A Chemical Water Quality Analysis of the Eightmile River, West Branch

Mary-Elizabeth L. Joaquin

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Central Connecticut State University
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Thesis Advisor
Dr. Clayton Penniman
Department of Biology

Abstract

Water quality is a function of the ecosystem within which the water body exists. Ensuring access to clean water has become a priority for many nations. The waters we rely on for drinking, cleaning, and recreation are affected by factors such as precipitation, erosion, and evaporation. Groundwater, surface water, and the biological members of surrounding ecosystems also affect water bodies.

This paper assesses selected chemical components of the West Branch of the Eightmile River. This branch of the Eightmile River is located in Lyme, East Haddam, Salem, Colchester, and East Lyme, Connecticut. The entire Eightmile River Watershed is currently being studied in an effort to obtain designation as a National Wild and Scenic River. In order to achieve this designation, the river must demonstrate at least one "Outstanding Resource Value" (ORV) as defined by the National Park Service (NPS).

Water quality previously determined by rapid bioassessment studies of macroinvertebrate species indicates that the West Branch of the Eightmile River would be designated as a Class A water body, providing one ORV for designation. In this study, dissolved oxygen, total suspended solids, turbidity, pH, temperature, reactive and total phosphorus, chloride, total inorganic nitrogen, and specific conductance were measured. These parameters for the West Branch of the Eightmile River were found to be consistent with a Class A water body as defined by the State of Connecticut Department of Environmental Protection and US Environmental Protection Agency water quality standards.

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Alicia Watson, Wetland enforcement Officer for the Town of Colchester deserves my gratitude for her enthusiasm and information about Lake Hayward, located in Colchester, Connecticut.

My parent's commitment, guidance and calming advice helped me carry through when frustration was dominating. The hours of time spent in the field gathering samples of biota and pictures with my children will remain a highlight of this project. Finally, but by no means insignificantly, my husband's willingness to adopt the title of "Thesis Widow" was tested and proven. His support and patience went above and beyond expectations helping to make this study possible.

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Introduction

Water quality and quantity are essential to maintaining the welfare of humans, flora and fauna on the earth. Water quality is one of the highest priority environmental issues today (US EPA 1995). Clean water is essential for uses such as drinking, recreation, irrigation, industry, transportation, commercial and recreational fishing, and wildlife habitat.

Eutrophication in many cases is a result of anthropogenic influences on waterbodies. Fertilizers, agricultural runoff, and sewage waste are some of the sources of nutrients to a water body. These nutrient additions can result in algal blooms, green water and may cause decline of the biota in a waterbody. This type of pollution limits the uses of waters for humans and other organisms. Other sources of pollution include urban runoff, deforestation, and construction. In an effort to save existing water sources, stop pollution, and remediate poor water sources, the US Environmental Protection Agency, state departments of environmental protection, and many other organizations have made and enforce rules, regulations, and standards to improve water quality nation-wide.

Designation as a Wild and Scenic River is a tribute to a watershed's excellent water quality in an area to be recognized and protected. The Wild and Scenic River Program, administered through the National Wild and Scenic Rivers System, was established by Congress in October 1968 under the Wild and Scenic Rivers Act (US National Park Service 2006). Designation will allow for federal guidance in order to maintain the existing environment, preserve the quality of life and property value, and maintain and potentially improve the current water quality and quantity.

The entire Eightmile River Watershed is currently being studied in an effort to obtain designation as a National Wild and Scenic River. In order to achieve this designation, the river must demonstrate at least one "Outstanding Resource Value" (ORV) as defined by the National Park Service (NPS). The Eightmile River has obtained six. These include the geology (Lewis 2005), water quality and quantity (Beauchene 2005), unique plant and animal species (Moorhead 2004), river ecosystem biodiversity, the cultural landscape, and archeology (University of Massachusetts 2004). It is also an intact, free-flowing river system containing large unfragmented forest regions (Beauchene 2005).

The Eightmile River Watershed is located primarily in Lyme, East Haddam, Salem, and some parts of Colchester and East Lyme, Connecticut. The purpose of this study was to acquire baseline water quality data for the West Branch of the Eightmile River. Preliminary investigations studying the macroinvertebrate communities (Beauchene 2005) indicated that this branch of the river could be classified as Class A water (Appendix A), showing potential for one ORV. In this study, dissolved oxygen, total suspended solids, turbidity, pH, temperature, reactive and total phosphorus, chloride, total inorganic nitrogen (nitrite, nitrate, and ammonia), and specific conductance were measured, to determine if the water quality complied with state and federal standards for classification as a Class A waterbody.

The importance of water quality in aquatic ecosystems has been well documented (Vannote *et al*. 1980, Mitsch and Gosselink 2000). The nutrient concentrations present in an ecosystem are reflected in water quality (Bormann and Likens 1979). The relationships between the hydrology and chemical cycles present in an aquatic system are extensive. The nutrients and energy that are available in an ecosystem are reflective of the topography, forestation, geology, and anthropogenic factors in the area. The concentrations of chemicals available are determined by accounting for all possible inputs into an ecosystem (Bormann and Likens 1979). The various pathways through which chemicals may enter a water system include precipitation, surface water flow, ground water flow, and overflow from the river itself; these influence the type and amount of physicochemical inputs into a water system (Bormann and Likens 1979).

A balance of energy within an ecosystem is reached when the amount of chemicals/nutrients flowing in equals the amount of energy flowing out (Clements 1936). In this same context, the water chemistry in the Eightmile River is reflective of its watershed. Many of the Eightmile River's Outstanding Resource Values are dependent upon the presence of outstanding water quality.

The River Continuum Concept (Vannote *et al*. 1980) explains that many characteristics, including the chemical cycles of each river, are reflective of all the smaller order streams, tributaries, surface and ground water flows within a given watershed feeding the largest order river. This is a classification system that relies upon "predictable and observable" features of streams (Vannote *et al*. 1980). The presence of organisms within a community and how these organisms function together is in part a reflection of stream flow, channel morphology, detritus loading, particulate organic matter size, and thermal response (Vannote *et al*. 1980).

Significance of Study

Many people in the towns surrounding the Eightmile River have become concerned over the growing development and population in the Eightmile River watershed. As urbanization grows the risk of forest fragmentation, habitat fragmentation, and nonpoint pollution also increases (Bormann and Likens 1979). As a result of this concern, a conservation team was organized consisting of members from each town, the Connecticut Department of Environmental Protection, Nature Conservancy, United States Department of Agriculture, National Park Service, and the Connecticut River Coastal Conservation District (Eightmile River Wild and Scenic Study 2005). The efforts of the Eightmile Conservation Team are directed towards obtaining Wild and Scenic River designation in order to provide federal funding and guidance for the towns to buy land and conserve natural and historical beauty (Eightmile River Wild and Scenic Study 2005). Recently each of the towns voted to support the conservation of this great resource (Irving 2006a, b, c).

The destructive role of nonpoint source pollution in fresh water has been well documented (Dodson 2005). Nonpoint sources of water pollution can be a major contributing factor to the downfall of water quality within urban areas (US EPA 2003a, b).

Water flow through a system correlates with the amount of nonpoint source pollution that enters the system and the speed at which the pollution leaves (US EPA 1995). The rate of flow in a waterbody is altered by the presence of dams (US EPA 1995). Dams change the natural flow of water and allow for pooling and settling of sediment. Dams also dry out areas below the structure by restricting flow and reducing wetlands. Directly upstream from the dam, flooded areas increase, resulting in riparian and terrestrial habitat destruction (US EPA 1995, Mitsch and Gosselink 2000). Previously constructed dams have been removed in the Eightmile watershed to allow for more natural water flow (Eightmile River Wild and Scenic Study 2005).

Currently parts of the West Branch and the East Branch of the Eightmile River are being affected by urban growth and increasing population. For the East Branch leachate from a landfill has reduced water quality (Beauchene 2005). On the West Branch potential development of a rock quarry, development of a golf course and urban growth are being monitored to ensure that they do not threaten the continued status of the Class A water (Beauchene 2005). All these activities could affect water quality by contributing to nonpoint source pollution in the watershed (US EPA 2003a, b, Beauchene 2005). While Class B is adequate to obtain Wild and Scenic River designation, efforts must be made to cease further pollution, and regain status as Class A. The surrounding estuaries and streams still maintain the Class A level (Beauchene 2005). While macroinvertebrate information for the Eightmile River has been collected to support the Wild and Scenic designation, it is also extremely important that in-depth water quality baseline information for specific areas be documented.

The Federal Water Pollution Control Act/Clean Water Act dictates the basic structure for regulating pollutants in the waters of the United States (US EPA 1977). Under Section 303 of the Clean Water Act, the State of Connecticut has developed statutory guidelines listed in the Connecticut General Statues § 22a-426 that regulate state water quality standards. These guidelines deal with classification of water bodies, allowable discharge types, numerical standards for classification, and maps of water bodies (CT DEP 2002).

Data for dissolved nutrients and other chemical constituents are used, in part, to assess aquatic environments for their ability to support survival and growth of the biota. The data collected in this study provides baseline water quality information to help detect potential nonpoint sources of pollution and to provide comparison values for detecting the effects of future development in this watershed.

General Morphology

The Eightmile River watershed is 99.78 km^2 in area (62 square miles), located within the boundaries of East Haddam, Colchester, Salem, and Lyme, Connecticut. This watershed contains over 257.44 km (160 miles) of river and streams (Beauchene 2005), varying in stream order from one through five (Connecticut River Coastal Conservation District 2004). In general, the topography of this area is very steeply sloped and the watershed consists of large areas of unfragmented forest (University of Massachusetts 2004).

The bedrock of the watershed is composed of metamorphic schist and gneiss (Rodgers 1985, Albeitz and Pokhrel 2004, CT DEP 2005a, b). The watershed contains twelve main types of bedrock (Rodgers 1985, CT DEP 2005a, b) (Appendix B). Outcrops in the area contain glacial till (Figure 1) overlying bedrock (Figure 2).

Figure 1. Glacial till

Ground water flow occurs mainly through fractures (Figure 3) in these areas.

Figure 2. Layering

Figure 3. Fracture flow

Soils within the watershed are the Fluvaquents-Udifluents Complex (Albeitz and Pokhrel 2004, CT DEP 2005a, b), predominantly Agawam fine sandy loam, Canton and Charlton, Hinkley and gravelly sandy loam, Ridgebury Leicester and Whitman extremely stony fine sandy loams, Merrimac sandy loam, and Narragansett silt loam (Baystate Environmental Consultants, Inc. 1991). Vegetation in the area is mostly deciduous forest with areas of coniferous cover (Albeitz and Pokhrel 2004).

The present study was concerned primarily with the West Branch of the river; which is located predominantly in East Haddam, Connecticut, and extends into a portion of Colchester and Lyme Connecticut (Figure 4). While the West Branch generally flows from north to south, the Eightmile River itself is an anomaly as it flows mostly in the eastern to western direction to merge with the Connecticut River (Woodworth 2003).

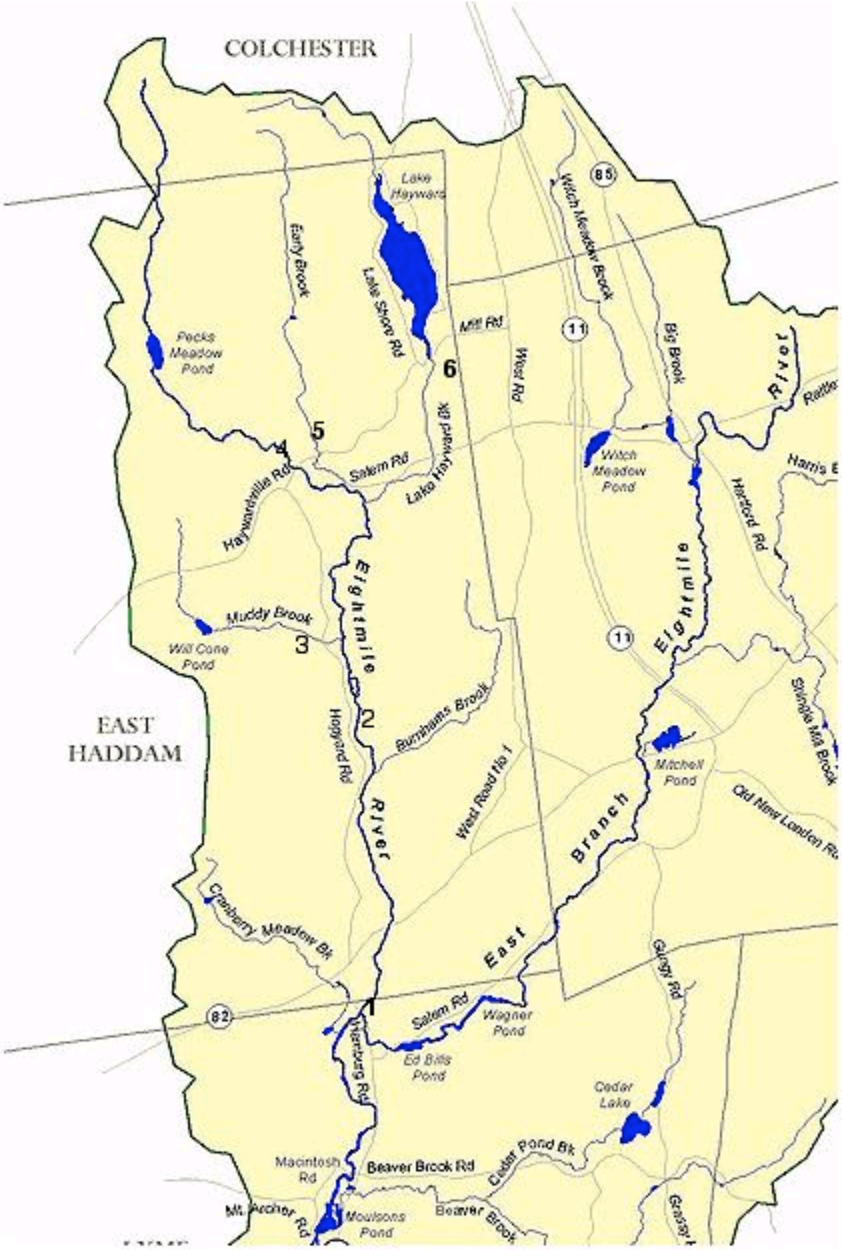

Figure 4. Collection sites 1 to 6 within the Eightmile River Watershed

The majority of the West Branch of the Eightmile River and its streams are located in areas considered “of Concern” by the CT Department of Environmental Protection (Connecticut River Watch Program 2004). These areas contain species that are on state and federal lists of endangered, threatened, and special concern and/or contain areas that are considered significant natural communities (CT DEP 2006). There are a total of 54 occurrences of rare plants within the Eightmile watershed, two of which are considered globally rare (Moorhead 2004).

Water quality of the West Branch is considered very high including B/A, B/AA, and A classes for all the tributaries (Albeitz and Pokhrel 2004, Beauchene 2005). For purposes of this study the West Branch of the Eightmile River is classified as a Class A waterbody (Beauchene 2005).

Site Morphology

Sites were chosen by considering their location within the watershed with respect to potential pollutant sources, targeting the main stem and significant tributaries, and to allow for access.

Site 1 - Eightmile River at Route 156 (Lyme)

Site 1 (Figure 5) is located on the West Branch of the Eightmile River at Route 156 in Lyme, Connecticut. This collection site is on the main stem of the Eightmile River. It is the closest collection site to the junction with the Connecticut River. This section of the river is classified as stream order five (CT River Coastal Conservation District 2004). Due to its high order, the River Continuum Concept indicates that primary production here will be primarily comprised of algae and rooted plants, community respiration occurs, and primary productivity could be limited by depth and turbidity (Vannote *et al.* 1980).

Figure 5. Site 1 collection location

A steeply eroded bank is present in this area from a slope which supports Route 156. This slope is supported primarily by the vegetation and the exposed root systems of many of the trees. The other riparian shoulder reflects a flatter floodplain area, littered with drift wood and detritus left from previous overflows. The entire width of the stream is shaded at the collection site; however, upstream and downstream much of the stream is open to direct sunlight.

The area is covered with smooth, fist-sized, round cobbles that are present upstream and downstream of the collection area. Upstream (Figure 6) is an area of greater depth and pooling where the flow slows considerably and settling occurs. Animal life such as beavers and an abundance of fish were observed here. While no mussels were observed in the river itself at this point, many shells were found along the banks of the river. The riparian area supports an abundance of vegetation as does the terrestrial landscape.

Further upstream is the Fox Hopyard Golf Course. This area is monitored for water quality by Hydro Dynamic Engineering, which utilizes a state certified laboratory to analyze water samples. Their findings indicated slightly elevated nitrogen compounds; although no phosphorus, pesticides or herbicides were found (Hydrodynamic Engineering, LLC 2005).

Downstream of the collection site is a concrete bridge constructed to support Route 156 over the Eightmile River (Figure 7). The stream bed under this bridge is composed of very fine sand sediment. It is remarkably barren of detritus and drift wood, very few animals were observed here.

Figure 6. View upstream at Site 1

Figure 7. View downstream from Site 1

Water at this site is clear with no sedimentation or color visible to the naked eye. It flows with little turbulence in the collection area. Just upstream, between the pooling area and the collection zone, a section of turbulent flow occurs.

Site 1 frequently had evidence of human activity. Litter was present as well as fishing lures and road trash. There was evidence of camp fires and frequently cars were observed parked in the vicinity.

Site 2 - West Branch of Eightmile River at Hopyard Road (East Haddam)

Site 2 is also classified a fifth-order stream (Figure 8) (CT River Coastal Conservation District 2004). This site varied in depth and width based on the collection date. It is also part of the West Branch of the Eightmile River and is located on Hopyard Road in East Haddam, Connecticut. The topography of this site is flatter than at Site 1, with a gentle slope up to Hopyard Road. Shading is present on the fringes of the river but a stretch of the center is open to sunlight year round. Many large boulders are present here with an abundance of detritus and drift wood. The stream sediments are darker in nature and seem to contain more silt than Site 1. The upstream (Figure 9) and downstream (Figure 10) conditions are similar to the collection site.

Figure 8. Site 2 collection location

Wildlife seemed more prevalent and diverse here. Many mussels, fish, macroinvertebrates, and vertebrates were observed. The vegetation also appeared more diverse, and seasonal, with many different types appearing in the riparian area in the summer when the stream width had decreased significantly.

The water at the Site 2 collection area is slightly turbulent due to the boulders. This creates pockets of still water. The water is clear and slightly tea colored.

Frequently, litter was strewn about the areas and a placement stone used to hold the measuring tape had been moved on two occasions. This particular spot is located at the boundary of Devil's Hopyard State Forest and has a parking area large enough for 1-2 cars, it is downstream from a camping area and Chapman Falls, a popular area for sightseeing.

Figure 9. Upstream view from Site 2

Figure 10. Downstream view from Site 2

Site 3 - Muddy Brook at Hopyard Road (East Haddam)

Site 3, Muddy Brook is classified as a second-order stream (Figure 11) (CT River Coastal Conservation District 2004), a headwater stream under the River Continuum Concept, representing the transitional stretch in the river system (Vannote *et al.* 1980). Muddy Brook intersects the Eightmile River upstream of Site 2. The water appears consistently clear, with no color. The area is thickly forested resulting in heavy shading of the stream. Turbulence is high in the collection area due to the steep slope of the stream and the creation of the stream bed from bedrock. This results in a steep drop off forming a “mini” waterfall which empties into a small, very shallow pool.

Figure 11. Site 3 collection site

Figure 12. Upstream view from Site 3

This stretch of stream cuts through steep terrain in a crevice between two hills (Figure 12). Flow rate in this area varied; however, the depth and width of the stream did not vary due to the nature of the terrain. Sedimentation is very low in the stream. The bottom consists of mostly large, smooth, flat bedrock with pockets of detritus and fine sand. The terrestrial zone is extremely steep on both sides and is forested (Figure 13). Actual riparian area exists only when the water level is very low during the summer. The areas just lining the stream had an abundance of sphagnum moss, which is also present on areas of rock peeking above the surface of the water.

Figure 13. Steep terrain sloping into Site 3

Will Cone Pond feeds Muddy Brook. During the months data were collected, a large house was being constructed on the pond bank. Paving activity on Mount

Parnassus Road and Hopyard Road began on July 30, 2005, application of oil and crushed stone completed the job on August 28, 2005.

Just downstream from the collection site is a stone bridge (Figure 14). Under the bridge is an abundance of fine sand with little to no detritus. White stalactites emerge from the spaces between the stones of the bridge. Just past the bridge, the pattern of steep, exposed bedrock and boulders, pocketed with pools of water, continues as the stream progresses downhill to the merge with the Eightmile River.

This area is open to trails that run through the State Forest. The trails run past it at the top of the hill and then open to Hopyard Road, crossing over and branching away from the stream. The location of the trail, combined with the very steep terrain, make it unlikely to be subjected to much direct human impact.

Figure 14. Stone bridge downstream of Site 3

Site 4 - Eightmile River West Branch at Haywardville Road (East Haddam)

Site 4 is classified as a third-order stream (Figure 15) (CT River Coastal Conservation District 2004), and is located in East Haddam. This stream runs through two culverts beneath Haywardville Road into a wetland that empties into the Eightmile River. The topography slopes steeply to the stream. Little to no riparian area exists between the water body and the terrestrial zone. The canopy completely covers the water body with plentiful underbrush in the collection area.

Figure 15. View at collection Site 4

Sediments on the bottom of the stream range from deep silt, to stones with much aquatic vegetation in the center of the stream. Detritus and sediment are abundant here. The water contains visible sediments and is tea colored. Flow proceeds with little to no turbulence. A diverse community of insects was observed at this site, along with fish and leeches.

Upstream there is a stone wall that was constructed to support a bridge for a road which is no longer in use. The function of this wall now is to hold back sediment which would otherwise impact the stream (Figure 16). Downstream both culverts pass under the road emptying into a wetland (Figure 17).

Figure 16. Bridge wall for road which is no longer in use near Site 4

Figure 17. Culverts downstream of Site 4

Human impact at this site is minimal. The vegetation and steep slopes are prohibitive to leisure activities. Haywardville Road is a fast area which is prohibitive to parking. Litter is frequently found in this water body as a result of litter thrown onto the road. Paving activity on Mount Parnassus Road and Hopyard Road began on July 30, 2005, application of oil and crushed stone completed the job on August 28, 2005.

Site 5 - Early Brook at Haywardville Road (East Haddam)

Site 5, Early Brook, is classified as a second-order stream (CT River Coastal Conservation District 2004) (Figure 18). It also crosses Haywardville Road in East Haddam (Figure 19). This collection site is similar to Site 4 in that it is covered heavily with canopy and underbrush vegetation. This stream proceeds under Haywardville Road through one culvert which empties into the same wetland as Site 4.

The wildlife seems abundant here also, with a wider variety of fish, but not as many insects. The riparian area is very steep and muddy. The stream bed has an abundance of rocks and larger stones that are covered with moss and underlying vegetation. On July 16, 2005, a large amount of decaying matter was observed at this site. Human activity is also limited here due to the same circumstances as at Site 4. The water is generally tea-colored and visible sedimentation is low. Flow generally proceeds with little to no turbulence. Paving activity on Mount Parnassus Road and Hopyard Road began on July 30, 2005, application of oil and crushed stone completed the job on August 28, 2005. On August 27, 2005, a greasy film was observed on the surface of this water.

Figure 18. View of collection Site 5

Figure 19. Culvert downstream of Site 5

Site 6 - Lake Hayward Brook at Mill Lane (East Haddam)

Site 6 is Lake Hayward Brook at Mill Lane Road in East Haddam (Figure 20). This stream is classified as a third-order stream (CT River Coastal Conservation District 2004) and is fed from Lake Hayward (Figure 21). The major recharge to this lake is by three permanent and a number of seasonal streams (Norvell and Frink 1975). These streams run through a wetland into the lake. The lake and the wetland are divided by Lake Hayward Road which allows connection through culverts but frequently floods over the road. The topography of this area is very steep and vegetated within a buffer zone; however, the area within the lake's watershed has been heavily developed (Figure 22).

Figure 20. View of collection Site 6

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Figure 21. Lake Hayward were it empties through culverts above Site 6

Figure 22. Topographic map showing Lake Hayward development

Due to this development and ensuing disputes, much research has been done on the Lake Hayward area (Eastern Connecticut Environmental Review Team 1988). The Lake Hayward area is classified by the National Wetlands Inventory as “palustrine forested broad leaf deciduous and seasonally saturated” (Norvell *et al*. 1979). Lake Hayward has been classified by the Connecticut Department of Environmental Protection as mesotrophic, with a maximum depth of 11.3 m (37 ft) and a minimum depth of 3.05 m (10 ft). Mesotrophic parameters were given as 15-25 ppb phosphorus, 300-500 ppb total nitrogen, with a visibility of 3.05-11.3 m (10-13 ft) (Norvell *et al*. 1979). The lake is classified as having Class A water (Norvell *et al*. 1979, Beauchene 2005). It was also predicted that the demonstrated increase in phosphorus levels would increase eutrophication resulting from erosion and development of the wetland (Norvell *et al*. 1979). Soils present in this area are classified as Inland Wetland Soils and are regulated under CT Public Act 155 (Eastern Connecticut Environmental Review Team 1988).

While the area is heavily populated, many restrictions have been put in place to minimize the effects of nonpoint source pollution. Currently, the area is monitored by Columbia Environmental Laboratory to enforce proper erosion and stability control. The monitoring includes tests for turbidity, nitrate and total phosphorus levels of a water course running into Lake Hayward west of Woodbine Road (Eastern Connecticut Environmental Review Team 1988). This testing is reflective of potential contaminants on the north side of Lake Hayward.

Figure 23. View downstream from Site 6

Figure 24. View upstream from Site 6

Materials and Methods

In the field, water samples were collected in 500 ml polypropylene wide-mouth bottles. Collections began at approximately at 7:00 AM on each date to minimize differences in in-stream conditions. Sampling began on 4 June, 2005, and continued with collections spaced approximately every two weeks, until the last collection date, 22 October, 2005. Samples were gathered first, while a preliminary observation of the each site was conducted for evidence of activity/inhabitants and changes in morphology. Any visible changes to the sites were noted and water samples were placed inside coolers on ice until arrival at the lab.

In-stream measurements were also taken for temperature, conductivity, and dissolved oxygen utilizing a YSI Model 85 meter. The YSI Model 85 meter was calibrated and checked bi-weekly. In-stream measurements were always taken in the following order: temperature, dissolved oxygen percent saturation, dissolved oxygen concentration in mg/l, conductivity, and specific conductance. Dissolved oxygen at all sites was measured as milligrams per liter and percent saturation (% saturation). Each parameter was measured in triplicate at different areas at each site. Further data collected included stream width in meters, depth in cm at each meter of width, and flow (m/s) utilizing a Marsh-McBirney Flow Mate Model 2000 portable flow meter. Flow measurements were taken at each meter mark across the stream. These measurements were used to calculate discharge (m^3/s) at each site for each collection date.

