whiskers = 10th-90th percentiles; points = 5th-95th percentiles; solid line = median value; broken line = mean value. Dotted line = water quality criteria value.