Water samples were taken back to the lab and reactive phosphate, pH, total suspended solids, chloride, nitrate and nitrite analyses were run the same day that the samples were collected. The remaining samples were refrigerated until the following day when total phosphate, ammonia, turbidity, and the final step in the total suspended solids analyses were conducted. All these analyses were conducted in triplicate from separate sample bottles.

Table A - Methods

Analysis	Reference
Nitrogen-Nitrate	Method 4500-NO_2^- (American Public Health Association *et al*. 1998)
Nitrogen-Nitrite	Hach Method 8192 (Hach 1995)
Nitrogen-Ammonia	(Strickland and Parsons 1972)
Reactive Phosphate	Method 4500-P E. Ascorbic Acid method (American Public Health Association *et al*. 1998)
Total Phosphate	Method 4500-P B. 5. Persulfate Digestion followed by Reactive Phosphate 4500-P E. Ascorbic Acid method (American Public Health Association *et al*. 1998)
Chloride	Method 4500-Cl^- B. Argentometric Method (American Public Health Association *et al.* 1998)
Turbidity	(Hach 1999)
Total suspended solids	Method 2540 D. Total suspended solids dried at 103-105˚ C (American Public Health Association *et al*. 1998)

Due to the fact that phosphate is present in dissolved form and is bound to organisms, and to sediment particles, two tests were done. The reactive phosphate test measures the amount of phosphate available in dissolved form and the total phosphate test uses a process of acid digestion to release organically bound forms of phosphate and phosphate adhering to sediment particles (Dodson 2005).

Reactive and total phosphate analyses included the preparation of 500 ml polypropylene wide-mouth sample bottles by acid washing with a 10-20% hydrochloric acid solution and rinsing three times with deionized water. All accompanying glassware utilized in the analyses, graduated cylinders, pipettes, and flasks were also acid washed in the same manner. For all other analyses, bottles were washed and rinsed with deionized water.

Whatman GFC filters for total suspended solids analyses were prepared at least twenty-four hours prior to sample collection. Filters were only handled with forceps. Three 100 ml rinses of deionized water were used to prepare each filter. Filters were then placed in pre-numbered aluminum pans. This process resulted in three replicates per site, a blank of deionized water, and a spare filter. Pans and filters were then placed in an enamel tray and loosely covered with aluminum foil; the pans were then placed in a drying oven at 103˚C for at least twenty-four hours, after which time they were allowed to cool in a desiccator for twenty minutes and then weighed individually.

For each total suspended solids analysis 500 ml of sample were filtered. The filter funnel was rinsed with approximately 20 ml of deionized water to ensure that residual particles from the sample made it onto the filter. The filters were then placed back into their individual aluminum pans, and the enamel tray was then loosely covered and placed back in the drying oven at 103˚C for at least twenty-four hours. After this time they were removed from the drying oven and placed into the desiccator again for twenty minutes until cool. The filters were weighed again to determine the amount of total suspended solids in the water.

A Beckman Model 45 pH meter was utilized for pH analyses. It was calibrated prior to readings and intermittently during the readings, utilizing Fisher pH 4.0 and 7.0 buffers. Readings were repeated in triplicate for each site.

Turbidity readings were taken using a Hach Model 2100 N turbidity meter. This meter was calibrated using the Hach StableCal formazin turbidity standards prior to the turbidity readings and throughout data readings (Hach 1999).

Results

Rainfall data from New London, CT (Earth Tech 2005), indicated a very dry time period from June through September when total monthly precipitation values were 4.62 cm, 5.41 cm, 3.35 cm, and 7.03 cm, respectively. October had significant rainfall, 39.14 cm, while November had 11.66 cm. Data were collected on three rainfall events, June 18th, July 2nd, and October 8th (Figures C1 through C3).

Discharge data between sites indicated peaks associated with rainfall events, and a general decrease in discharge rates from July through September as precipitation decreased and the temperature increased (Figure C10 through C15).

Discharge within each site fluctuated with seasons and precipitation. Site 1 discharge ranged from 0.00 to 0.81 m^3/s, averaging 0.17 m^3/s (Figures 25 and D4 through D6). In-stream data for Site 1 for collections on July 2 and July 16, 2005, were misplaced and thus do not appear in the graphs.

Site 2 discharge ranged from 0.00 to 0.51 m^3/s, averaging 0.16 m^3/s (Figures 25 and D4). Site 3 discharge ranged from 0.00 to 0.02 m^3/s, averaging 0.01 m^3/s. Site 4 discharge rate ranged from 0.20 m^3/s to undetectable, averaging 0.03 m^3/s. Site 5 discharge ranged from 0.08 m^3/s to undetectable, averaging 0.01 m^3/s. Site 6 discharge ranged from 0.21 m^3/s to undetectable, averaging 0.04 m^3/s.

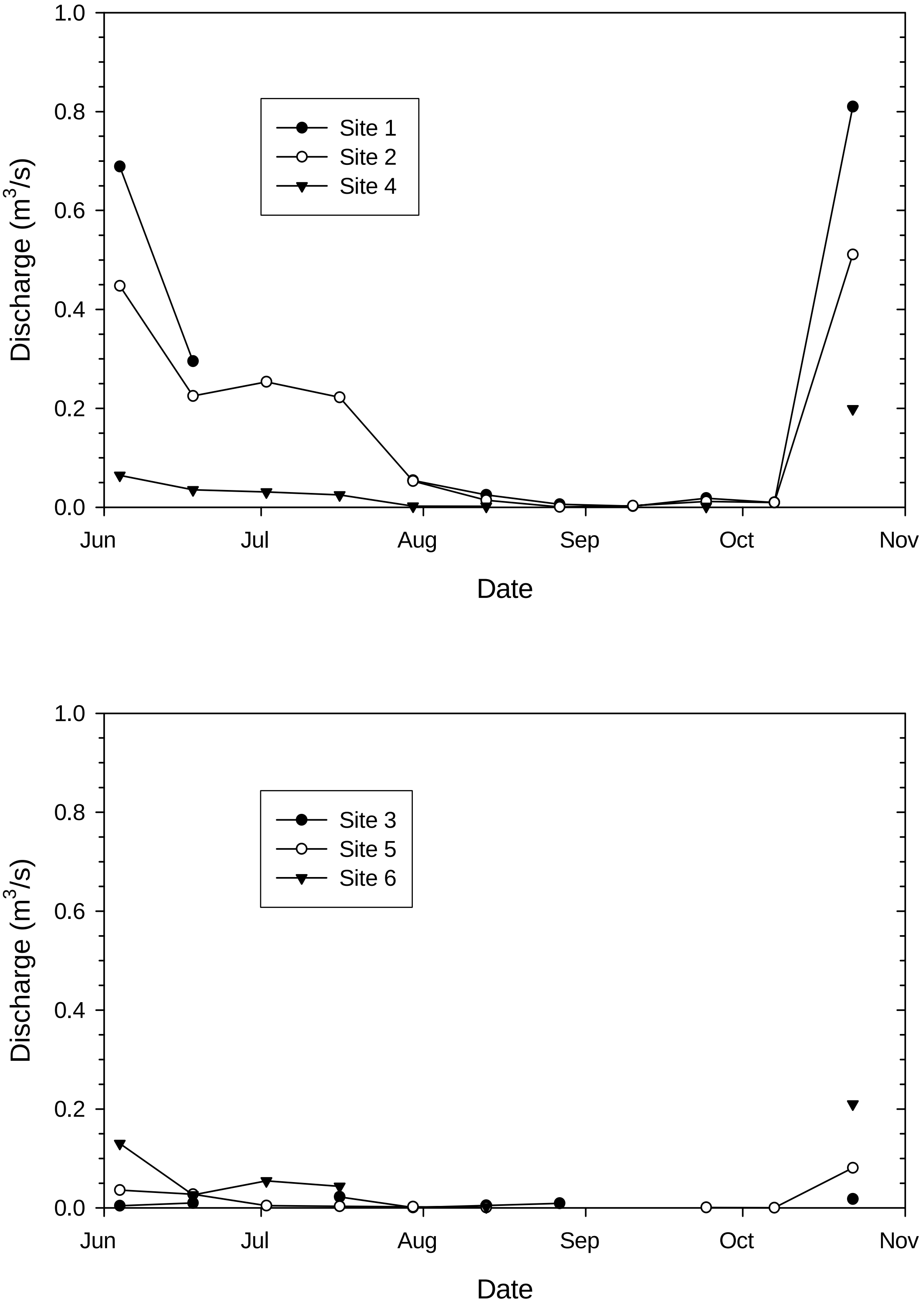


Figure 25. Discharge (m^3/s, mean $\pm$ 1 SE) at Sites 1, 2, and 4, located on the West Branch mainstem of the Eightmile River, and Sites 3, 5, and 6, which are tributaries of the West Branch of the Eightmile River, for all collection dates during 2005.

The temperature among the sites was generally the same with Site 6 higher at times (Figures C16 through C21 and D7 through D9). Figures 26 and 27 also show that Sites 1, 2, and 4 grouped together as these represent the mainstem of the Eightmile River, and Sites 3, 5, and 6 grouped together as these are tributaries feeding the Eightmile River at various points along the West Branch.

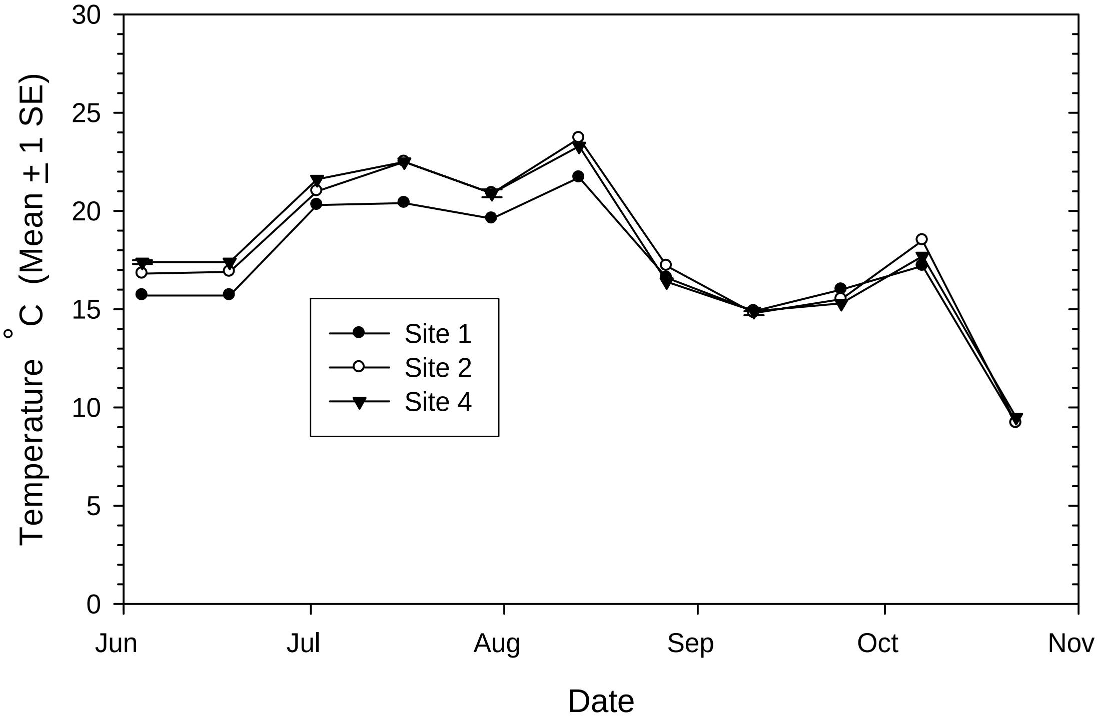


Figure 26. Temperature (˚C, mean ± 1 SE) at Sites 1, 2, and 4, the West Branch mainstem of the Eightmile River, for all collection dates during 2005.

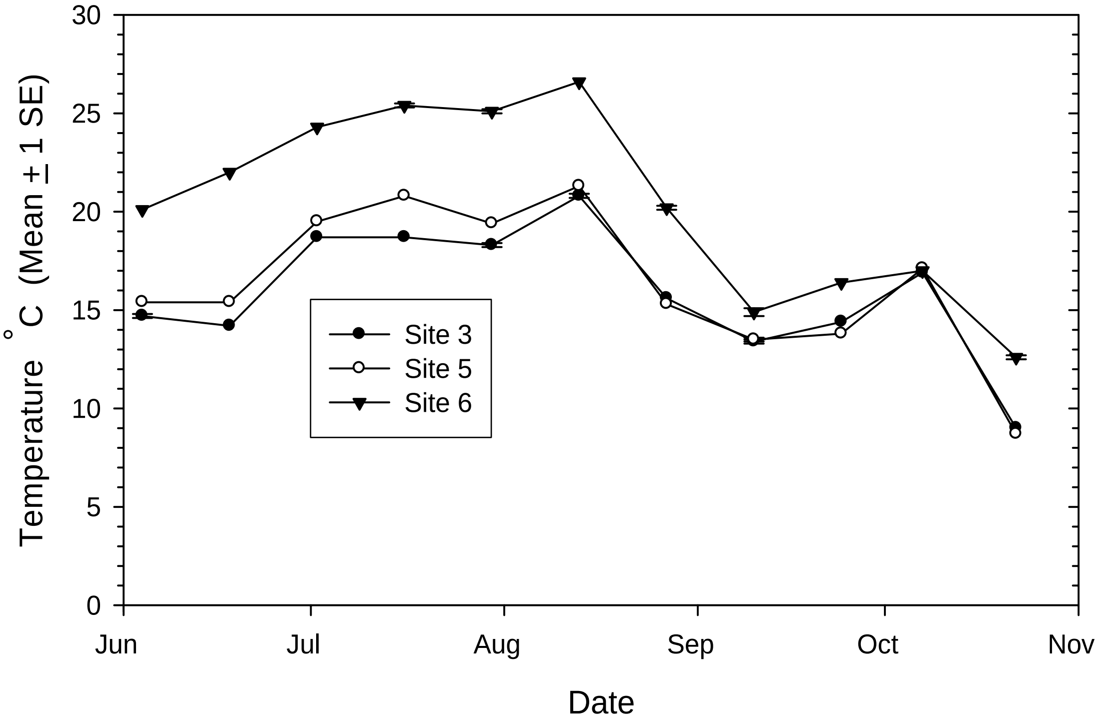


Figure 27. Temperature (˚C, mean + 1 SE) at Sites 3, 5, and 6, tributaries of the West Branch of the Eightmile River, for all collection dates during 2005.

The dissolved oxygen percent saturation also demonstrates a similar pattern among sites (Figures C28 through C33 and D13 through D15). While each site taken individually shows some variance; in general, the dissolved oxygen saturation present is reflective of the temperature of the water, dropping when the waters are at their warmest (Figures 27 and 28).

Dissolved oxygen (mg/l) at Site 1 ranged from 6.00 to 8.92 mg/l, and remained generally above 60% saturation (Figure D10). Site 2 ranged from 6.85 to 9.59 mg/l, and percent saturation was generally above 70% (Figure D10). Site 3 ranged from 7.54 to 10.13 mg/l; percent saturation varied from 74% to 100% (Figure D11). Site 4 ranged from 4.55 to 8.48 mg/l; percent saturation varied from 54% to 89% (Figure D11). Site 5 ranged from 5.93 to 9.88 mg/l, with percent saturation ranging from 67% to 100%

(Figure D12). Site 6 ranged from 5.30 to 8.73 mg/l, and percent saturation ranged from 56% to 96% (Figure D12). All sites showed a sharp decrease in dissolved oxygen on September 10, 2005 (Figures 28 through 30 and C22 through C33). This date represents the lowest data for dissolved oxygen in percent saturation and mg/l.

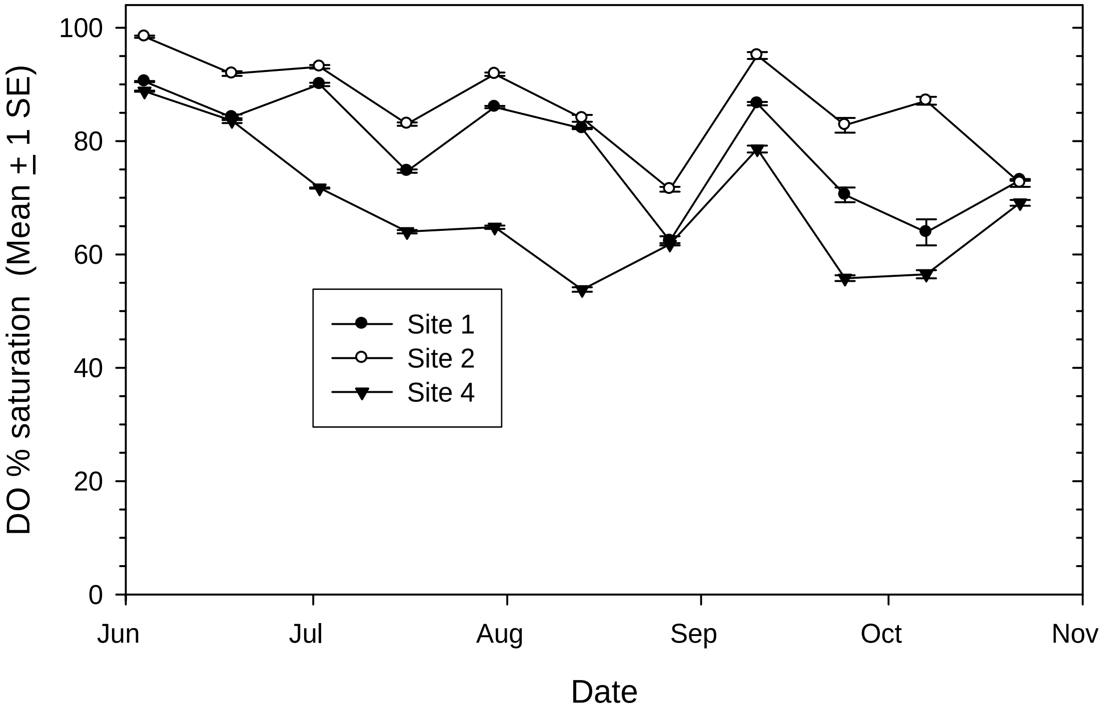


Figure 28. Dissolved oxygen (% saturation, mean + 1 SE) at Sites 1, 2, and 4, the West Branch mainstem of the Eightmile River, for all collection dates during 2005.

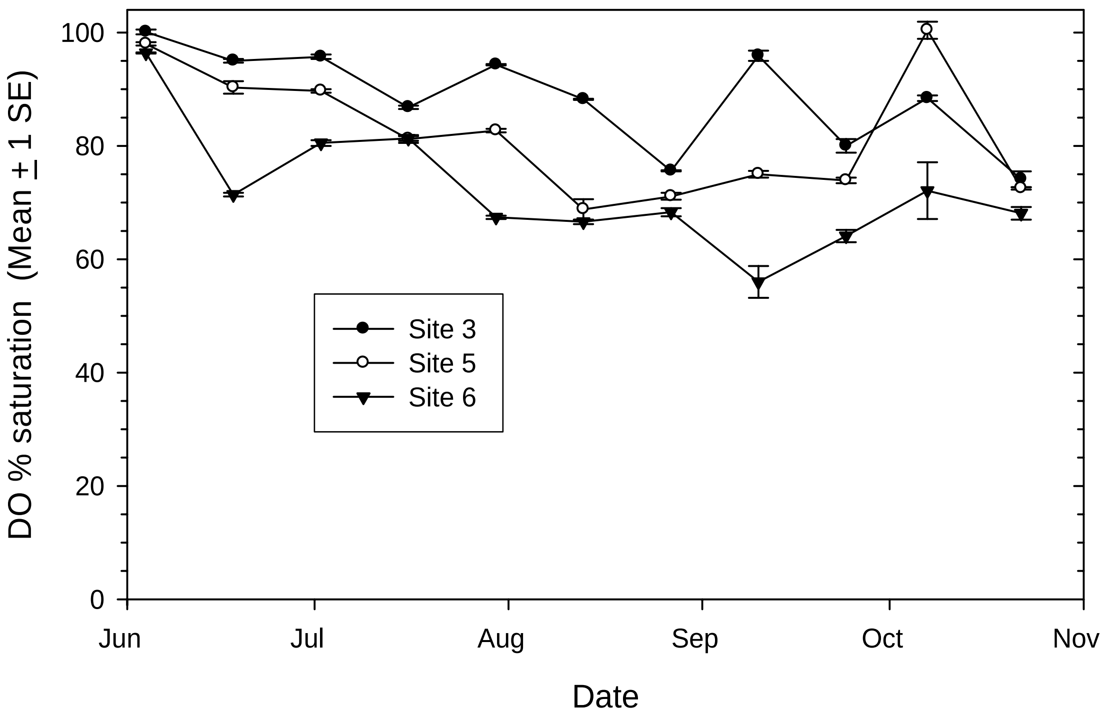
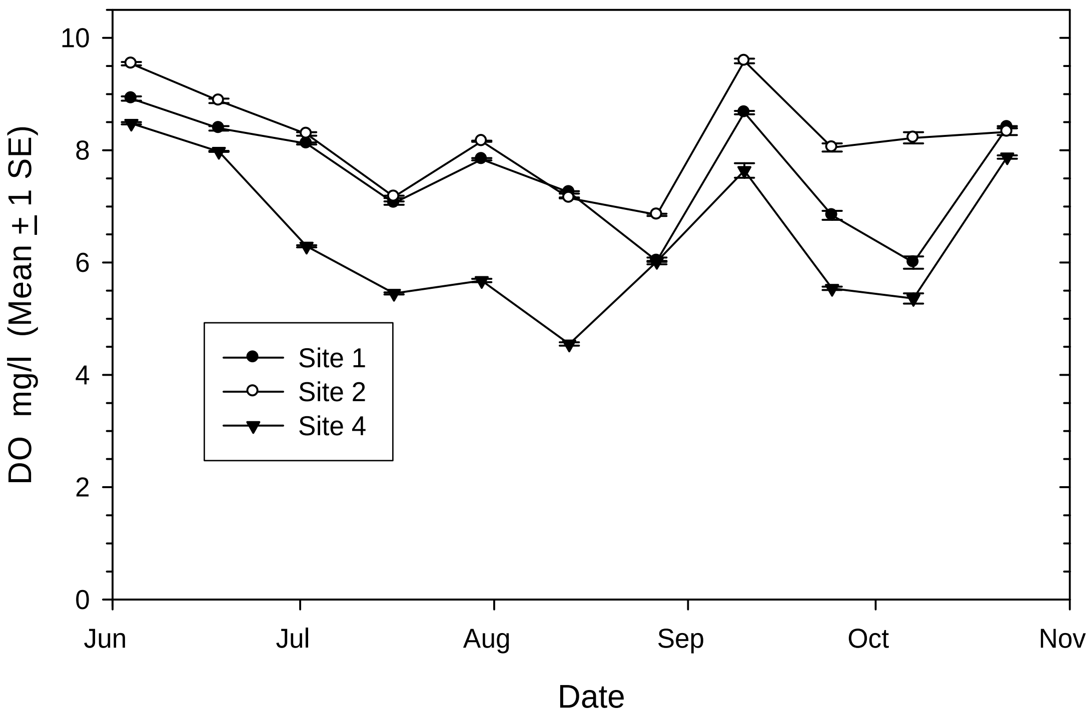


Figure 29. Dissolved oxygen (% saturation, mean + 1 SE) at Sites 3, 5, and 6, tributaries of the West Branch of the Eightmile River, for all collection dates during 2005.

Turbidity data shows a great range between sites (Figures 30 and 31, C52 through C57, and D25 through D27). Individually, Site 1 ranged from 0.42 to 1.21 NTU, averaging 0.81 NTU from June through October (Figure D25). Site 2 ranged from 0.69 to 3.00 NTU, averaging 1.41 NTU (Figure D25). Site 3 ranged from 0.18 to 3.29 NTU, averaging 0.67 NTU (Figure D26). Site 4 ranged from 0.39 to 2.62 NTU, averaging 1.13 NTU (Figure D26). Site 5 ranged from 0.31 to 1.31 NTU, averaging 0.79 NTU (Figure D27). Site 6 ranged from 0.39 to 3.27 NTU, averaging 1.49 NTU (Figure D27).



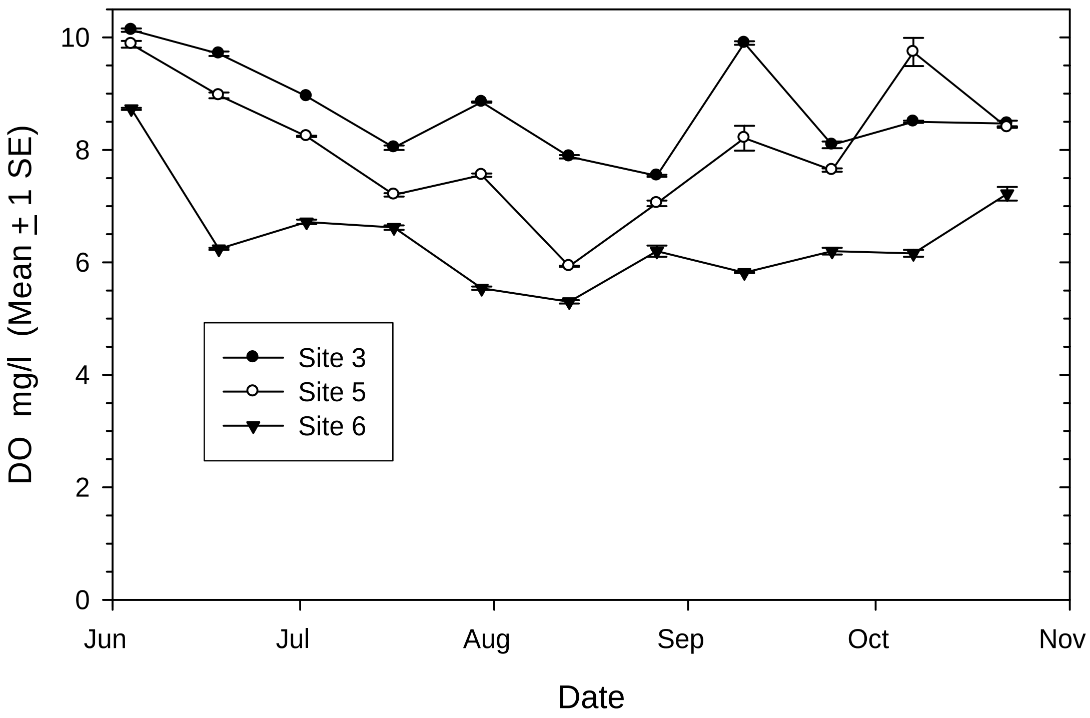
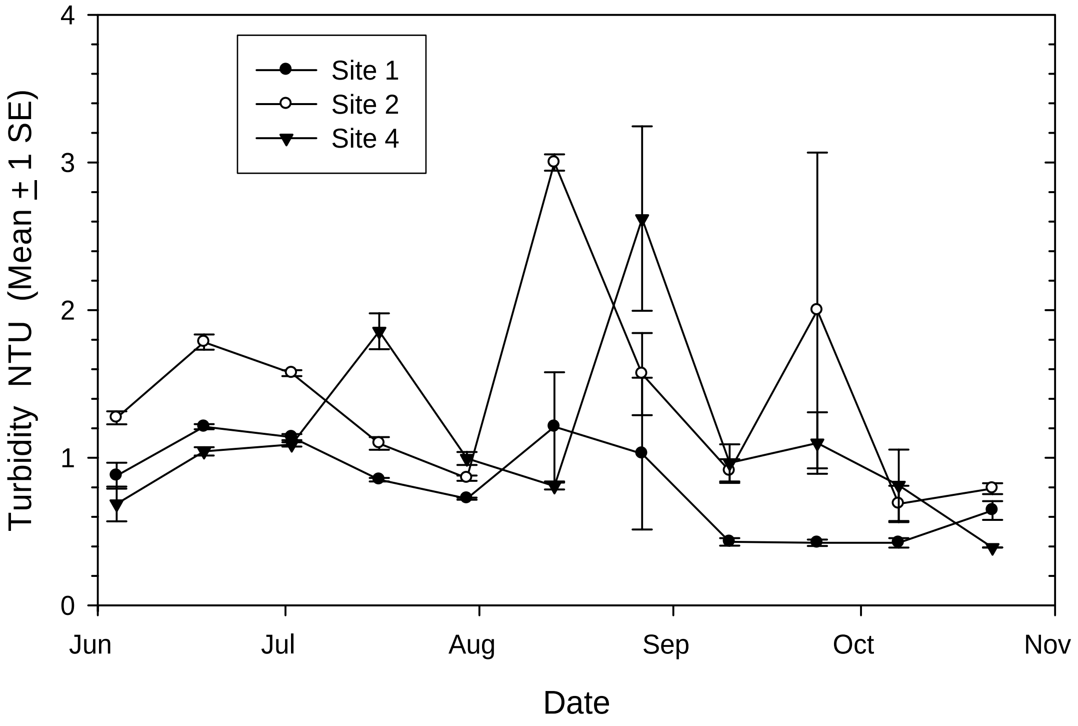


Figure 30. Dissolved oxygen (mg/l, mean ± 1 SE) at Sites 1, 2, and 4, located on the West Branch mainstem of the Eightmile River, and Sites 3, 5, and 6, which are tributaries of the West Branch of the Eightmile River, for all collection dates during 2005.



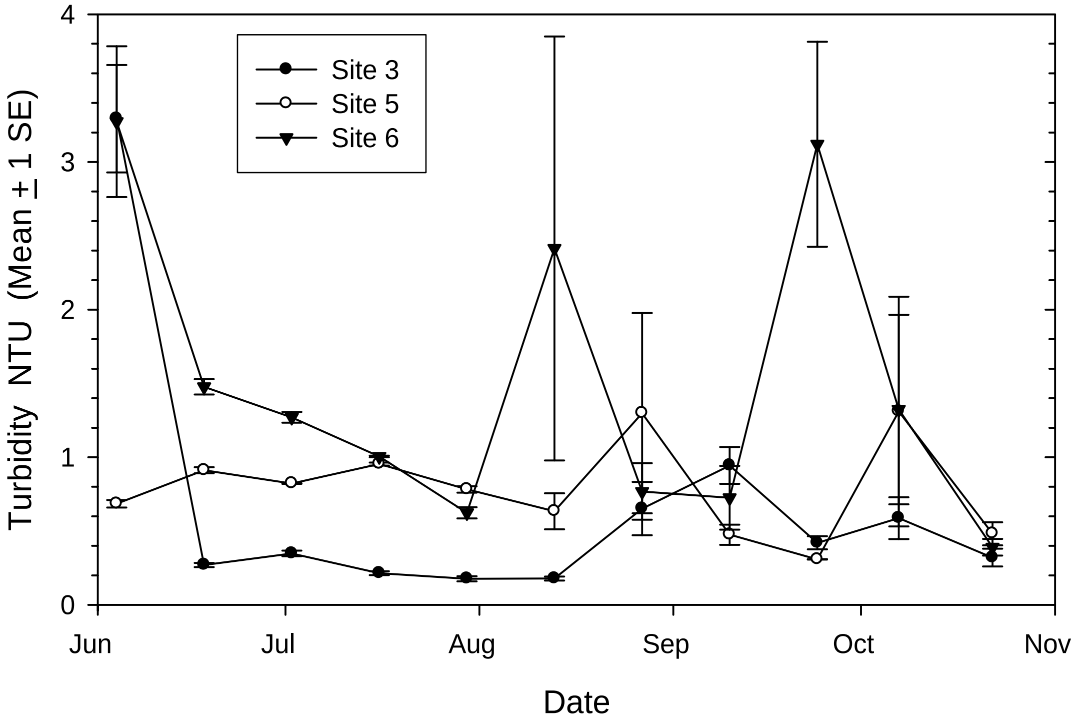
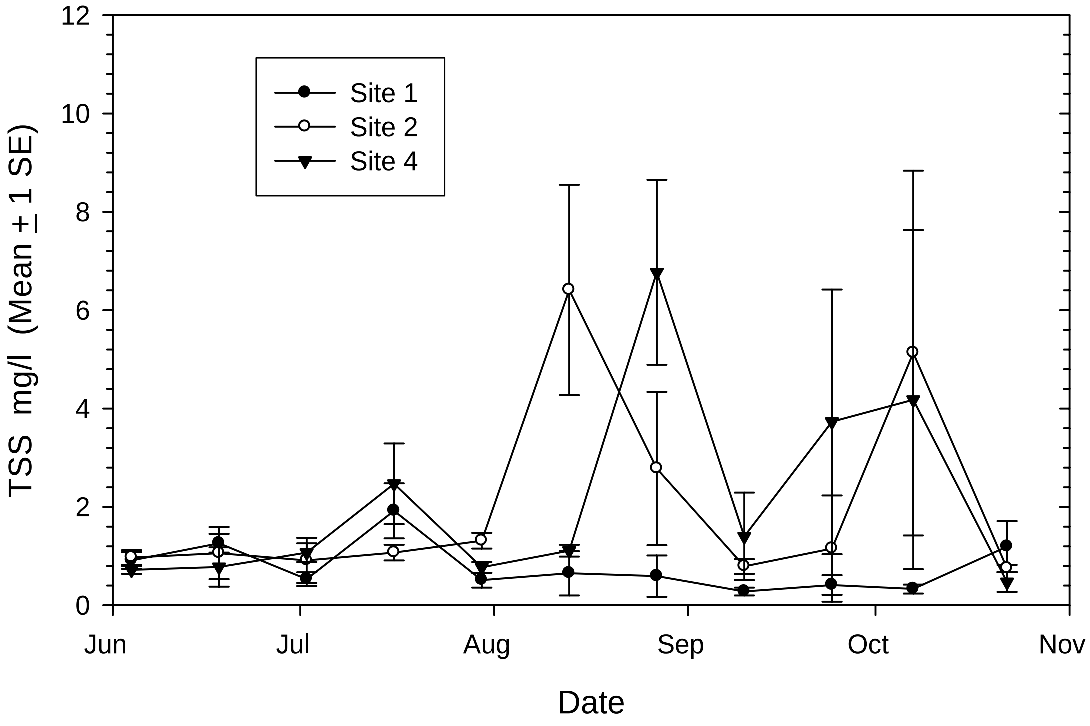


Figure 31. Turbidity (NTU, mean ± 1 SE) at Sites 1, 2, and 4, located on the West Branch mainstem of the Eightmile River, and Sites 3, 5, and 6, which are tributaries of the West Branch of the Eightmile River, for all collection dates during 2005.



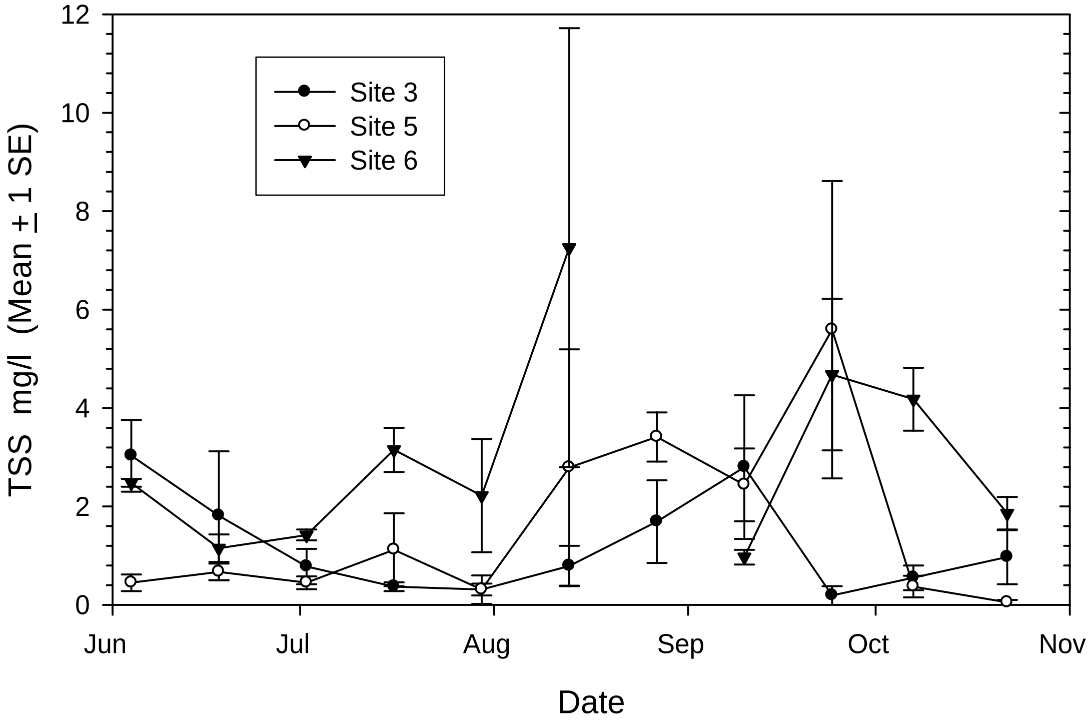


Figure 32. Total suspended solids (mg/l, mean ± 1 SE) at Sites 1, 2, and 4, located on the West Branch mainstem of the Eightmile River, and Sites 3, 5, and 6, which are tributaries of the West Branch of the Eightmile River, for all collections during 2005.

Total suspended solids sites for Site 1 ranged from 0.28 to 1.92 mg/l, averaging 0.78 mg/l (Figure D22). Site 2 ranged from 0.75 to 6.41 mg/l, averaging 2.03 mg/l (Figure D22). Site 3 ranged from 0.19 to 3.03 mg/l, averaging 1.21 mg/l (Figure D23). Site 4 ranged from 0.47 to 6.77 mg/l, averaging 2.13 mg/l (Figure D23). Site 5 ranged from 0.05 to 5.59 mg/l, averaging 1.60 mg/l (Figure D24). Site 6 ranged from 0.97 to 7.26 mg/l, averaging 2.94 mg/l and demonstrated higher peaks in August and October (Figures 32, C46 through C51, and D22 through D24).

Conductivity readings show a gradual increase from June through October for all sites (Figures 33 and 34, C34 through C45, and D16 through D21). Site 1 specific conductance ranged from 38.9 to 89.2 µs/cm, conductance ranged from 35.3 to 74.2 µs (Figures D16 and D19). Site 2 specific conductance ranged from 35.7 to 89.0 µs/cm, conductance ranged from 29.0 to 72.9 µs (Figures D16 and D19). Site 3 specific conductance ranged from 22.6 to 63.9 µs/cm, conductance ranged from 17.6 to 50.8 µs (Figures D17 and D20). Site 4 specific conductance ranged from 17.8 to 51.6 µs/cm, conductance ranged from 14.3 to 41.1 µs (Figures D17 and D20). Site 5 specific conductance ranged from 41.2 to 104.3 µs/cm, conductance ranged from 36.8 to 82.0 µs (Figures D18 and D 21). Site 6 specific conductance ranged from 35.4 to 163.6 µs/cm, conductance ranged from 35.9 to 132.2 µs (Figures D18 and D21).

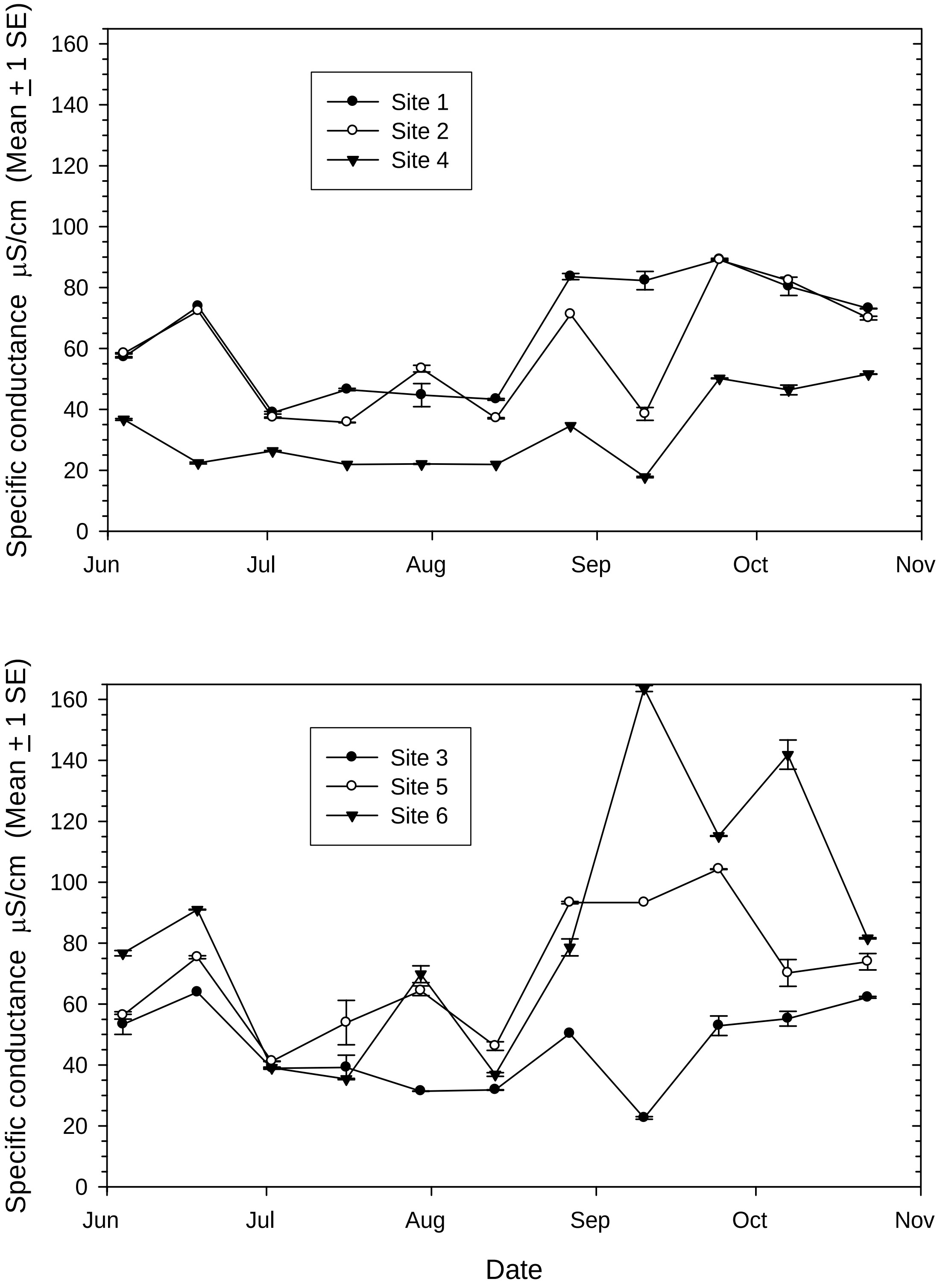


Figure 33. Specific conductance (µS/cm, mean ± 1 SE) at Sites 1, 2, and 4, the West Branch mainstem of the Eightmile River, and Sites 3, 5, and 6, tributaries of the West Branch of the Eightmile River, for all collection dates during 2005.

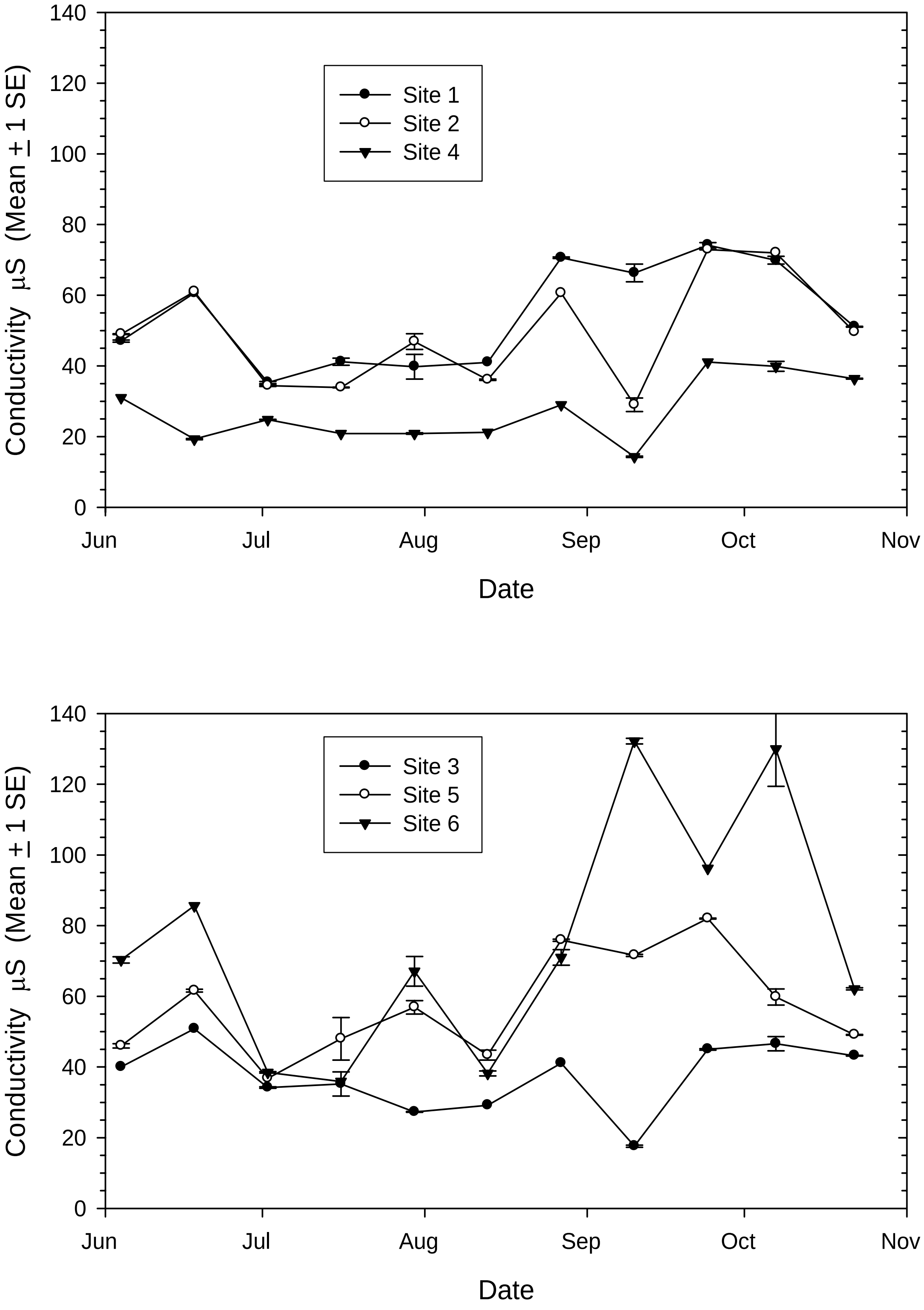


Figure 34. Conductivity (µS, mean + 1 SE) at Sites 1, 2, and 4, the West Branch mainstem of the Eightmile River, and Sites 3, 5, and 6, tributaries of the West Branch of the Eightmile River, for all collection dates during 2005.

pH at Site 1 ranged from 6.51 to 6.85, Site 2 ranged from 6.79 to 6.98 (Figures 35 and 36, E1 through E6, and F1 though F3), Site 3 ranged from 6.79 to 7.07, Site 4 ranged from 5.74 to 6.79, Site 5 ranged from 6.44 to 6.78, and Site 6 ranged from 5.78 to 6.84.

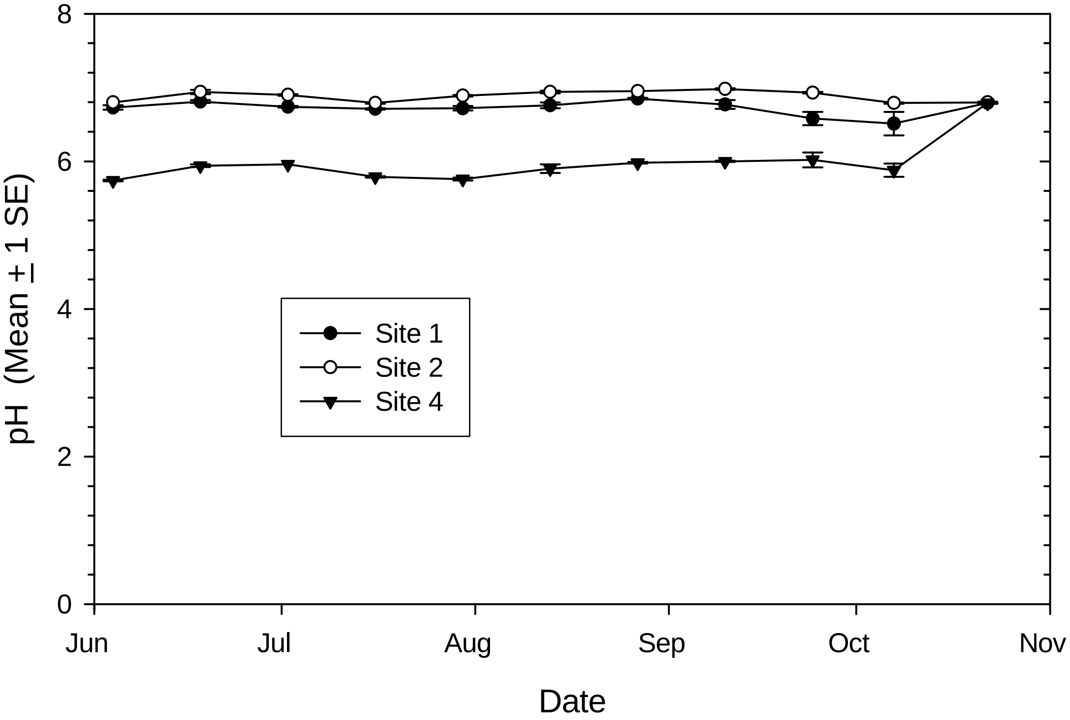


Figure 35. pH at Sites 1, 2, and 4, the West Branch mainstem of the Eightmile River, for all collection dates during 2005.

Comparison of chloride between sites revealed lower levels in June with a slight peak in July and August; in September, values dropped for all sites (Figures 37, E7 through E12, and F4 through F6). October produced variable results with Site 6 demonstrating a large peak on October 7, 2005 (Figure E11), and Sites 1, 2, and 3 dropping (Figures F4 and F5), and Sites 4 and 5 peaked slightly on the same date (Figures F5 and F6).

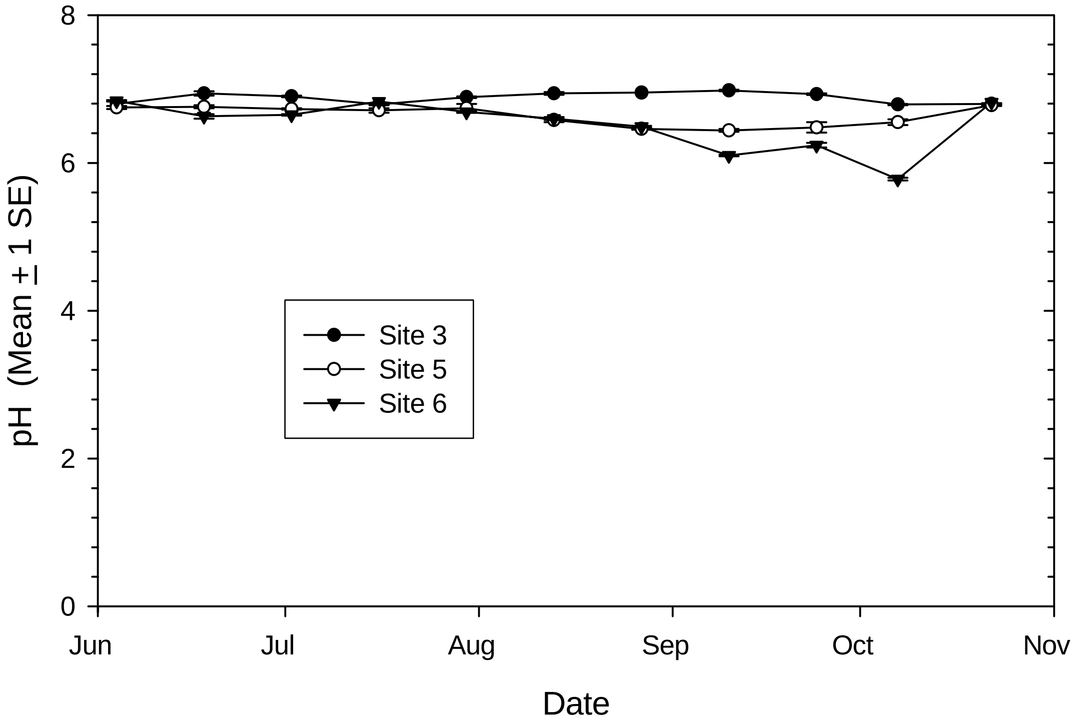


Figure 36. pH at Sites 3, 5, and 6, tributaries of the West Branch of the Eightmile River, for all collection dates during 2005.

Chloride levels at Site 1 ranged from 10.3 to 16.4 mg/l (Figure F4). Site 2 ranged from 9.0 to 22.1 mg/l (Figure F4). Site 3 ranged from 6.4 to 15.4 mg/l (Figure F5). Site 4 ranged from 4.3 to 13.8 mg/l (Figure F5). Site 5 ranged from 11.5 to 23.6 mg/l (Figure F6). Site 6 ranged from 15.3 to 43.3 mg/l (Figure F6).

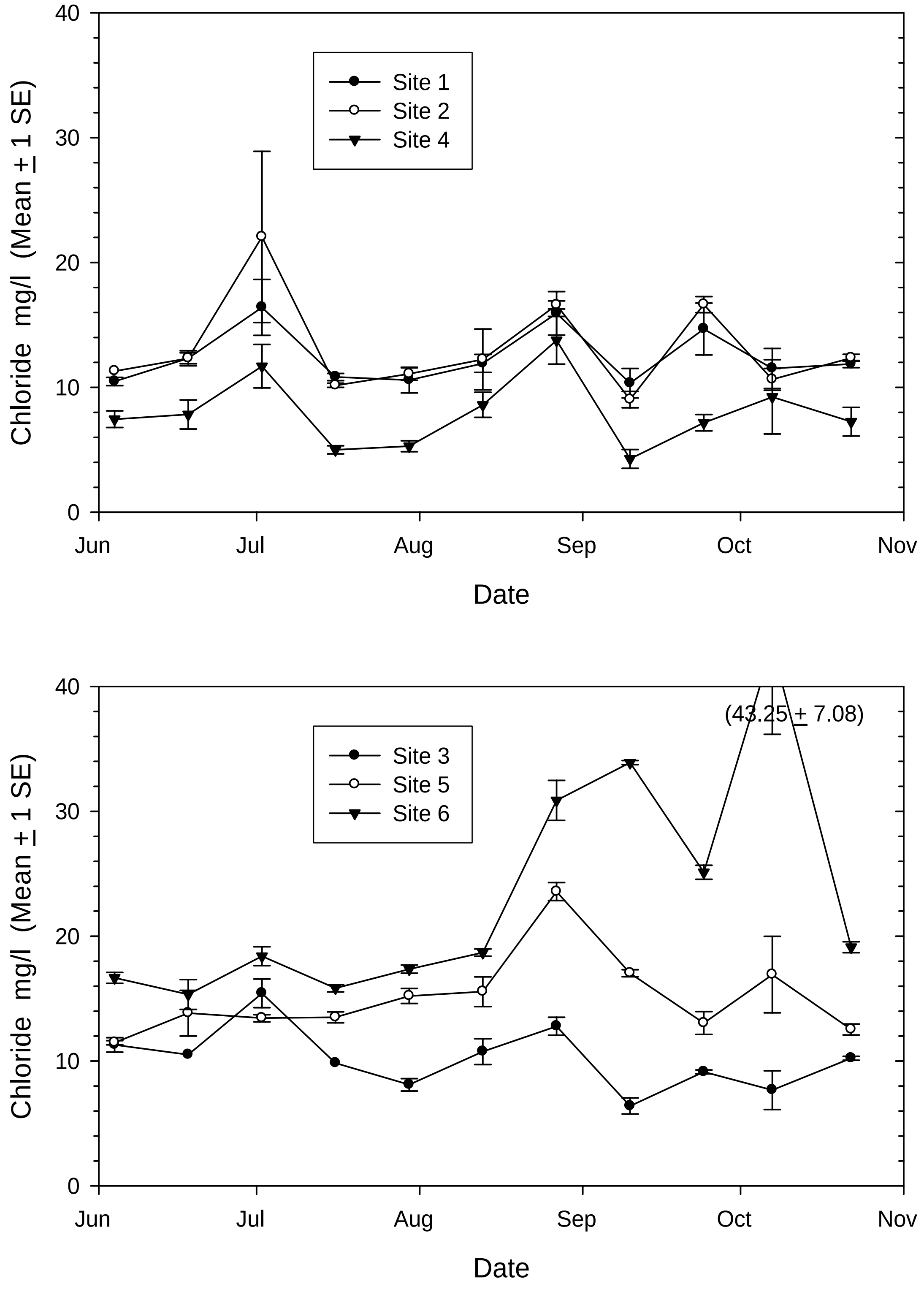


Figure 37. Chloride (mg/l, mean ± 1 SE) at Sites 1, 2, and 4, the West Branch mainstem of the Eightmile River and Sites 3, 5, and 6, tributaries of the West Branch of the Eightmile River, for all collection dates during 2005.

Reactive phosphate within all the sites varied (Figures 38 and 39, E13 through E18, and F7 through F9). Site 1 ranged from 0.0 to 8.0 µg/l, averaging 0.9 µg/l (Figure F7). Site 2 ranged from 0.0 to 1.3 µg/l, averaging 0.2 µg/l (Figure F7). Site 3 ranged from 0.0 to 2.9 µg/l, averaging 0.6 µg/l (Figure F8). Site 4 ranged from 0.0 to 7.7 µg/l, averaging 2.4 µg/l (Figure F8). Site 5 ranged from 0.0 to 8.3 µg/l, averaging 1.5 µg/l (Figure F9). Site 6 ranged from 0.0 to 16.9 µg/l, averaging 2.4 µg/l (Figure F9).

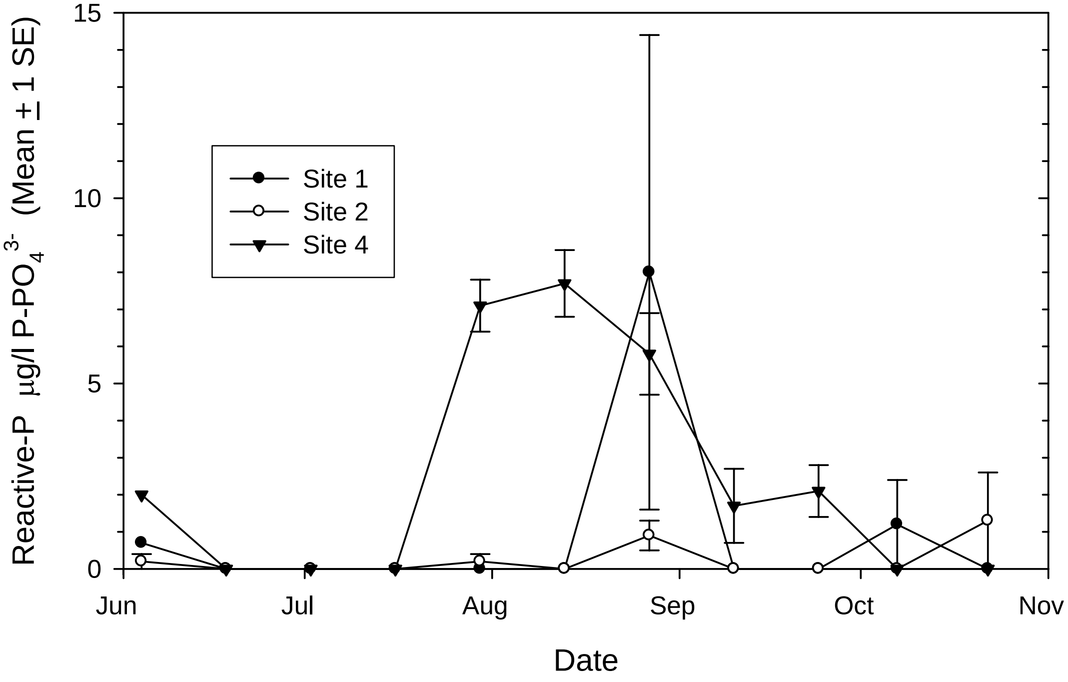


Figure 38. Reactive phosphate (P-PO_4^{3-} µg/l, mean + 1 SE) at Site 1, 2, and 4, the West Branch mainstem of the Eightmile River, for all collection dates during 2005.

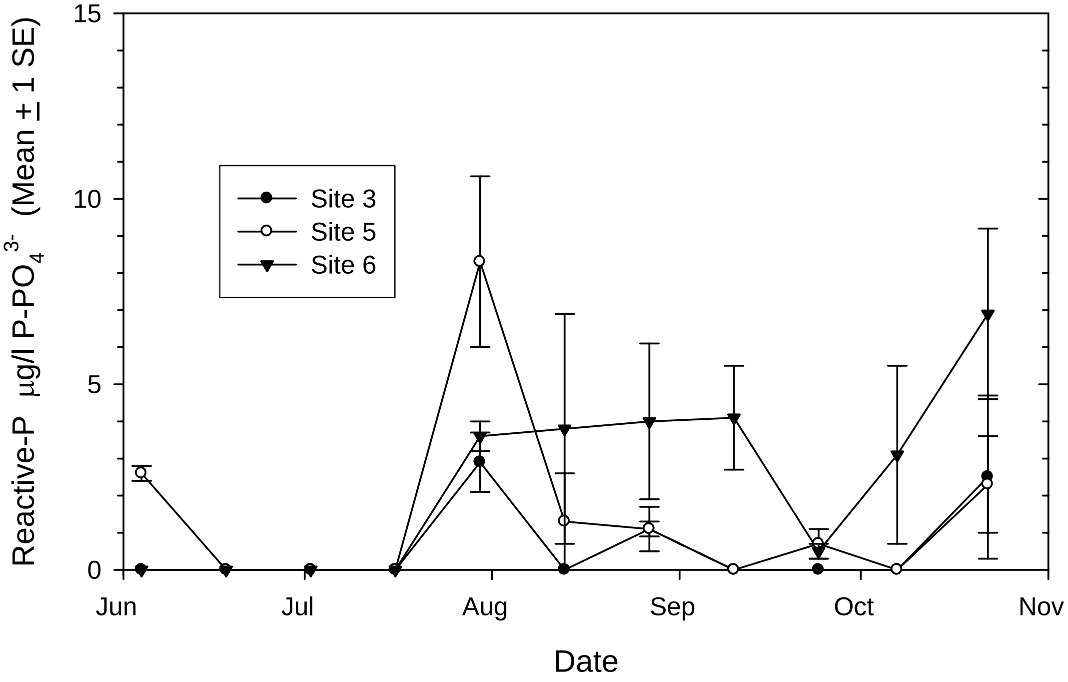
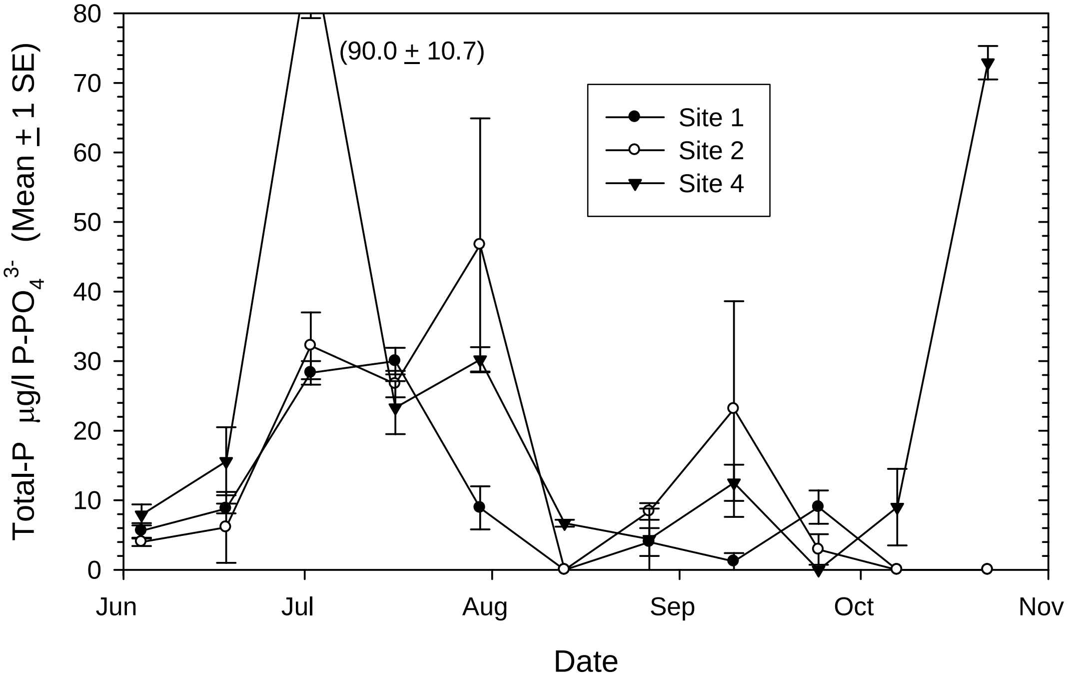


Figure 39. Reactive phosphate (P-PO_4^{3-} µg/l, mean ± 1 SE) at Sites 3, 5, and 6, tributaries of the West Branch of the Eightmile River, for all collection dates during 2005.

Total phosphate increased in association with rainfall events, which occurred on June 18, July 2, and October 8 (Figures 40, C1 through C3, E19, E20, and E24). The increase in total phosphate is detectable on the following collection date October 22 (Figure 40). Site 1 ranged from 0.0 to 30.0 µg/l, averaging 8.7 for the testing period (Figure F10). Site 2 ranged from 0.0 to 46.7 µg/l, averaging 13.6 µg/l (Figure F10). Site 3 ranged from 0.0 to 33.3 µg/l, averaging 8.7 µg/l (Figure F11). Site 4 ranged from 0.0 to 90.0 µg/l, averaging 24.8 µg/l (Figure F11). Site 5 ranged from 0.0 to 71.8 µg/l, averaging 21.6 µg/l (Figure F12). Site 6 ranged from 2.7 to 85.5 µg/l, averaging 22.9 µg/l for the testing period (Figure F12).



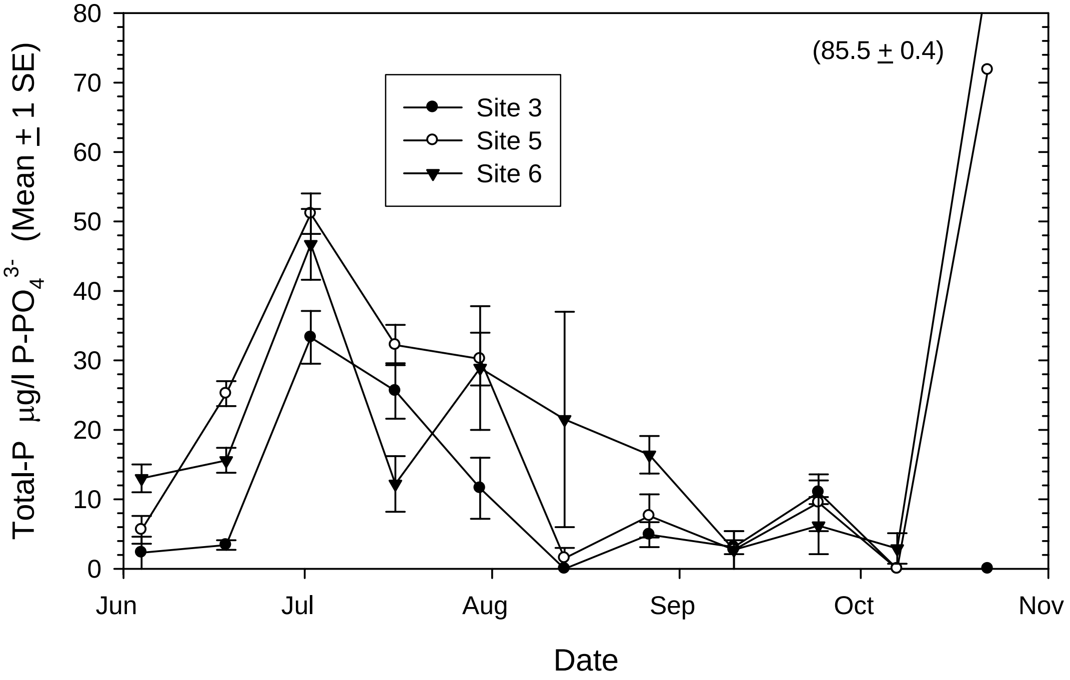


Figure 40. Total phosphate (P-PO_4^{3-} µg/l, mean + 1 SE) at Sites 1, 2, and 4, the West Branch mainstem of the Eightmile River, and Sites 3, 5, and 6, tributaries of the West Branch of the Eightmile River, for all collection dates during 2005.

Nitrate was also highly variable among sites (Figures 41 and 42, E25 through E30, and F13 through F15). Site 1 ranged from 1.7 to 385.0 µg/l, averaging 198.3 µg/l (Figure F13). Site 2 ranged from 0.0 to 64.2 µg/l, averaging 21.8 µg/l (Figure F13). Site 3 ranged from 0.0 to 114.6 µg/l, averaging 50.6 µg/l (Figure F14). Site 4 ranged from 0.0 to 12.5 µg/l, averaging 1.8 µg/l (Figure F14). Site 5 ranged from 0.0 to 290.4 µg/l, averaging 90.7 µg/l (Figure F15). Site 6 ranged from 0.0 to 438.3 µg/l, averaging 103.2 µg/l (Figure F15).

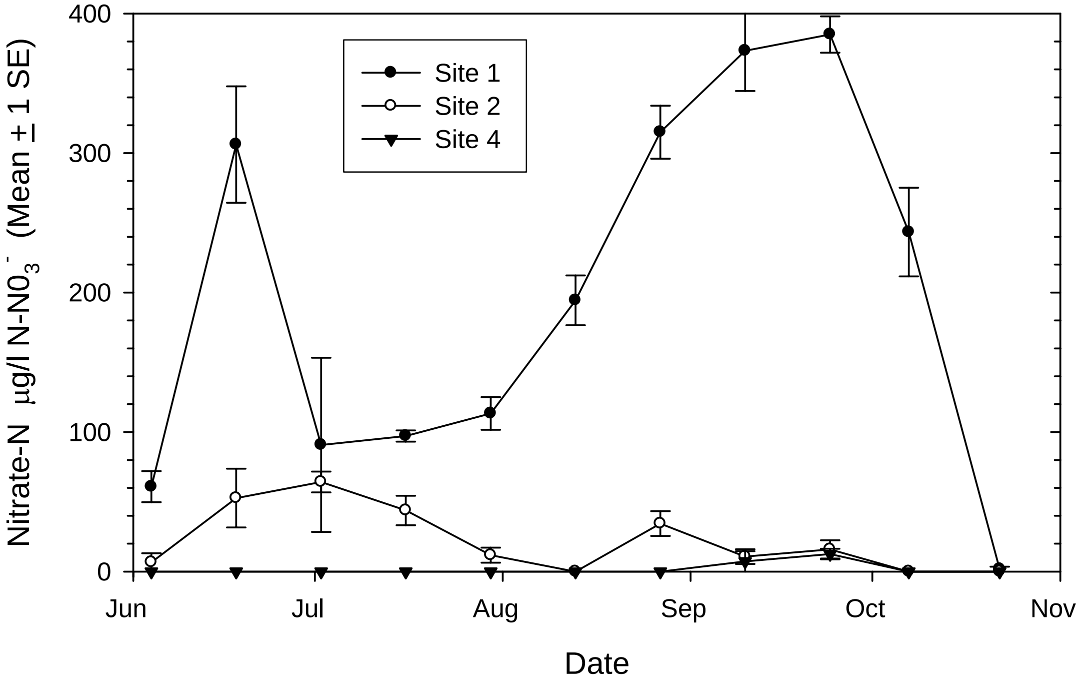


Figure 41. Nitrate-N (N-NO$_3^-$ µg/l, mean ± 1 SE) at Sites 1, 2, and 4, West Branch of the Eightmile River mainstem, for all collection dates during 2005.

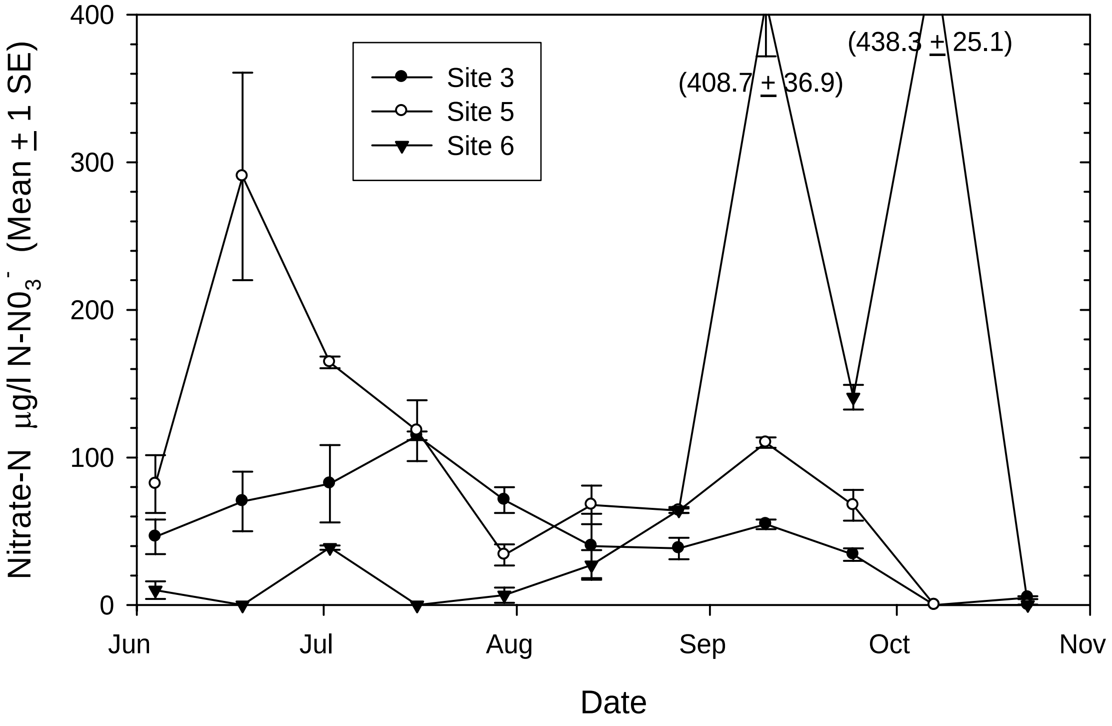
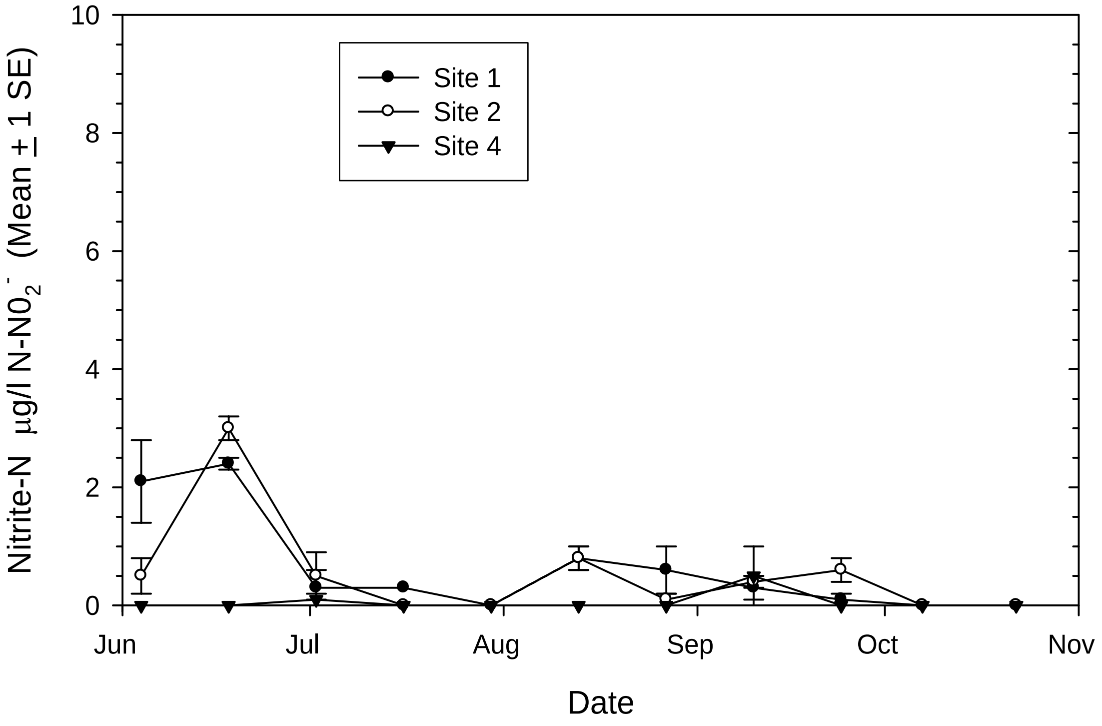


Figure 42. Nitrate-N (N-NO$_3^-$ µg/l, mean ± 1 SE) Sites 3, 5, and 6, tributaries of the West Branch of the Eightmile River, for all collection dates during 2005.

Nitrite data among sites demonstrated variability different from nitrates (Figures 43, E31 through E36, and F16 through F18). Higher levels of nitrite appear during June and July tapering off to negligible amounts in October. Individually, sites vary considerably (Figures F16 through F18). Site 1 ranged from 0.0 to 2.4 µg/l, averaging 0.6 µg/l (Figure F16). Site 2 ranged from 0.0 to 3.0 µg/l, averaging 0.5 µg/l (Figure F16). Site 3 ranged from 0.0 to 1.2 µg/l, averaging 0.3 µg/l (Figure F17). Site 4 ranged from 0.0 to 0.5 µg/l, averaging 0.1 µg/l (Figure F17). Site 5 ranged from 0.0 to 1.8 µg/l, averaging 0.8 µg/l (Figure F18). Site 6 ranged from 0.0 to 7.6 µg/l, averaging 2.0 µg/l (Figure F18).



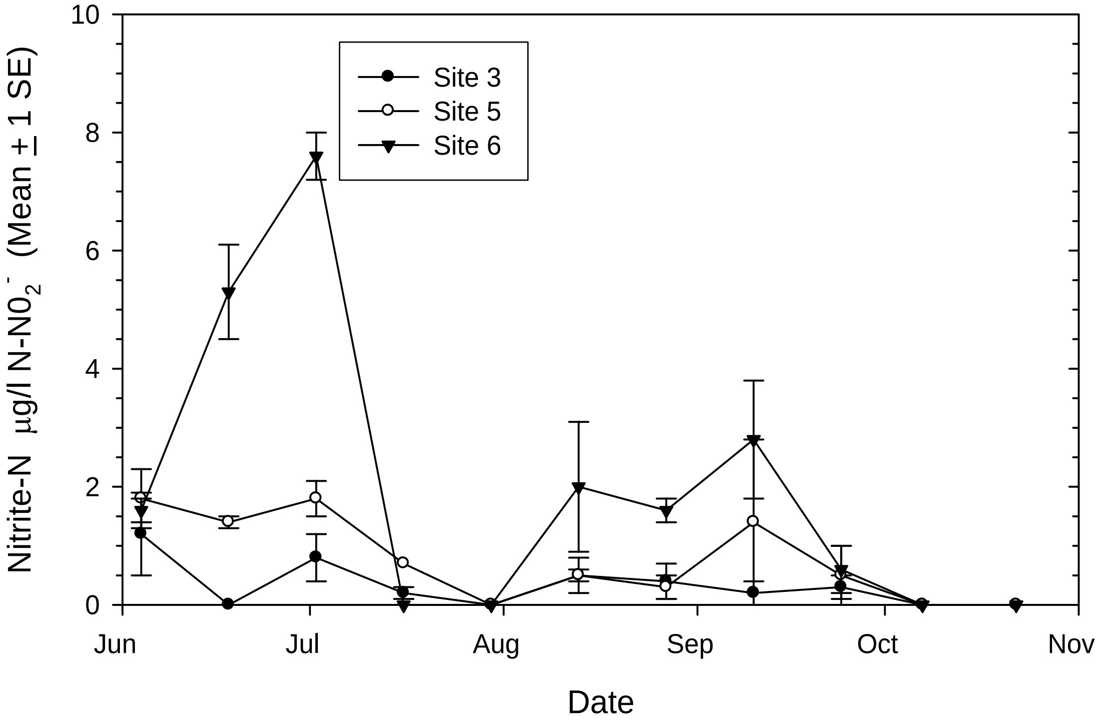


Figure 43. Nitrite-N (N-NO$_2^-$ µg/l, mean ± 1 SE) at Sites 1, 2, and 4, the West Branch mainstem of the Eightmile River, and Sites 3, 5, and 6, tributaries of the West Branch of the Eightmile River, for all collection dates during 2005.

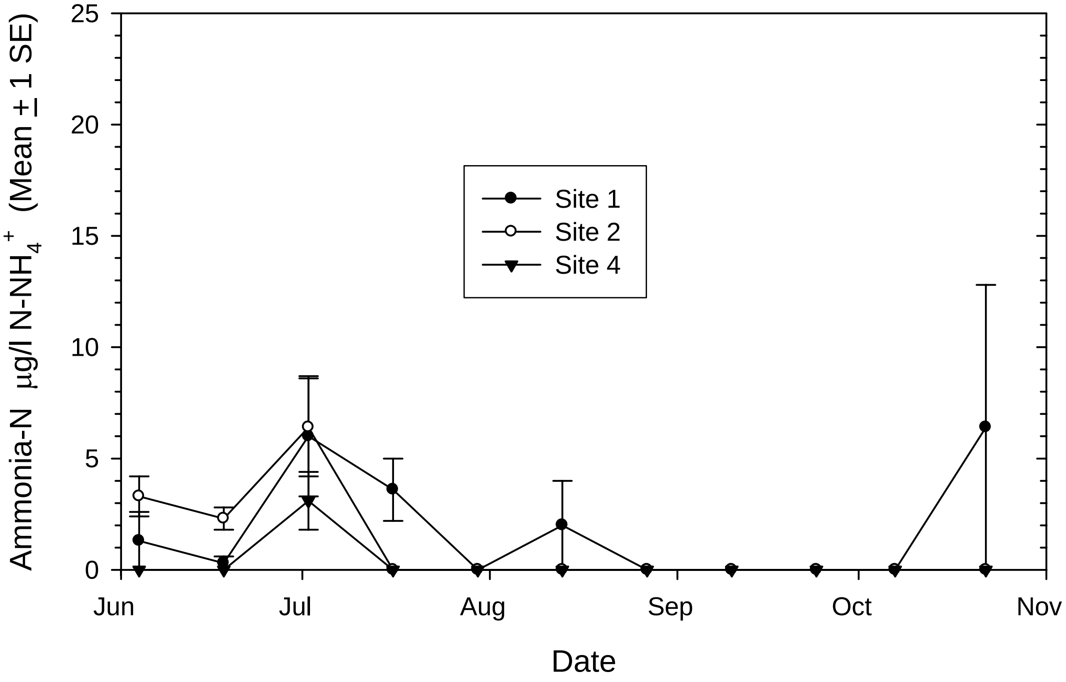


Figure 44. Ammonia-N (N-NH_4^+ µg/l, mean ± 1 SE) at Sites 1, 2, and 4, the West Branch mainstem of the Eightmile River, for all collection dates during 2005.

Ammonia data mirror nitrite data closely (Figures 44 and 45), showing higher amounts in June and July and tapering off in October (Figures E37 through E42 and F19 through F21). Site 1 ranged from 0.0 to 6.4 µg/l, averaging 1.8 µg/l (Figure F19). Site 2 ranged from 0.0 to 6.4 µg/l, averaging 1.1 µg/l (Figure F19). Site 3 consistently measured at 0.0 µg/l for ammonia (Figure F20). Site 4 ranged from 0.0 to 3.1 µg/l, averaging 0.3 µg/l (Figure F20). Site 5 ranged from 0.0 to 4.3 µg/l, averaging 0.6 µg/l (Figure F21). Site 6 ranged from 0.0 to 78.1 µg/l, averaging 13.0 µg/l (Figure F21).

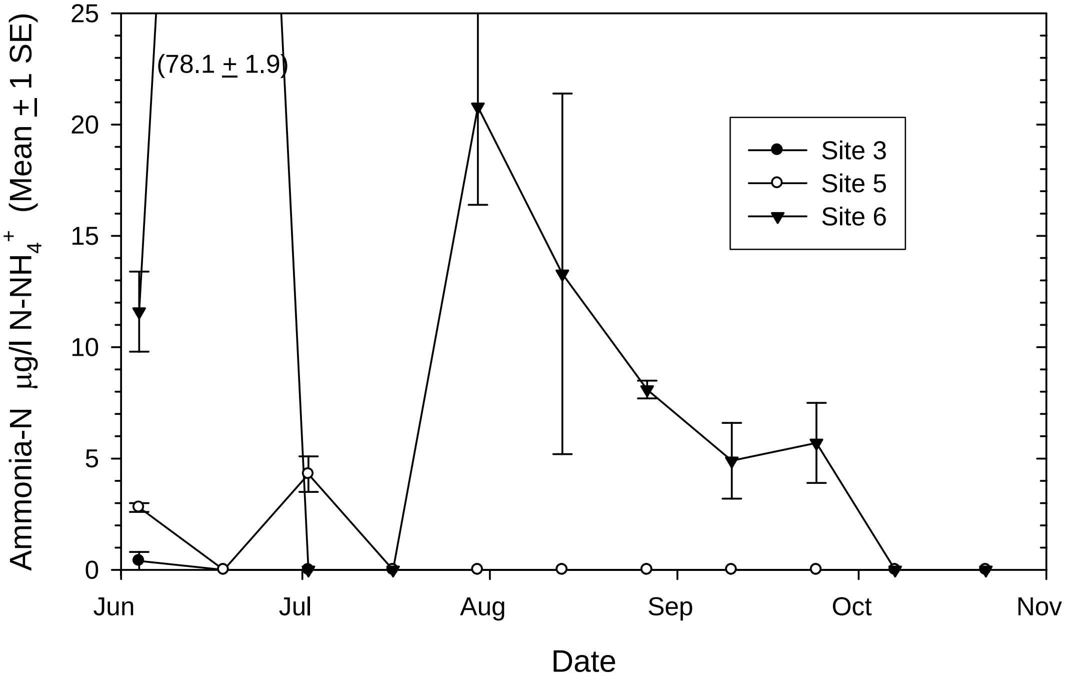


Figure 45. Ammonia-N (N-NH_4^+ µg/l, mean + 1 SE) Sites 3, 5, and 6, tributaries of the West Branch of the Eightmile River, for all collection dates during 2005.

Discussion

The Connecticut River in East Haddam and the Salmon River in East Hampton exhibited similar values for many of parameters measured in the current study for the Eightmile River (United States Geological Survey 2006). In general the Eightmile River met or exceeded the standards for Class A water quality (Appendix A).

Precipitation creates surface runoff, which transports various pollutants such as sediments, feces, and fertilizer, and then runs down gradient to rivers, lakes and streams. Surface runoff can significantly alter aquatic ecosystems by carrying excessive nutrients (US EPA 2003a).

During the present study there was a marked lack of rainfall for much of the time. Average precipitation over the past thirty years shows the average for June to be 9.52 cm, July, 8.10 cm, August, 9.27 cm, September, 9.63 cm, and October, 9.07 cm, for a total of 45.59 cm for the same annual period as the present study (Northeast Regional Climate Center 2006). In 2004, the total amount of rainfall for the same time period as the present study was lower at 42.88 cm (Northeast Regional Climate Center 2006); the distribution of precipitation over time was similar. The total rainfall during the study period in 2005 was significantly higher at 57.15 cm (Earth Tech 2005), however the distribution was skewed toward October which received the majority in one rainfall event.

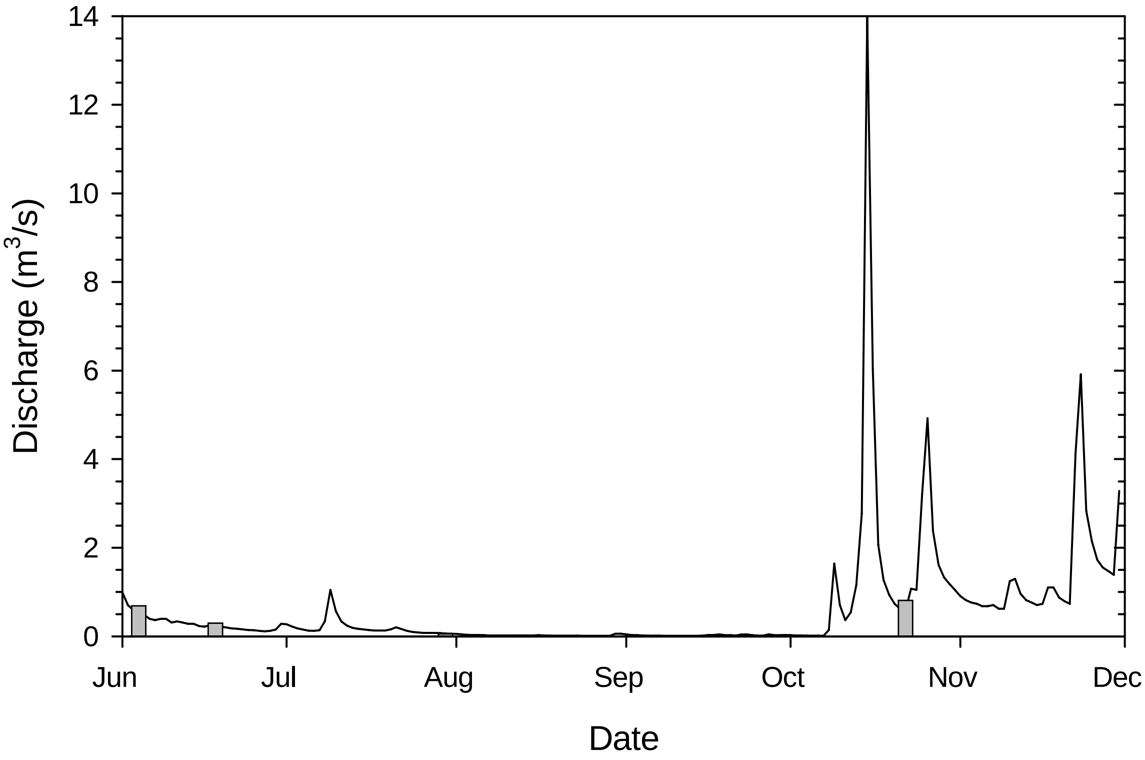


Figure 46. Discharge (mean daily discharge, m^3/s) from the USGS stream gauge on the East Branch of the Eightmile River (Lyme, CT). Vertical bars represent flow measurements taken on the collection days for the present West Branch study (discharge, m^3/s).

The lack of rainfall during August and September, 2005, followed by the heavy rainfall in October resulted in water rushing into the streams. The end result of this flow can be scouring of the stream bed and a sharp decrease in the number of macroinvertebrates detected (Connecticut River Watch Program 2004). The sharp increase in water flow could also alter the chemical components present in the water during this period.

Data were collected on 18 June, 2 July, and 8 October after three rainfall events. However, it is questionable if these events were of significant enough rainfall to affect a change in water chemistry. The relative dry period results in a parched landscape which would soak up much of the rain prior to its arrival at the stream. It is likely that the relative dry spell that occurred during the summer months of collection affected the outcome of the water chemistry by decreasing the amount of both groundwater and surface water entering the system, thus decreasing the amount of materials transported into the stream. It is also likely that evaporation from the stream would concentrate the concentrations of chemicals present in the system, and therefore it may have affected other parameters including nutrients, the rate of discharge, and temperature of the water, and thus, dissolved oxygen content.

Discharge data shows the expected relationship with the precipitation. While groundwater flow was not documented in the present study, the peaks demonstrated in Figures 25 reflect discharge for the mainstem at Sites 1, 2, and 4, increasing in relation to rainfall events. This increase in discharge can be attributed to the time delay as precipitation percolates through the subsurface material making its way into the stream bed. Site 1, 2, and 4 demonstrate the highest discharge rates. This is expected as these sites represent the mainstem of the Eightmile River.

The variability in flow for all sites can be attributed to temperature increasing the evaporation rate, relative humidity, precipitation, and amount of groundwater flow. Despite flow decreasing to undetectable levels at sites 3, 4, 5, and 6 for several collections (Appendices C and D), enough water was present to allow for discrete sampling.

Water temperature plays an important role in determining which species will inhabit an area. Temperature for Class A water as outlined by the Connecticut Department of Environmental Protection requires that, “There shall be no changes from natural conditions that would impair any existing or designated uses assigned to this Class, and in no case exceed 85º F, or in any case raise the temperature of the surface water more then 4º F" (CT DEP 2002).

The average temperature found for the Eightmile River was 17º C. Comparison to the Salmon River (at East Hampton, CT) shows a similar average of 17.25º C for the same time period (US Geological Survey 2006). The Connecticut River (at East Haddam, CT) also had an average temperature of 17º C during this time (Appendix A, US Geological Survey 2006).

Competition permitting, species will choose to exist in a temperature range that enables optimal growth. While each collection site showed mild differences in temperature, the patterns represent expected changes associated with the seasons (Appendices C and D). Each collection site individually remains well within the parameters required to support high biodiversity. This is evidenced by the presence of trout that cannot tolerate greater than a maximum temperature of 24º C (Connecticut River Watch Program 2004). The in-stream temperature is a function of both the rate of stream discharge and the amount of shading at all the collection sites.

The difference in temperature between Site 6 and the other five sites could be linked to its association with Lake Hayward, which is classified as mesotrophic. The months where significant differences are indicated could be attributed to the warming of the lake. Significant warming of the lake could be expected, as little to no rainfall occurred during the summer season. The maximum depth of the lake is 11.3 m and the minimum is 3.05 m (Norvell *et al.* 1979), this relative shallowness of the lake also could result in increased water temperature.

Dissolved oxygen enters a water system from the atmosphere and from algal, bacterial, and plant photosynthesis (US EPA 2006a). Water that move over rocks or waterfalls create a greater mixing of water and air resulting in higher dissolved oxygen in these areas (US EPA 2006a). Altitude, seasons, time of day, and the temperature of the water will also cause variations in the amount of dissolved oxygen present (US EPA 2006a). The amount of dissolved oxygen present in water directly affects the species of plants and animals that inhabit these areas (US EPA 2006a).

Generally, each site maintained a relatively high dissolved oxygen content (Appendices C and D). Oxygen concentrations remained well within the parameter of not less than 5 mg/l for Class A water (Appendix A, CT DEP 2002). All sites displayed a pattern consistent with seasonal changes, demonstrating lower dissolved oxygen levels in both percent saturation and mg/l as the temperatures increased, recovering as the temperatures cooled.

In August, the dissolved oxygen of all sites dropped significantly. This can be attributed to higher water temperatures, lack of precipitation and resulting decrease in water movement. As Site 1 is the main branch of the Eightmile River, it is reflective of the drop at all other sites. The highest dissolved oxygen for all sites was in June; this also is explained by the temperature and precipitation.

The drop in the percent saturation of dissolved oxygen at the sites begins to occur in mid-July. As the waters increase in temperature, the dissolved oxygen reflects a downward trend that reverses in mid-September and is back to the initial level by the end of September. This is reflective of the inverse relationship between the water's temperature and the percent saturation of dissolved oxygen. As temperature increases, it is expected that percent saturation of dissolved oxygen will decrease.

The level of dissolved oxygen in mg/l and percent saturation in the Eightmile River on average measured 7.58 mg/l and 79.3%, compared to the Connecticut River which was higher measuring 8.6 mg/l and 85.75%, and Salmon River which was much higher than both the other two water bodies averaging 9.9 mg/l and 101.5%. (United States Geological Survey 2006, Appendix A)

It is necessary to state here that Salmon River was sampled only in July and October for all parameters listed in Appendix A. This may have led to a higher average for dissolved oxygen content. August and September are the months that would have had the lowest dissolved oxygen levels, due to the lack of precipitation and increased temperature, because the Salmon River was not sampled during these months, this average may be inaccurate when compared to averages including these months. The Connecticut River in East Haddam was sampled in June, August, October, and December (US Geological Survey 2006, Appendix A).

Turbidity is a measurement of the clarity of water, reflective of suspended solids and colloidal material in a system. Sources of suspended solids include erosion, urban waste and runoff, and excessive algal growth (US EPA 2006b). Suspended solids have a large impact on aquatic ecosystems. The amount of suspended solids present affects how much light may pass through the water (US EPA 2006b). This in turn affects the amount of photosynthesis occurring, potentially resulting in lower oxygen production (US EPA 2006b). Oxygen is also affected because the suspended solids attract heat increasing water temperature and decreasing the solubility of oxygen in the water (US EPA 2006b).

The amount of suspended solids and turbidity was low at all sites, not appearing to have “concentrations or combinations which would impair designated uses; none aesthetically objectionable; none which would significantly alter the physical or chemical composition of the bottom; none which would adversely impact aquatic organisms living in or on the bottom substrate” (CT DEP 2002).

The average turbidity for the Eightmile River was 1.05 NTU. This average was in between values for Salmon River which was lower at 0.85 NTRU, and the Connecticut River which was 3.63 NTRU (United States Geological Survey 2006, Appendix A). Turbidity did not exceed 5 NTU over ambient levels (CT DEP 2002), and did not exceed levels necessary to protect and maintain uses. Suspended solids and turbidity measurements were generally low, rising slightly as temperatures rose.

Site 6 measured the highest for turbidity and total suspended solids on all collection dates. This can be attributed to the location of the stream as it drains from Lake Hayward through a muddy area under Mill Lane then through culverts into Hayward Brook. The road debris, path of flow, and eroded sides of the stream bed could cause an increase in turbidity during times of precipitation and high runoff, as seen in October. Peaks in August are associated with limited flow and the low volume of water remaining for sampling.

Site 5 had a significant bed of algae covering the bottom of the stream during August; this may have caused the increase in turbidity seen in August and September at this site.

Conductivity and specific conductance are a measurement of water’s ability to conduct electricity and are an indirect measurement of the concentration of ions in the water (Whiting 2006). The concentration of certain cations can determine what macroinvertebrates are present in a waterbody (Whiting 2006). Over the period of collection, conductance and specific conductance increased at all sites. This change is consistent with the lack of precipitation, and decrease in stream flow, all of which could have contributed to concentrating ions within the water. A sharp decline in conductivity on October 23, 2005, correlates with the influx of water due to a sharp increase in precipitation, resulting in dilution. Conductivity at Site 6 is much higher than at the other sites and this is consistent with the total suspended solids and turbidity.

Specific conductance measured in the Connecticut River averaged 140.75 µs/cm during this time period. The Salmon River averaged 132.5 µs/cm, while the Eightmile River averaged 59.3 µs/cm (United States Geological Survey 2006, Appendix A).

The pH indicates the acidity or alkalinity of a waterbody (US EPA 2006c). It can affect the organisms present in the water; generally, most organisms prefer a range of 6.5 to 8.0 (US EPA 2006c). The pH also has the ability to affect what chemicals are available in the water. Lower pH values cause some chemicals to be released into the water, while higher values cause binding of these chemicals making them unavailable (US EPA 2006c). pH is altered by the atmospheric deposition, surrounding rock formations, and wastewater discharges.

The pH in all sites was relatively constant (Appendices E and F). All values are as naturally occurs and reflect patterns of decomposition and production. When compared to other waterbodies in the area, the average for the Eightmile River was 6.61, Salmon River averaged 7.8, and the Connecticut River averaged 7.2 (United States Geological Survey 2006, Appendix A). Associated with rainfall events, a slight decrease in the pH can be seen possibly due to the acidity of precipitation and the rocks that surface runoff comes into contact with as it proceeds to the stream.

Chloride is an anion of some salts, it is an inorganic dissolved solid that contributes to the level of conductivity and total solids in a water body (Kaushal *et a*l. 2005. The US Environmental Protection Agency lists a value of 250 mg/l in freshwater as being the upper limit to protect the health of aquatic organisms (US EPA 1988). For the duration of this study all sites for all collection dates remained below 30 mg/l, with the exception of Site 6 on October 7, 2005. On this date Site 6 rose to 43.3 mg/l chloride.

An average chloride concentration of 13.7 mg/l was found for the West Branch of the Eightmile River. The Connecticut River averaged 16.93 mg/l, and the Salmon River averaged 20.75 mg/l in comparison (United States Geological Survey 2006, Appendix A).

Phosphorous is essential to life as it is a building block of several essential organic molecules (Dodson 2005). Under natural conditions it is a limiting chemical for organism's growth as much is bound in organisms like plants, animals and to sediment particles (Dodson 2005). Redistribution of phosphorus occurs when the organisms die and are broken down; the phosphorus is released back into the water where it moves downstream until it is either captured and bound into another organism or settles on the bottom (Dodson 2005).

In many cases, increases in phosphate are caused by nonpoint surface runoff that is attributed to fertilizers (US EPA 2003a, b). These are in the form of monoammonium phosphate, diammonium phosphate, triple superphosphate, and ammonium phosphate sulfate (US EPA 2003a, b). The level of phosphate in surface runoff may be directly correlated to the loss of nutrients from soil (US EPA 2003a, b). This can result in algal blooms and loss of oxygen in water due to excessive consumption of oxygen by organisms (US EPA 2003a, b).

Reactive phosphate was present at Sites 4 and 5 at time of the first collection on June 4, 2005. This may be attributed to the wetlands that are upstream of these collection sites. As the flow during this period was greater, it stands to reason that any feces and/or detritus present upstream would be washed downstream in greater quantities. Total phosphate measured at this time also indicated low levels of phosphate. As July progressed through the second and sixteenth collection dates, no detectable reactive phosphate was measured; however, total phosphate was higher on July 30, 2005. On July 30, reactive phosphate was detectable at all sites except Site 1, while total phosphate levels were declining. This trend continued through August and the beginning of September. At this time the concentration of reactive phosphate declined to an undetectable level and total phosphate remained measurable but in much lower amounts. The detectable phosphate at Sites 2, 3, 5, and 6 and the lack of detectable levels of phosphate at Sites 1 and 4, on October 23, 2005, can be attributed to the increase in stream flow washing away nutrients.

There is an extensive forested buffer zone surrounding all of the collection sites. Despite the presence of this zone, as well as the marked lack of development in the immediate area, and the low levels of detectable reactive phosphorus and total phosphorus, it can not be concluded that the phosphorus present in the water is completely of natural origin.

Site 1 demonstrated a peak of reactive phosphate on August 27, 2005 (Appendix F). This peak correlates with a peak in nitrates on the same date. This can be explained by a potential application of fertilizer to the Fox Hopyard Golf Course which is just upstream.

Comparative data from the Connecticut River shows the total phosphorus average at 0.12 mg/l, orthophosphate at 0.04 mg/l, and total phosphate at 0.08 mg/l. The Salmon River had an orthophosphate average of 0.02 mg/l, total phosphate of 0.02 mg/l (United States Geological Survey 2006, Appendix A). The Eightmile River averaged 16.7 µg/l for total phosphate (as $P\text{-}PO_4^{3-}$) and 1.3 µg/l for reactive phosphate (as $P\text{-}PO_4^{3-}$).

Nitrogen is present in all ecosystems. Sources of nitrogen include excretion in urine and feces as ammonia, storage in organic material, atmospheric nitrogen, commercial fertilizers, and soil reserves that manifest themselves in surface runoff (US EPA 2003a, b).

Excessive dissolved nitrogen is a common cause of water problems (US EPA 2003a, b). Nitrogen is may be present in water as nitrate (NO_3^-), nitrite (NO_2^-), and ammonia (NH_4^+) (US EPA 2003a, b). Nitrate is a likely form of nitrogen to seep into ground water (US EPA 2003a, b). In aquatic cycles, nitrogen is able to move and convert to all of these forms. The process of nitrification converts ammonia to nitrite and then nitrate (US EPA 2003a, b). Ammonia and nitrate are taken up by some organisms and converted to nitrogen-containing organic matter. This process immobilizes the nitrogen while the organism is alive; it is released again through the processes of decay and excretion (US EPA 2003a, b).

Site 1 exhibited an increase in nitrate levels from June to October. A peak occurred on August 27, 2005; this could be related to the combination of nitrate input from Sites 2, 3, 5, and 6. As this peak correlated with a peak in reactive phosphorus, it is possible that the Fox Hopyard Golf Course, which is located just upstream of Site 1, applied fertilizer prior to testing. Nitrite was present in small amounts and showed a steady decline over time. Ammonia was detectable in a small amount on July 16, 2005. On October 22, 2005, no evidence of any nitrate, nitrite, or ammonia was detectable. This can be attributed to the significant rainfall event washing/diluting nutrients.

Site 2 nitrate levels demonstrate a spike on June 18, 2005. Nitrite also spiked on this date, and a small amount of ammonia was present. This spike could be associated with inputs from Sites 3 and 5, which demonstrated measurable nitrate present on this testing date as well as on June 4, 2005. Nitrate and nitrite on other dates are present in slight amounts through August and September dropping off in October. Ammonia is not detectable on any other date except for July 2, 2005, when it was present in small amounts.

Site 3 nitrate showed an increase through July 16, 2005, then decreased progressively; nitrite decreases from June through September, becoming undetectable in October. Ammonia remains undetectable from June through October.

Site 4 nitrate was undetectable except for September 10, 2005, and September 24, 2005 when it was present in small amounts. Nitrite is detectable slightly only in July and on September 10, 2005. Ammonia is present only in small amounts on July 2, 2005.

Site 5 demonstrates an increase in nitrate until July 30, 2005, when a steep drop occurs. Nitrate is present again in August proceeding on a downward trend though

October when it becomes undetectable. Nitrite is present in moderate amounts except for July 30, 2005, and October 22, 2005, when it is undetectable. Ammonia is only present in a small amount on July 2, 2005.

Site 6 demonstrates moderate levels of nitrate through October 22, 2005, with spikes on September 10, 2005 and October 22, 2005, and becoming undetectable on October 22, 2005. Nitrite was higher June through July 2, 2005. None was detected on July 16, 2005 or on July 30, 2005. August and September demonstrated elevated nitrite levels, while none was detected in October. In June, ammonia was detected in very elevated amounts. Ammonia was measurable in all collections. Ammonia exhibits a downward trend from July 30, 2005, through September, with levels becoming undetectable in October. The spike in June is consistent with the low level of nitrate at the same collection, dissolved oxygen was lower than normal but not significantly.

Nitrate in the Eightmile River over the period of collection averaged 77.7 µg/l. Nitrite averaged 0.7 µg/l. In comparison the Salmon River averaged 0.15 mg/l for total nitrate, 0.11 mg/l for nitrate and nitrite combined, approximately 0.112 mg/l for nitrate, and less then 0.008 mg/l for nitrite (United States Geological Survey 2006, Appendix A). The Connecticut River averaged 0.44 mg/l for total nitrogen, 0.46 mg/l for nitrate and nitrogen combined, 0.44 mg/l for nitrate, and 0.024 mg/l for nitrite (United States Geological Survey 2006, Appendix A).

Conclusion

Water quality conditions, previously determined by Rapid Bioassessment studies of macroinvertebrate species, indicate that the Eightmile River met Connecticut Class A water quality standards (Beauchene 2005). In this study, for all of the chemical constituents measured (see Appendices C through F), the condition of the West Branch of the Eightmile River was found to be consistent with Class A water as defined by the State of Connecticut Department of Environmental Protection water quality standards (CT DEP 2002).

Temperature at each collection site remains well within the temperature range required to support high biodiversity. This is evidenced by the presence of trout that dwell here which require a maximum temperature 24º C (Connecticut River Watch Program 2004).

Dissolved oxygen is well within the parameters for a Class A waterbody (CT DEP 2002). Dissolved oxygen content should be not less than 5 mg/l at any time; and the Eightmile River consistently demonstrated high percent oxygen saturation at all sites.

Suspended and settleable solids do not appear to be in concentrations that impair the waterbody, and they do not appear to alter the bottom. No suspended solids were noted that would significantly alter the chemical composition of the water or negatively affect aquatic organisms. Turbidity of the waterbody as a whole is not 5 NTU over the surrounding water bodies. Turbidity did not exceed 5 NTU over ambient levels and did not appear to exceed levels necessary to protect and maintain uses.

Chloride is not present in significant values at any of the sites, indicating that no significant sewage problems or road runoff are affecting the water.

The pH at all sites remained relatively constant. All values are as naturally occurs and reflect patterns of decomposition and production. Associated with rainfall events, a slight decrease can be seen possibly due to the acidity of precipitation and the rocks that surface runoff comes into contact with as it proceeds to the stream.

Nitrogen is affected by the forested area. Some collection sites are affected by anthropogenic practices; however, the wetlands naturally present in these areas appears to act as sinks for the excess nitrogen preventing effects to the mainstem of the river. The mainstem of the Eightmile River remains well within the parameters allowable for nitrogen (CT DEP 2002).

In the future an assessment of the chemical constituents of the Eightmile River from December through June may prove useful to complete the baseline data available for comparison. As development in this area increases it would also be useful to closely monitor Muddy Brook and Lake Hayward's contribution to the river, as these two sites drain from the areas that have the most potential to cause contamination.

The Outstanding Resource Values of the Eightmile River have been demonstrated in this study. The water chemistry of the Eightmile River is reflective of the watershed area that creates it. It is clear that the hydrology, stream flow, rock formation, and remaining forested areas have created a relatively clean water source and one that meets requirements for protection. It appears that this will occur as the towns involved voted the Wild and Scenic designation into acceptance and are undertaking the responsibilities of ensuring the continued health of the Eightmile River in 2005.

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Mary-Elizabeth L. Joaquin

Mary-Elizabeth L. Joaquin is an Agricultural and Marketing Representative I in the State of Connecticut Department of Agriculture. Her primary responsibilities include testing, monitoring, and outreach activities focused on Avian Influenza. Prior to completing her Master of Art's Degree in Environmental Biology at Central Connecticut State University she graduated from the University of Connecticut with a Bachelor in Science Degree from the College of Agriculture and Natural Resources in Animal Science. Mary is married and the mother of two children making their home in New London County, Connecticut.

Appendix A - Class A Water Quality Guidelines/Standards

Water Quality Parameter	Water Quality Standard	Eightmile River [1]	Salmon River [2]	Connecticut River [2]
Dissolved Oxygen	Class A: not less than 5 mg/l at any time (CT DEP 2002)	7.58 mg/l 79.3%	9.9 mg/l 101.5%	8.6 mg/l [3] 85.7% [3]
Color	None other than natural origin (CT DEP 2002)	Clear - tea color	N/A	N/A
Suspended and Settleable Solids	None in concentrations or combinations which would impair designated uses; none aesthetically objectionable; none which would significantly alter the physical or chemical composition of the bottom; none which would adversely impact aquatic organisms living in or on the bottom substrate (CT DEP 2002)	2.66 mg/l	N/A	N/A
Turbidity	Shall not exceed 5 NTU over ambient levels and none exceeding levels necessary to protect and maintain all designated uses (CT DEP 2002) 1.94 NTU (US EPA 2000)	1.05 NTU	0.85 NTRU	3.63 NTRU
pH	As naturally occurs (CT DEP 2002)	6.61	7.8	7.2

Appendix A (continued) - Class A Water Quality Guidelines/Standards

Water Quality Parameter	Water Quality Standard	Eightmile River [1]	Salmon River [2]	Connecticut River [3]
Allowable Temperature Increase	There shall be no changes from natural conditions that would impair any existing (CT DEP 2002)	17º C	17.25º C	17º C
Total Phosphorus (µg/l)	None other than of natural origin (CT DEP 2002) 31.25 µg/l (US EPA 2000)	Total P 16.7 µg/l Reactive P 1.3 µg/l	0.04 µg/l [3] 0.02 µg/l [3]	0.04 µg/l 0.12 µg/l [3]
Chloride	250 mg/l (US EPA 1988)	13.7 mg/l	20.75 mg/l	16.93 mg/l
Total Nitrogen $NO_2 + NO_3$ Nitrate Nitrogen	0.71 mg/l (US EPA 2000)	78.4 µg/l 77.7 µg/l	0.32 mg/l 0.11 mg/l ≈ 0.102 mg/l	0.53 mg/l 0.44 mg/l ≈ 0.42 mg/l
Nitrite Nitrogen		0.7 µg/l	<0.008 mg/l	<0.024 mg/l [3]
Specific Conductance		59.3 µS/cm	132.5 µS/cm	140.75 µS/cm

[1] Average values for each parameter over this study.

[2] Average values for each parameter from US Geological Survey (2005, 2006) for the Salmon River near East Hampton, CT, and the Connecticut River near East Haddam, CT.

[3] Values are estimated by the US Geological Survey (2005, 2006).

Appendix B - CT DEP Bedrock Definitions 2005

Bedrock Type	Definition
Brimfield schist	"Gray, rusty-weathering, medium- to coarse-grained, interlayered schist and gneiss, composed of oligoclase, quartz, K-feldspar, and biotite, and commonly garnet, sillimanite, graphite, and pyrrhotite. K-feldspar partly as augen 1 to 3 cm across. Minor layers and lenses of hornblende and pyroxene-bearing gneiss, amphibolite, and calc-silicate rock" (CT DEP 2005a, b) Age Ordovician 435-500 million years ago (mya) (CT DEP 2005a, b)
Tatnic Hill Formation	"Medium to dark grey, medium grained gneiss or schist composed of quartz, adesine, biotite, garnet and sillimanite, locally kyanite, muscovite or k-feldspar interlayered with locally mappable units and thinner layers of rusty weathering graphitic pyrrhotitic, two mica schist amphibolite and calc-silicate rock" (Rogers 1985, CT DEP 2005a, b) Age Ordovician 435-500 mya (Rogers 1985, CT DEP 2005a, b)
Hebron Schist (Silurian and Ordovician)	"Interlayered dark grey medium to coarse grained schist, composed of adesine, quartz, biotite, and local k-feldspar and greenish – grey, fine to medium grained, calc silicate rock composed of lab radorite, quartz, biotite actinolite hornblende and diopside and locally scapolite local lenses of graphitic two mica schist." (Rogers 1985, CT DEP 2005a, b) Age Silurian 410-435 mya (Rogers 1985, CT DEP 2005a, b)
Potter Hill Granite Gneiss	"Light pink to grey, tan weathering fine medium grained rarely porphyritic, well foliated (not lineated) granitic gneiss, composed of microline quartz, oligoclase (or albite) biotite and magnetite, minor muscovite and local Garnet." (Rogers 1985, CT DEP 2005a, b) Age Proterozoic (Precambrian) 570-800 mya (Rogers 1985, CT DEP 2005a, b)
Waterford Group	"May be equivalent in part to Monson Gneiss (Proterozoic?) Interlayered part (but layer locally distinct) of Waterford group light to dark generally medium grained gneiss, composed of plagioclase quartz and biotite with hornblende in some layers and microline in others. Some layers of Amphibolite." (Rogers 1985, CT DEP 2005a, b) Age Proterozoic (Precambrian) 570-800 mya (Rogers 1985, CT DEP 2005a, b)
Rope Ferry Gneiss (Proterozoic Z?)	"Interlayered but layers commonly lenticular to indistinct) light to dark grey fine to medium grained with hornblende in some layers and microline in others, local layers of amphibolite." (Rogers 1985, CT DEP 2005a, b) Age Proterozoic (Precambrian) 570-800 mya (Rogers 1985, CT DEP 2005a, b)

Appendix B (continued) - CT DEP Bedrock Definitions 2005

Bedrock Type	Definition
New London Gneiss – (Proterozoic Z?)	“Massive grey granodioritic gneiss also interlayered light grey gneiss and dark grey amphibolite gneiss generally medium grained composed of oligoclase quartz biotite and magnetite also microcline in massive gneiss.” (Rogers 1985, CT DEP 2005a, b) Age Proterozoic (Precambrian) 570-800 mya (Rogers 1985, CT DEP 2005a, b)
Joshua Rock member (of New London gneiss) (Proterozoic?)	“(May include intrusive rocks of Ordovician age) medium grained (weathers with red spots of Hematite) medium grained foliated gneiss composed of microperthite quartz albite aegerine – augite and magnetite rare riebeckite.” (Rogers 1985, CT DEP 2005a, b) Age Proterozoic (Precambrian) 570-800 mya. (Rogers 1985, CT DEP 2005a, b)
Mamacoke Formation (Proterozoic?)	“Interlayered (but locally distinct) light to dark grey medium grained gneiss, composed of plagioclase quartz, and biotite, sillimanite, garnet hornblende or microline in certain layers, in upper part locally contains quartz sillimanite nodules or thin layers of quartz amphibolite or calc-silicate rock.” (Rogers 1985, CT DEP 2005a, b) Age Proterozoic (Precambrian) 570-800 mya (Rogers 1985, CT DEP 2005a, b)
Plainfield Formation (Proterozoic?)	“Interlayered light grey thin bedded quartzite in places with feldspar mica graphite or pyrite light to medium grained gneiss composed of quartz, oligoclase and biotite (rarely microline) medium to dark grey schist composed of quartz, oligoclase biotite sillimanite and garnet, dark grey or green gneiss composed of plagioclase quartz biotite and hornblende (commonly diopside) amphibolite, diopsite bearing quartzite and calcsilicate rock. In places quartz sillimanite nodules”. (Rogers 1985, CTDEP 2005a, b) Age Proterozoic (Precambrian) 570-800 mya. (Rogers 1985, CT DEP 2005a, b)
Quartzite unit (in Plainfield formation) (Proterozoic?)	“Light grey, glassy, generally thin bedded quartzite also feldspathic and micaceous quartzite containing quartz sillimanite nodules.” (Rogers 1985, CT DEP 2005a, b) Age Proterozoic (Precambrian) 570-800 mya (Rogers 1985, CT DEP 2005a, b)

Appendix C

Figure C1. Daily precipitation measured at the New London, CT, WWTF - June and July 2005 (cm).

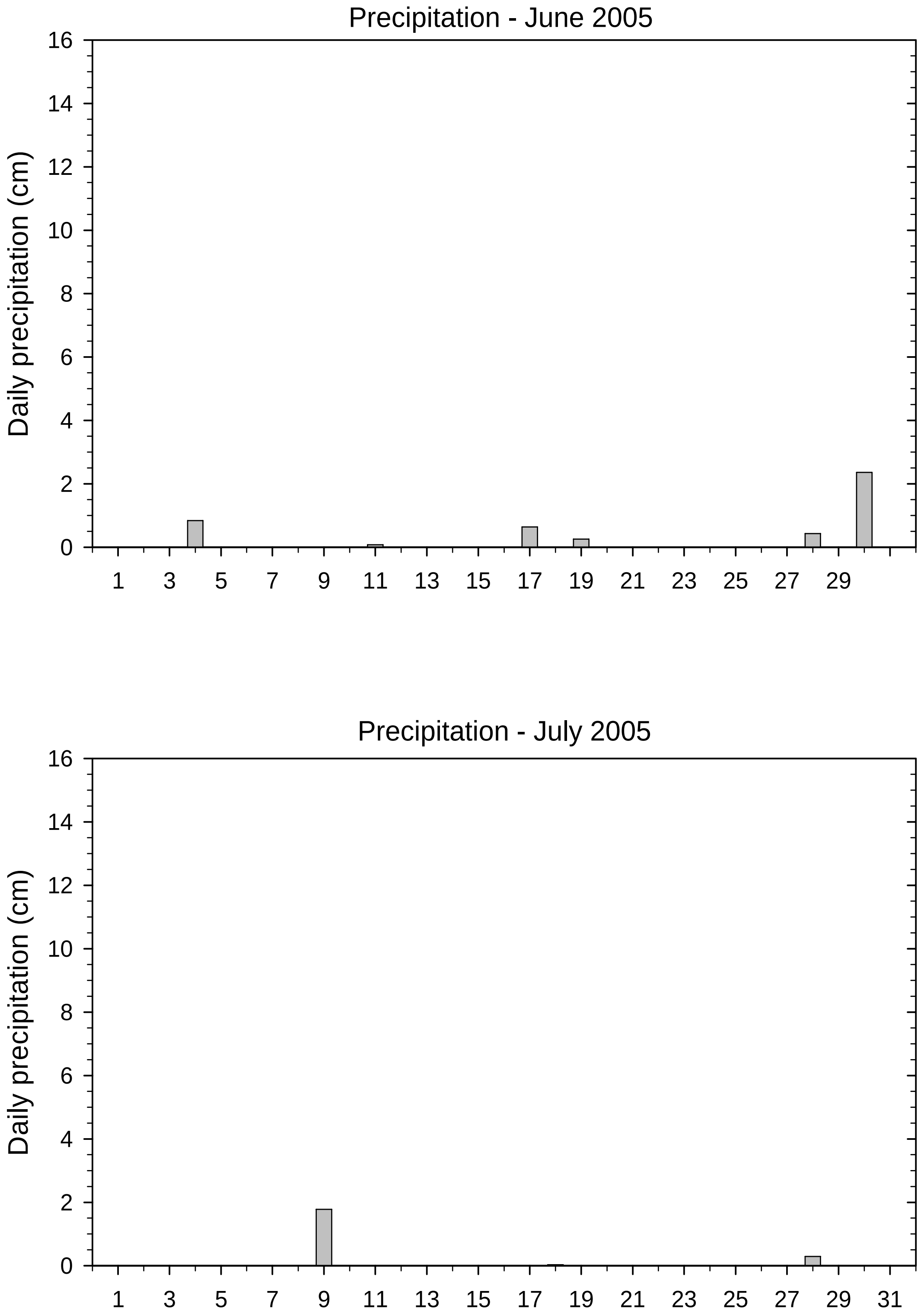


Figure C2. Daily precipitation measured at the New London, CT, WWTF - August and September 2005 (cm).

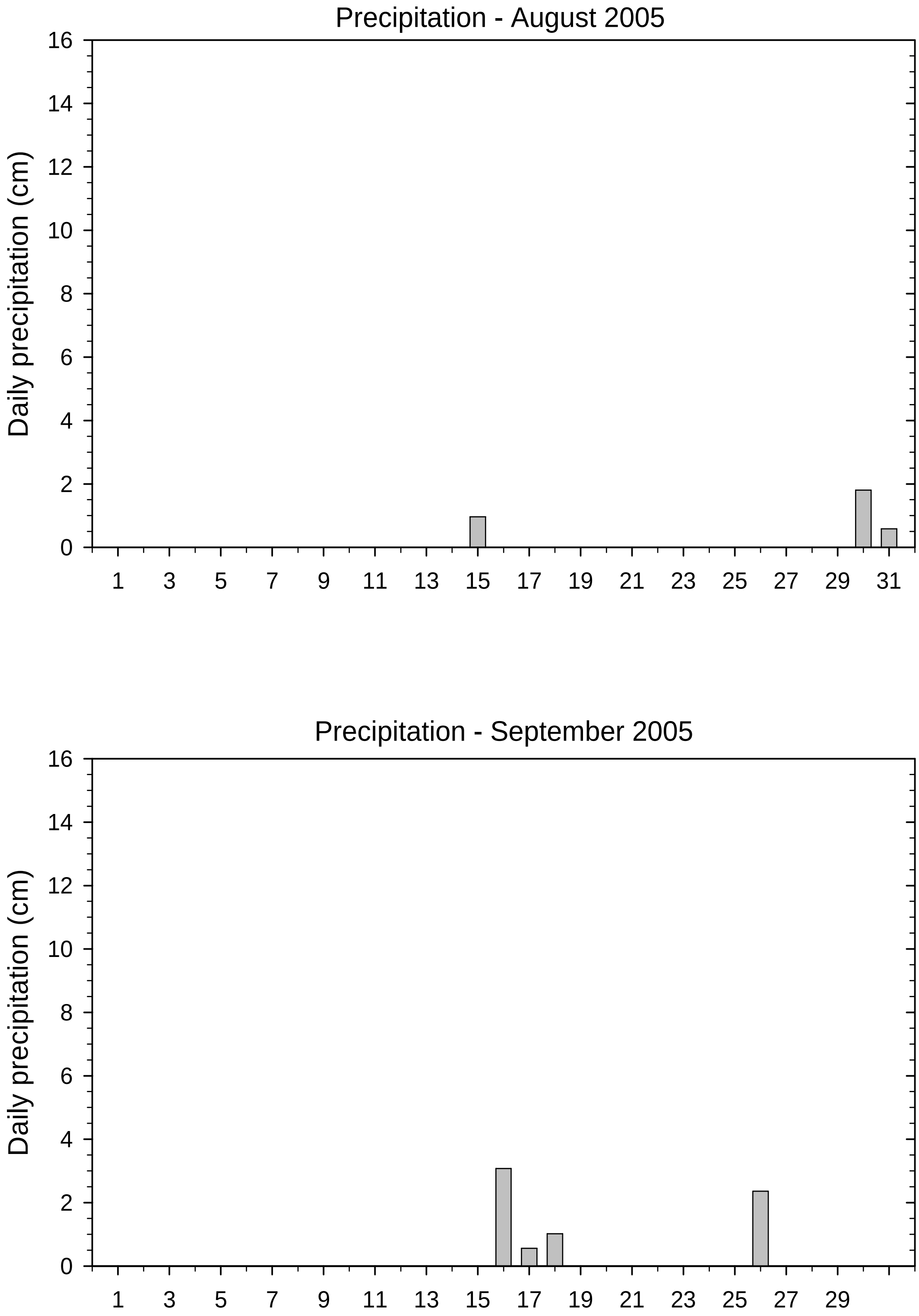
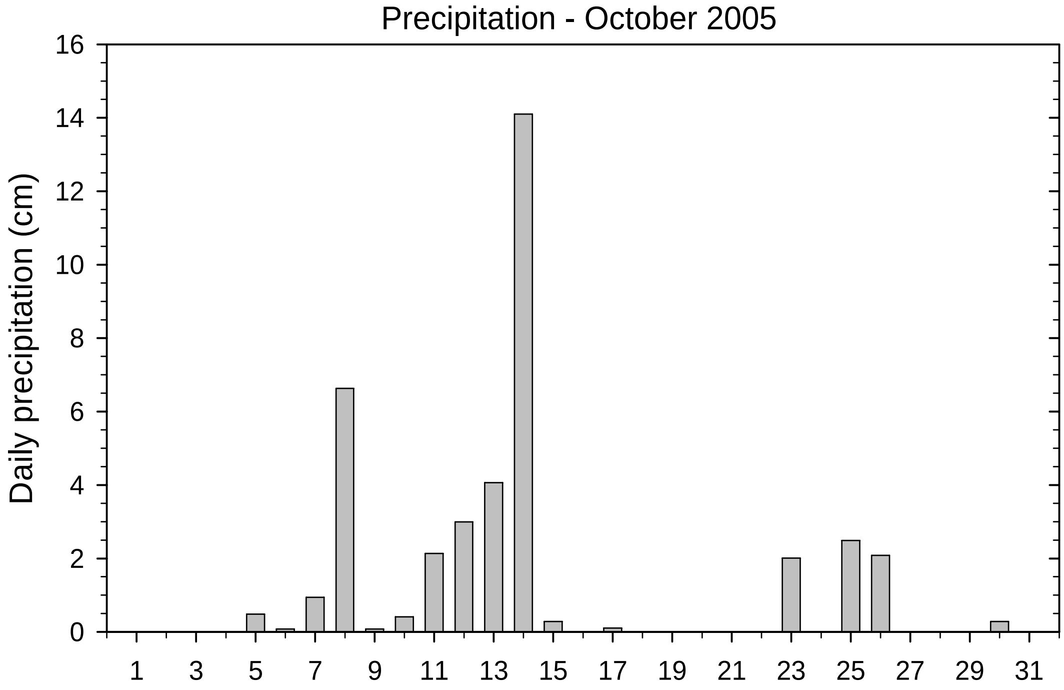


Figure C3. Daily precipitation measured at the New London, CT, WWTF - October and November 2005 (cm).



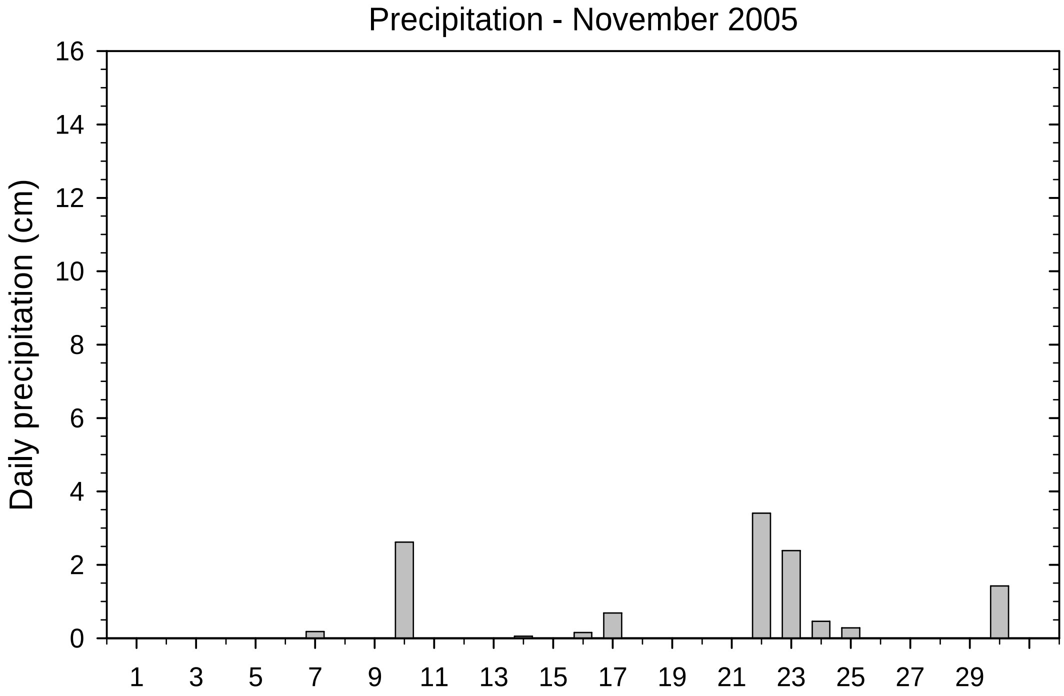


Figure C4. Average stream depth (cm) for collection dates June 4 and June 18, 2005, for all collection sites on the Eightmile River West Branch.

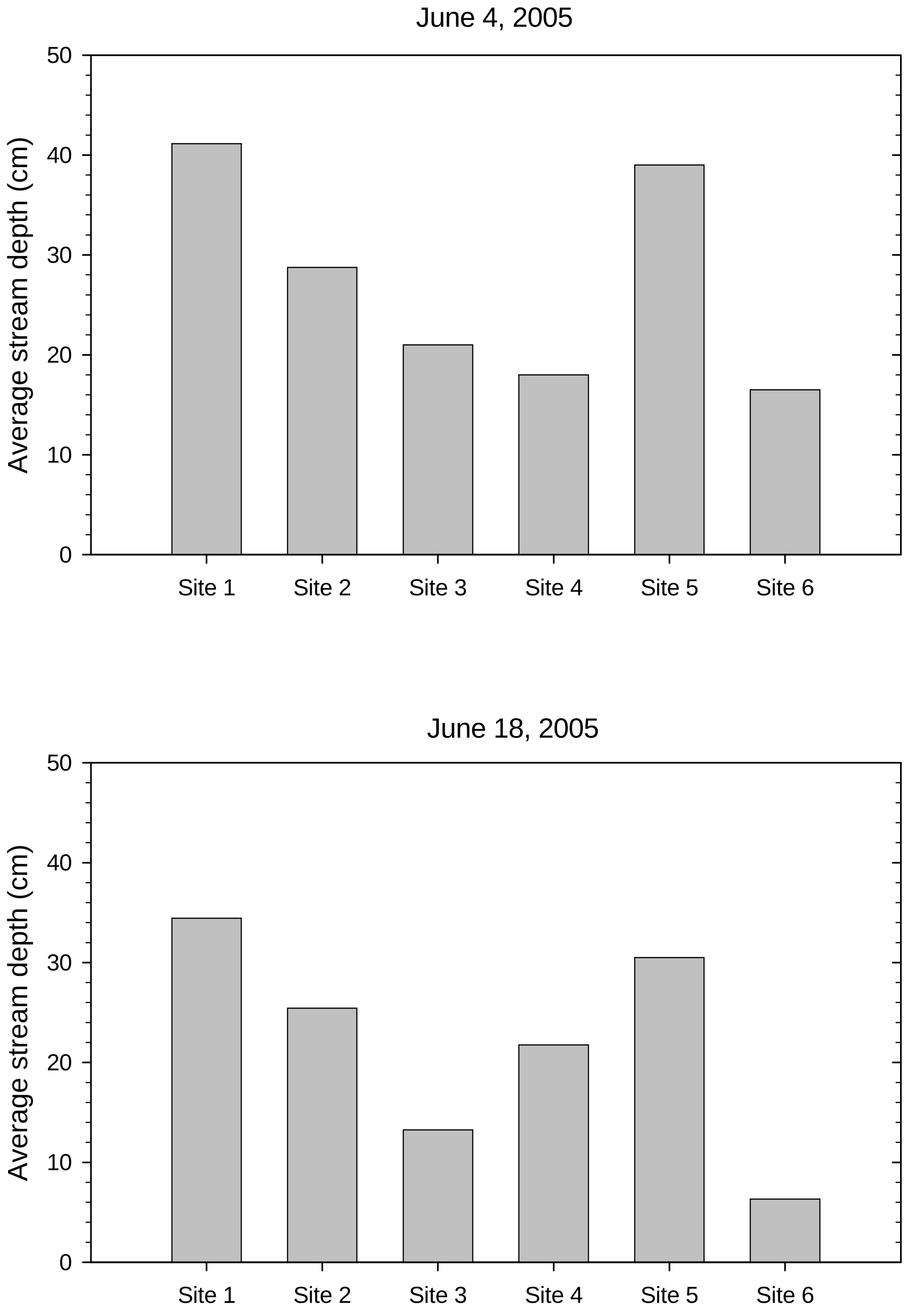
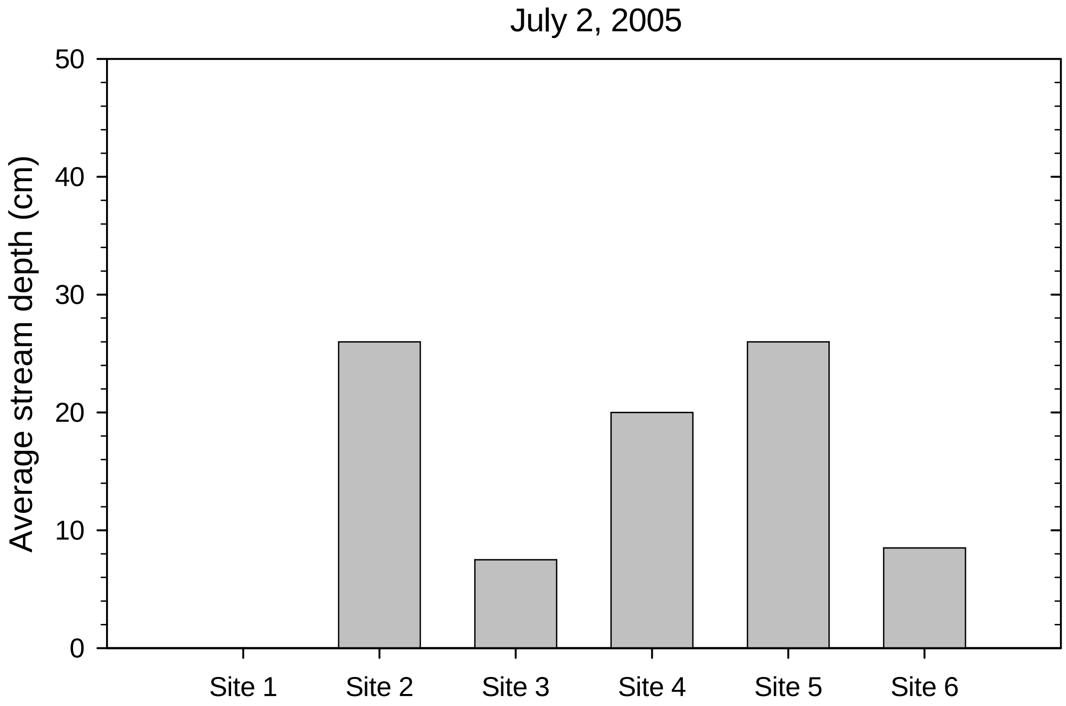


Figure C5. Average stream depth (cm) for collection dates July 2 and July 16, 2005, for all collection sites on the Eightmile River West Branch.



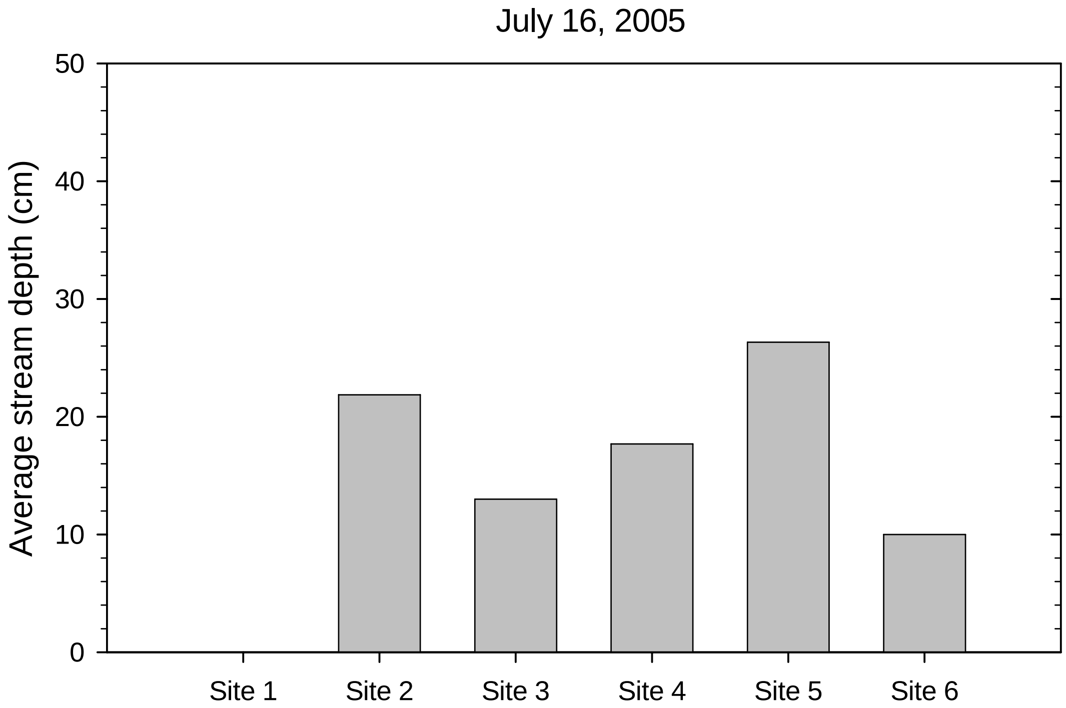
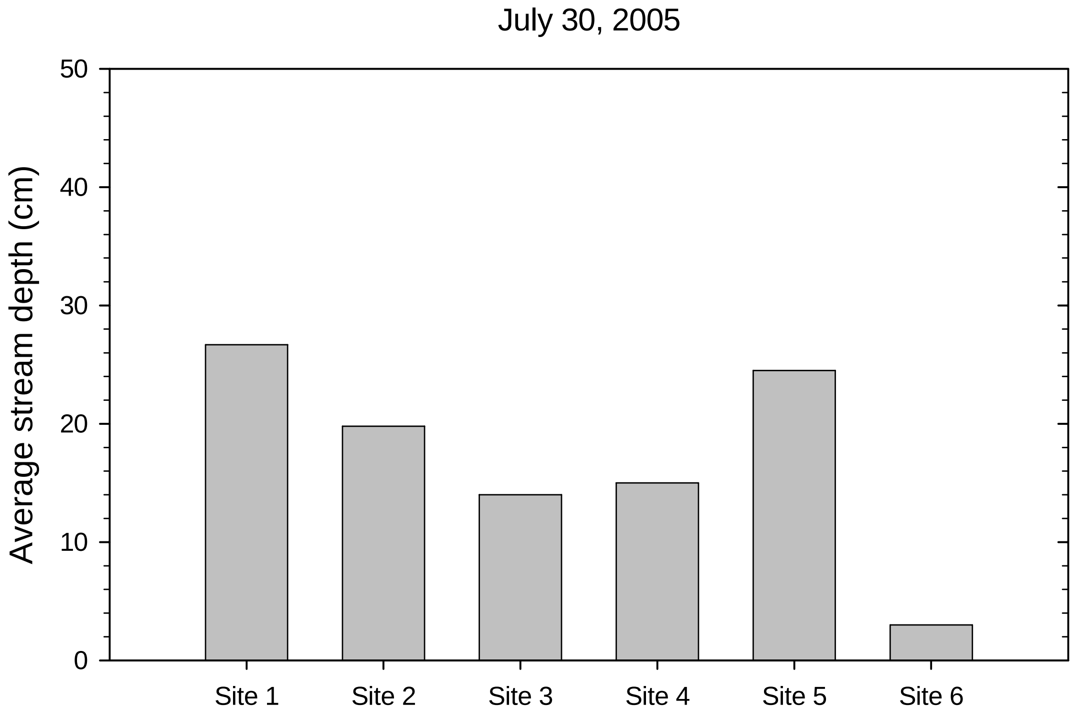


Figure C6. Average stream depth (cm) for collection dates July 30 and August 13, 2005, for all collection sites on the Eightmile River West Branch.


July 30, 2005

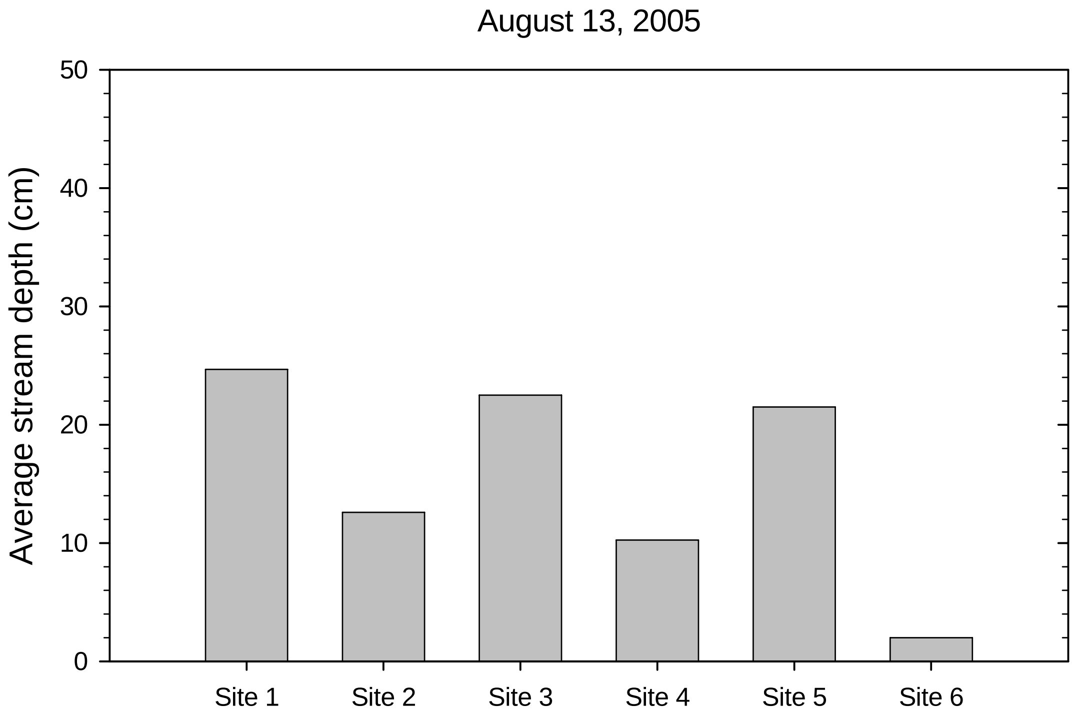
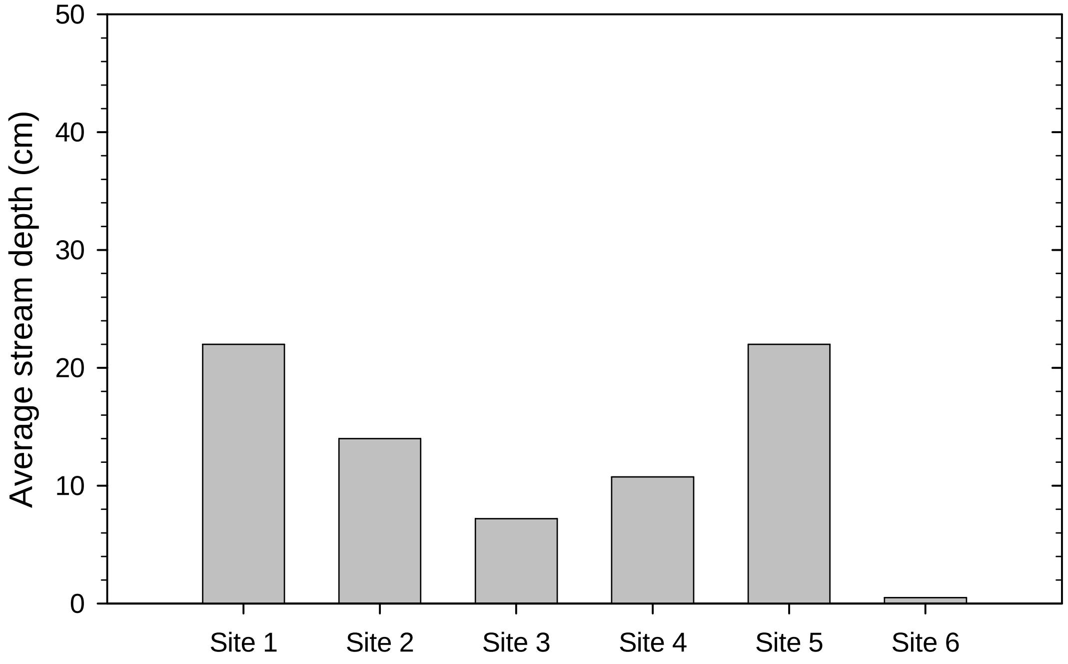

August 13, 2005

Figure C7. Average stream depth (cm) for collection dates August 27 and September 10, 2005, for all collection sites on the Eightmile River West Branch.

August 27, 2005



September 10, 2005

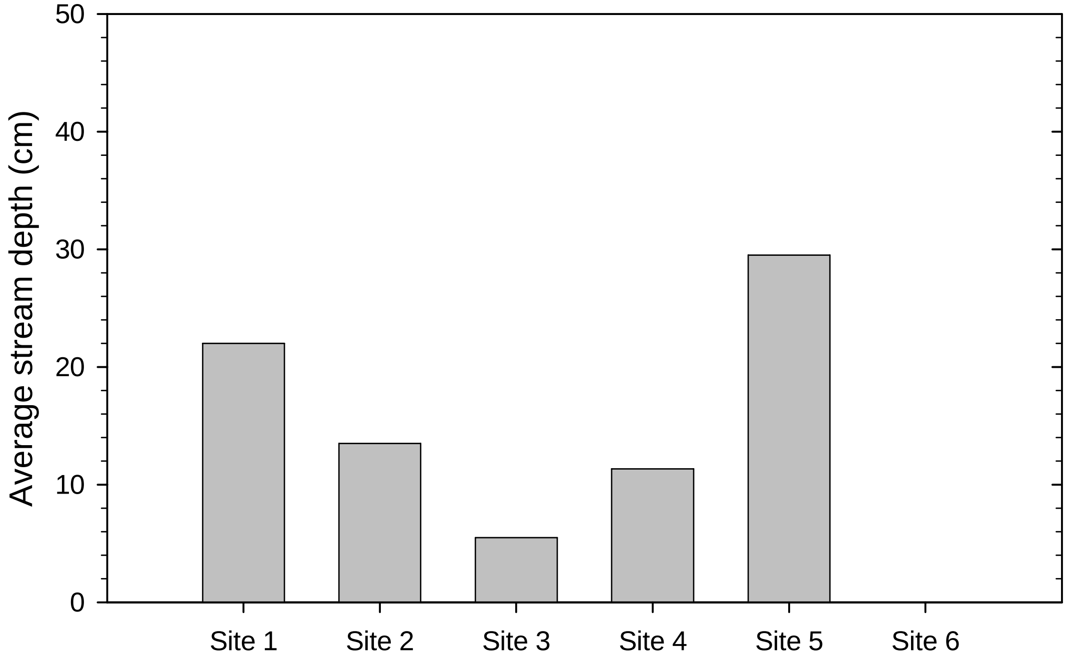
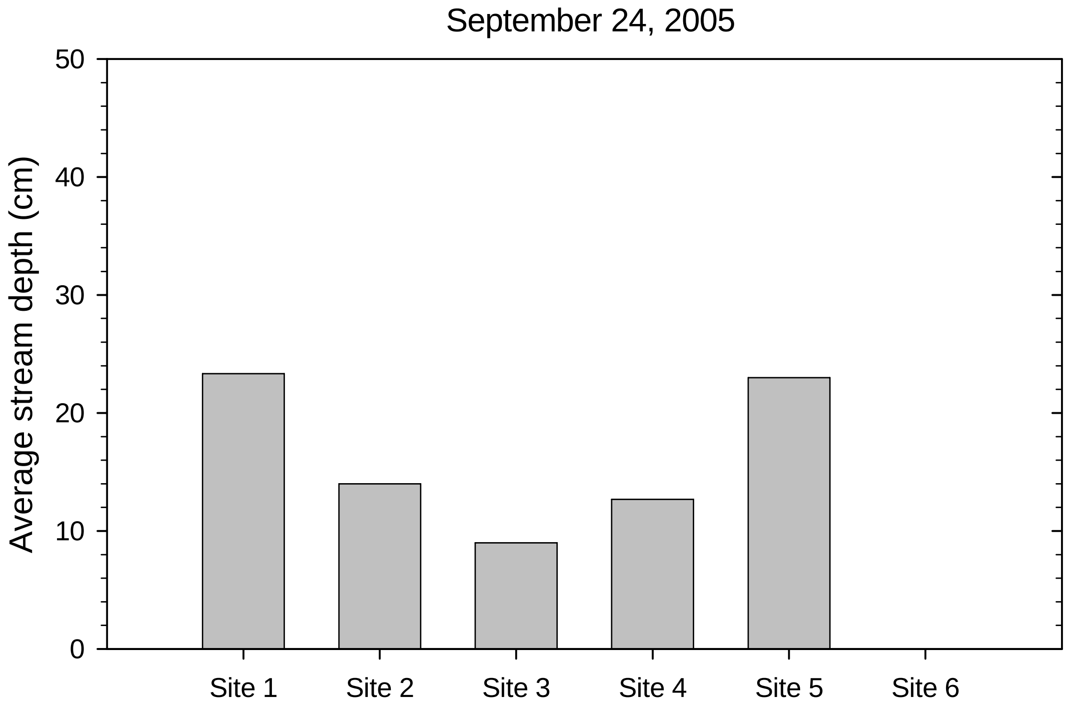


Figure C8. Average stream depth (cm) for collection dates September 24 and October 7, 2005, for all collection sites on the Eightmile River West Branch.


September 24, 2005

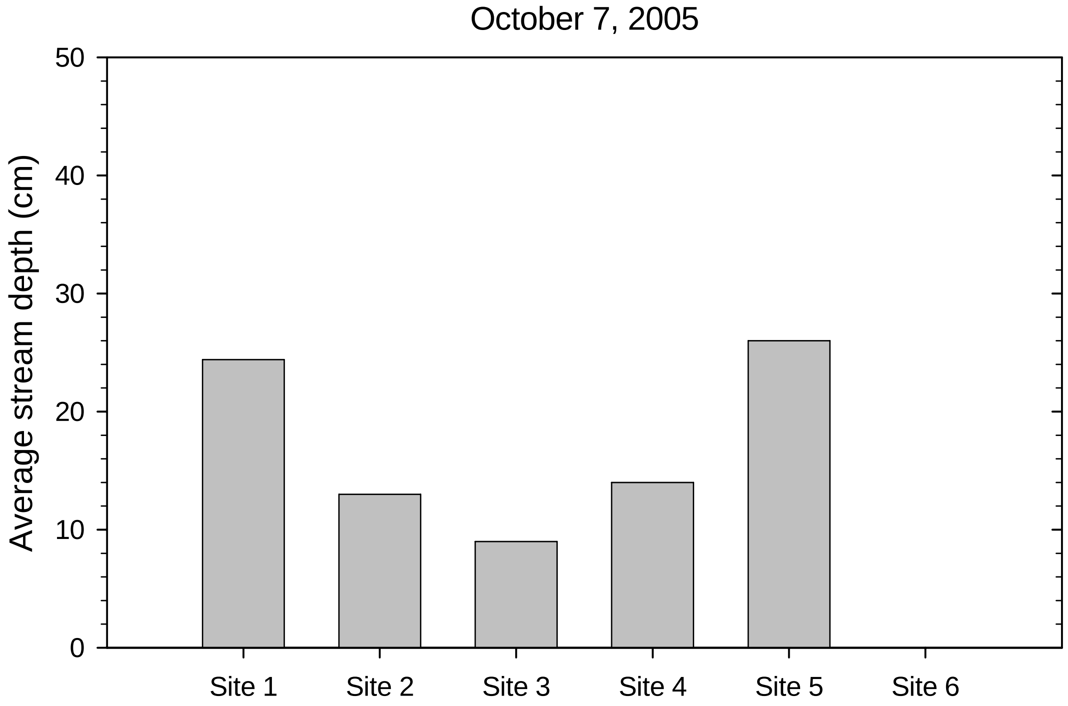

October 7, 2005

Figure C9. Average stream depth (cm) for collection date October 22, 2005, for all collection sites on the Eightmile River West Branch.

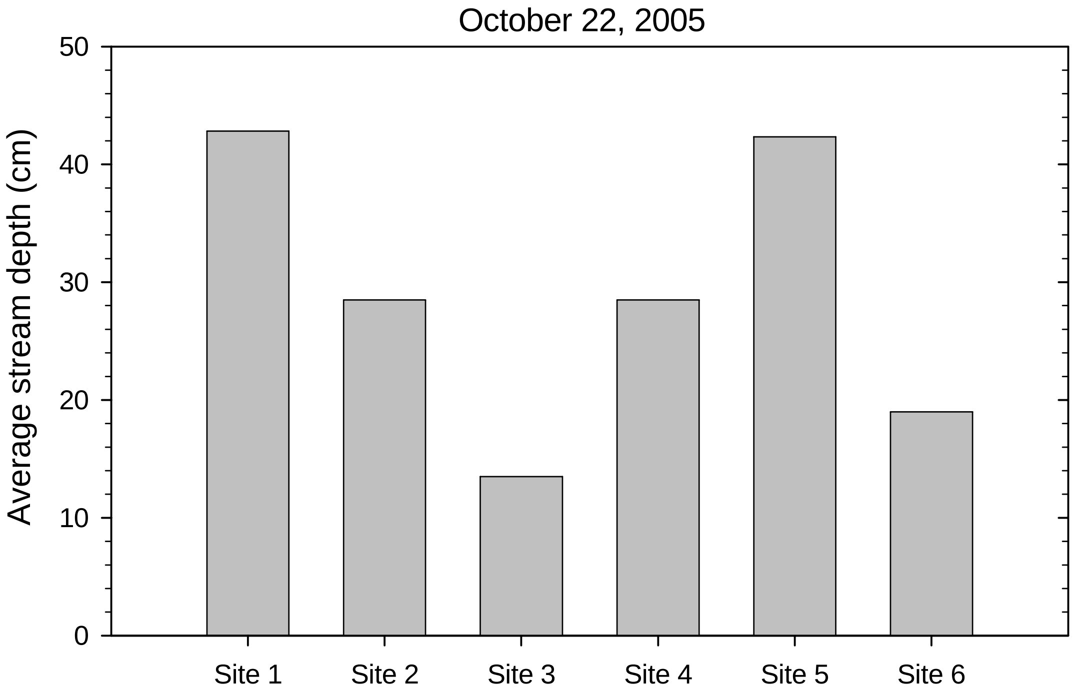
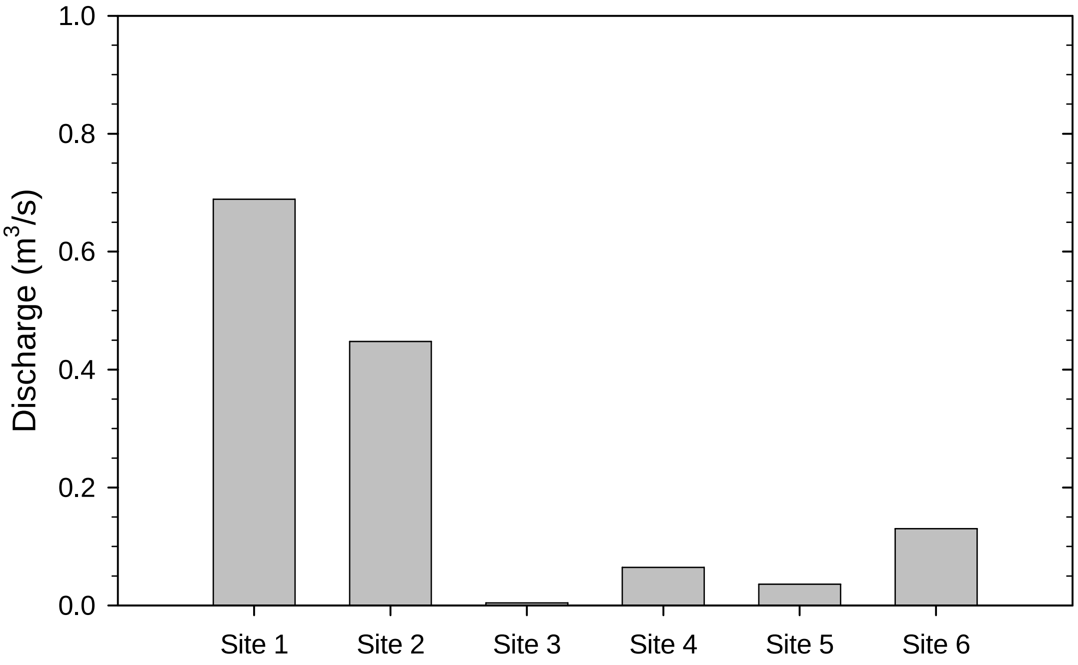


Figure C10. Discharge (m^3/s) for collection dates June 4 and June 18, 2005, for all collection sites on the Eightmile River West Branch.


June 4, 2005

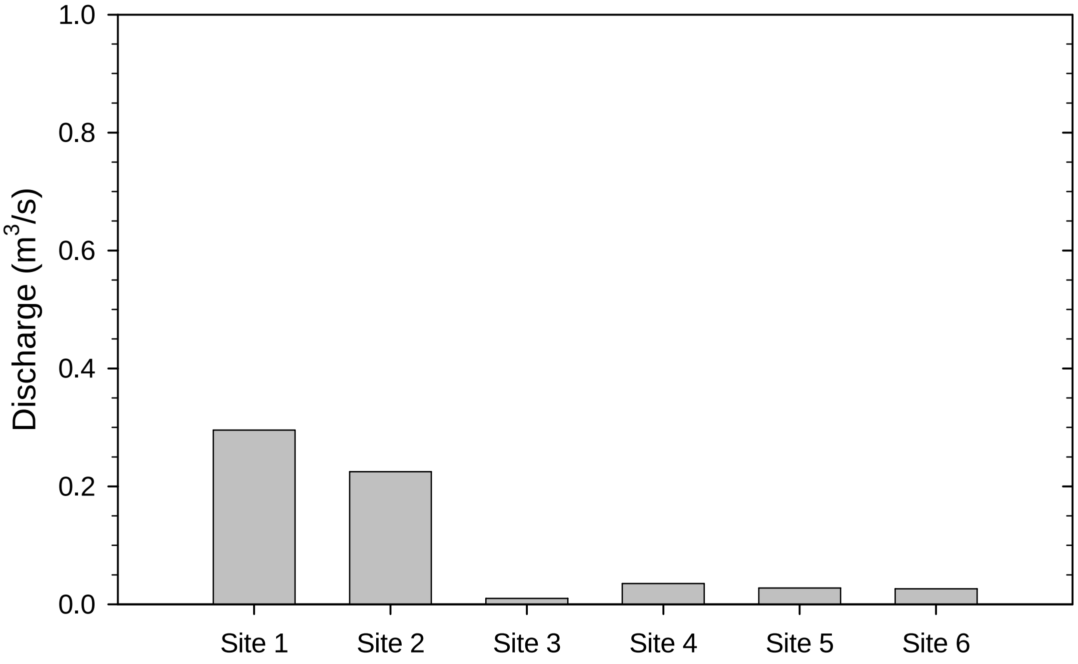

June 18, 2005

Figure C11. Discharge (m^3/s) for collection dates July 2 and July 16, 2005, for all collection sites on the Eightmile River West Branch.

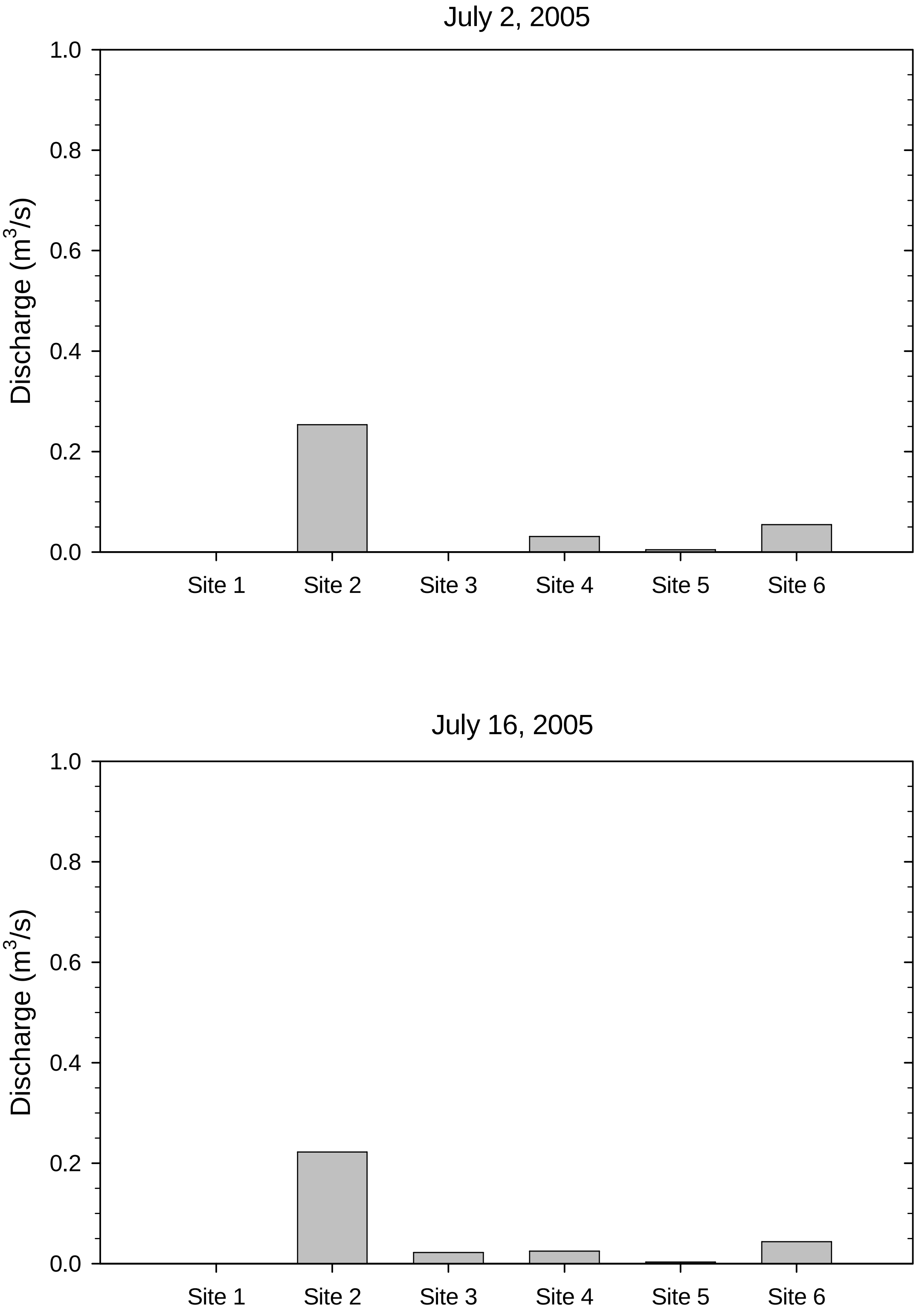
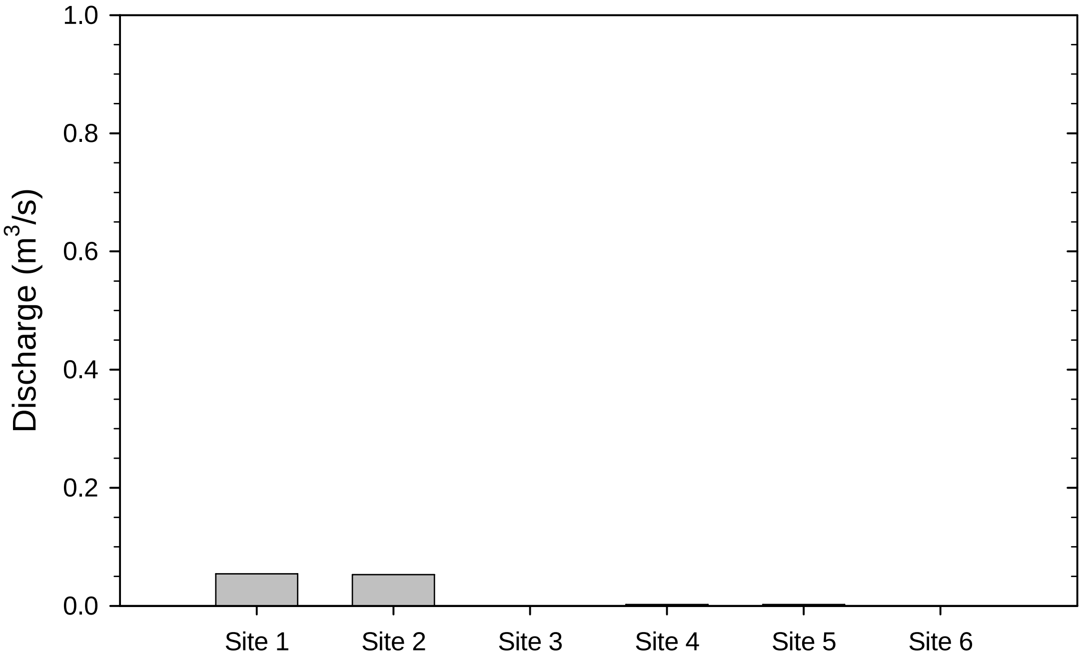


Figure C12. Discharge (m^3/s) for collection dates July 30 and August 13, 2005, for all collection sites on the Eightmile River West Branch.

July 30, 2005



August 13, 2005

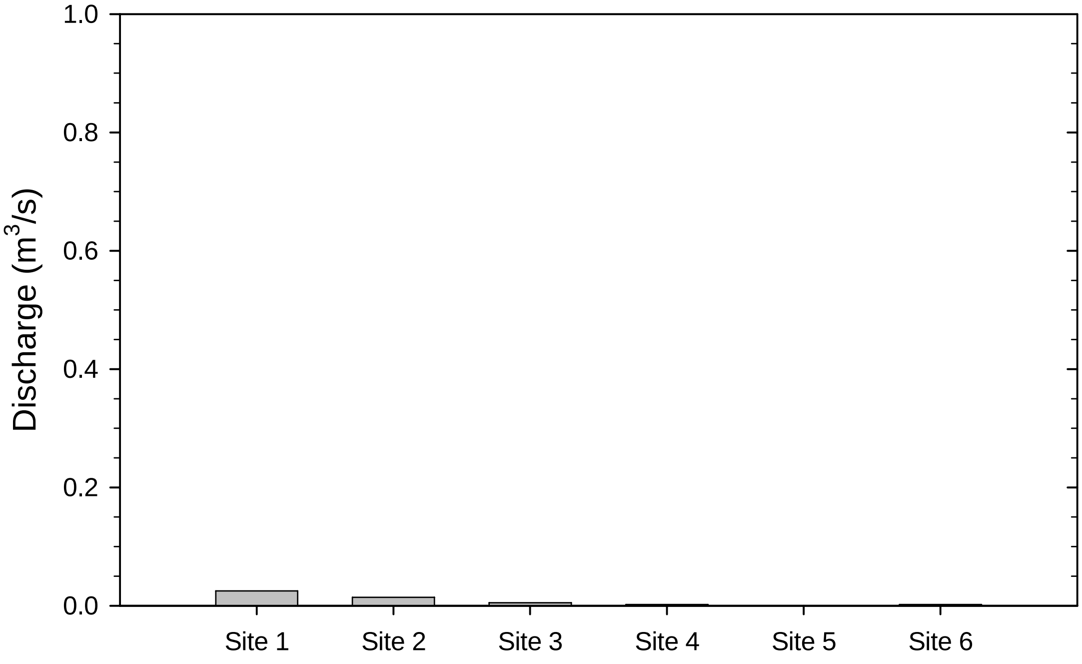
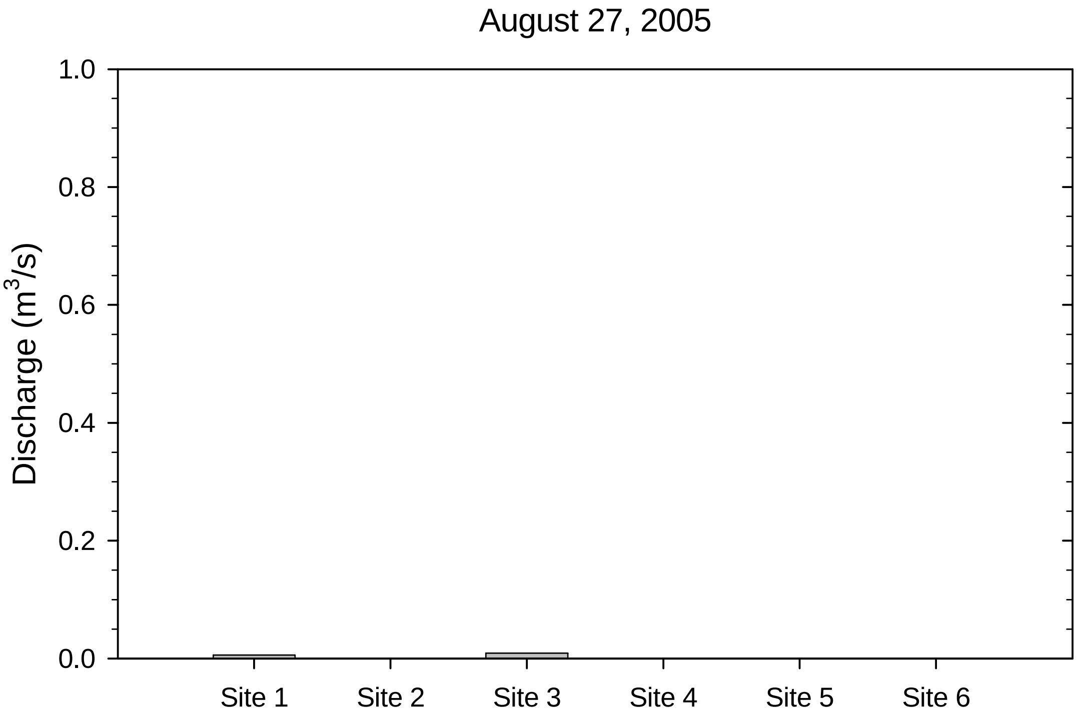


Figure C13. Discharge (m^3/s) for collection dates August 27 and September 10, 2005, for all collection sites on the Eightmile River West Branch.



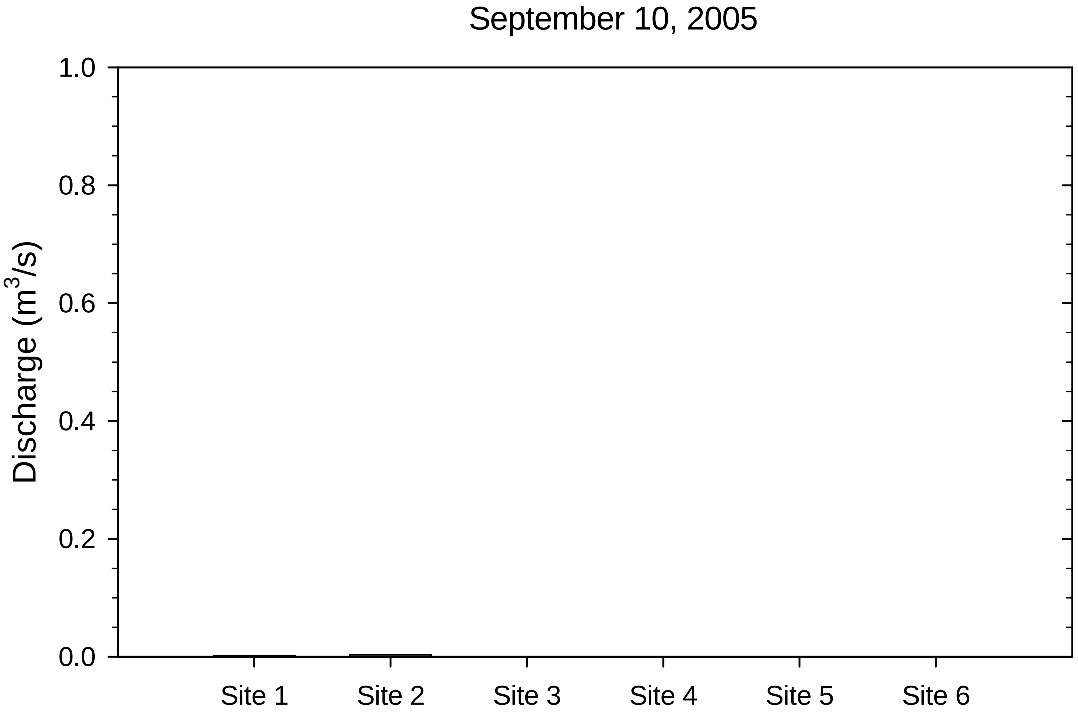
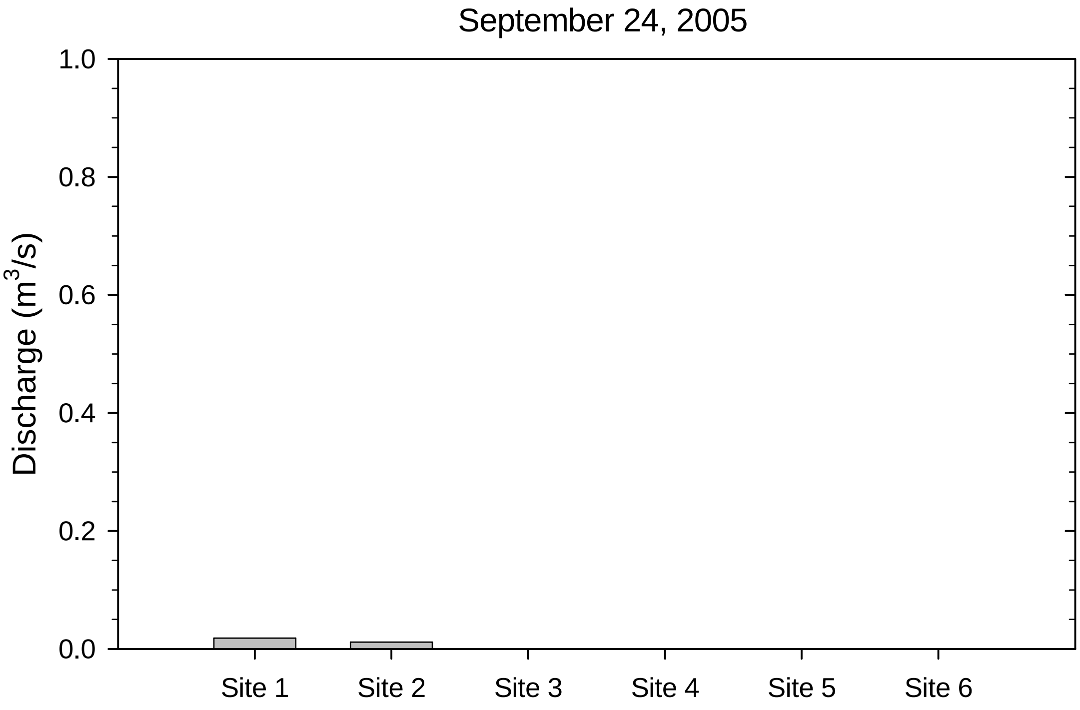


Figure C14. Discharge (m^3/s) for collection dates September 24 and October 7, 2005, for all collection sites on the Eightmile River West Branch.



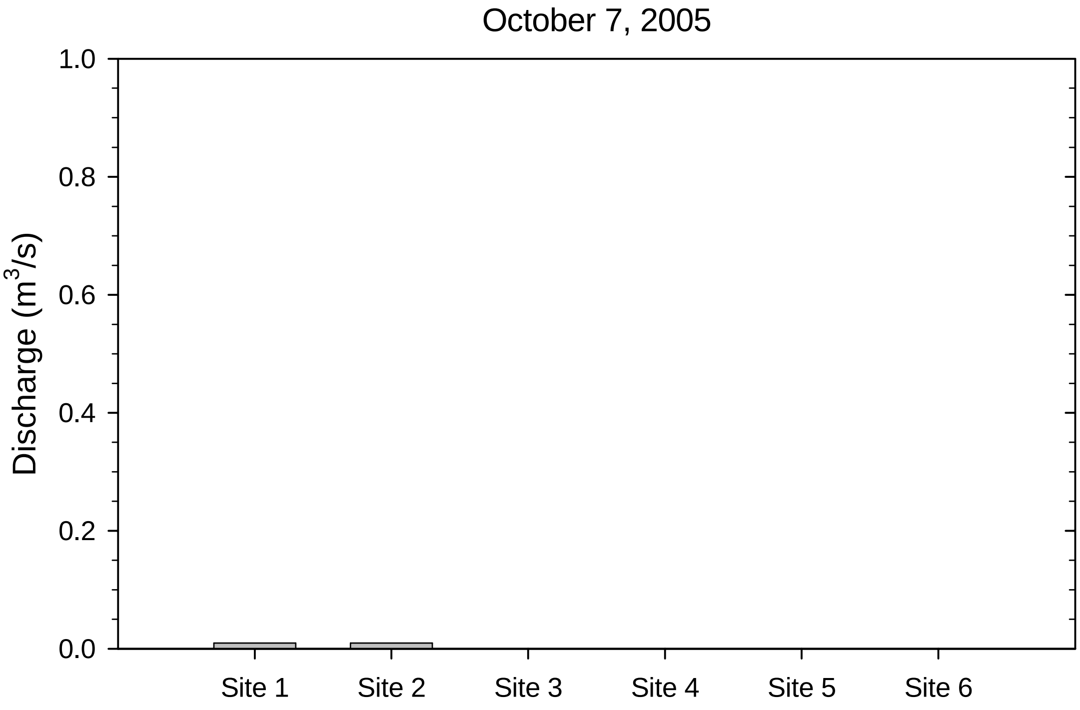


Figure C15. Discharge (m^3/s) for collection date October 22, 2005, for all collection sites on the Eightmile River West Branch.

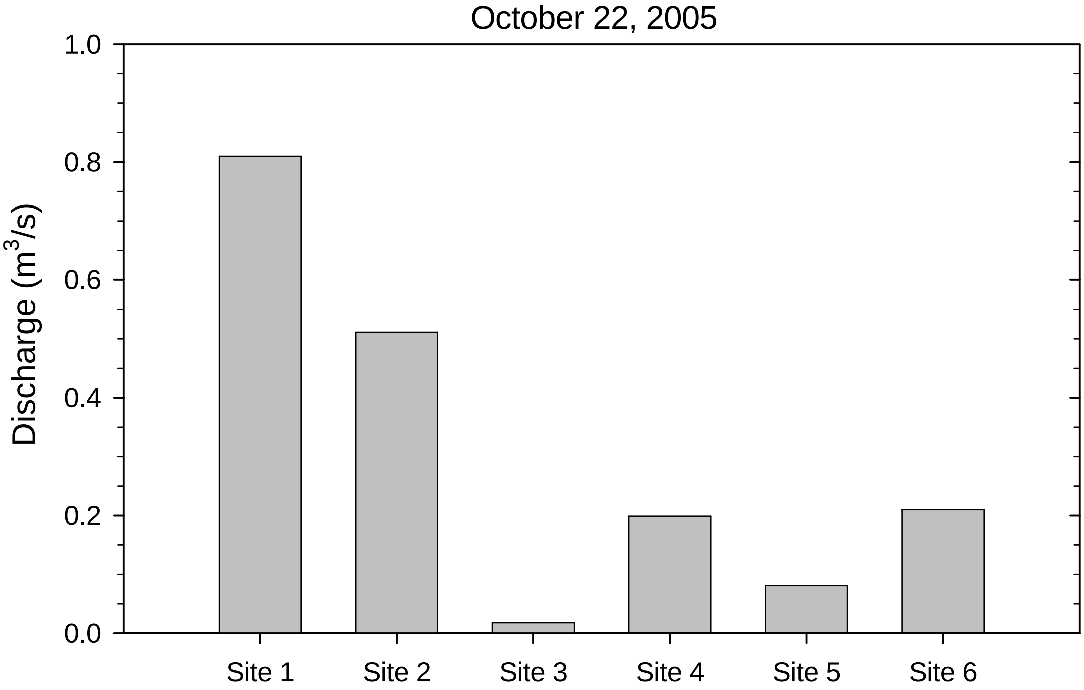
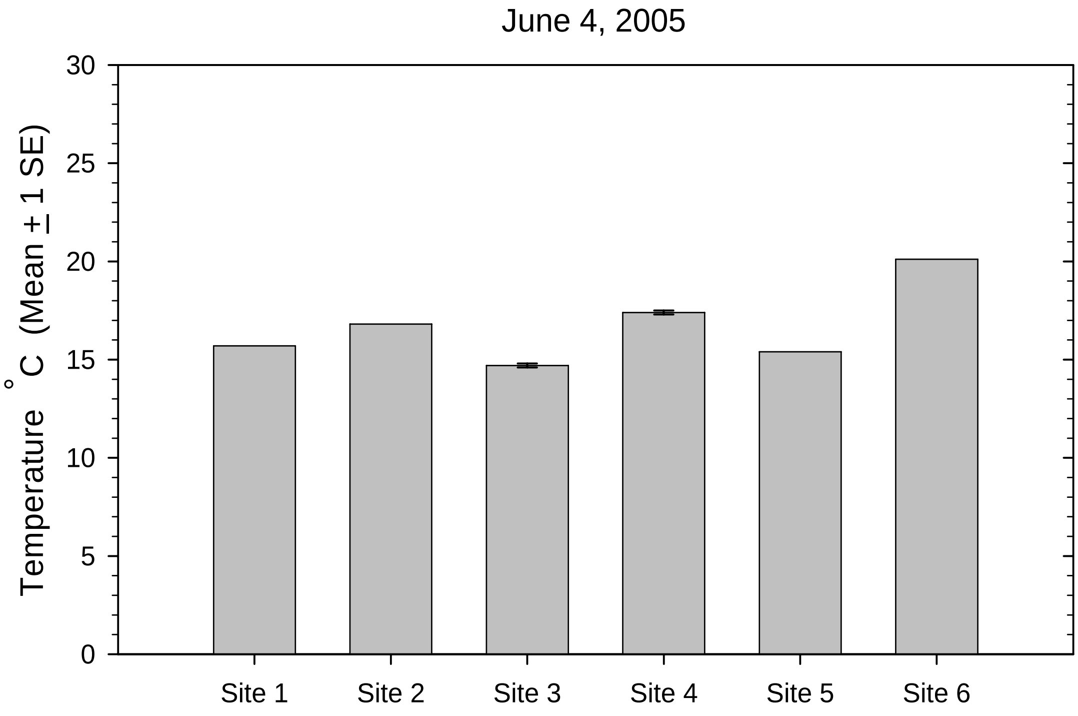


Figure C16. Temperature (° C, mean ± 1 SE) for collection dates June 4 and June 18, 2005, for all collection sites on the Eightmile River West Branch.



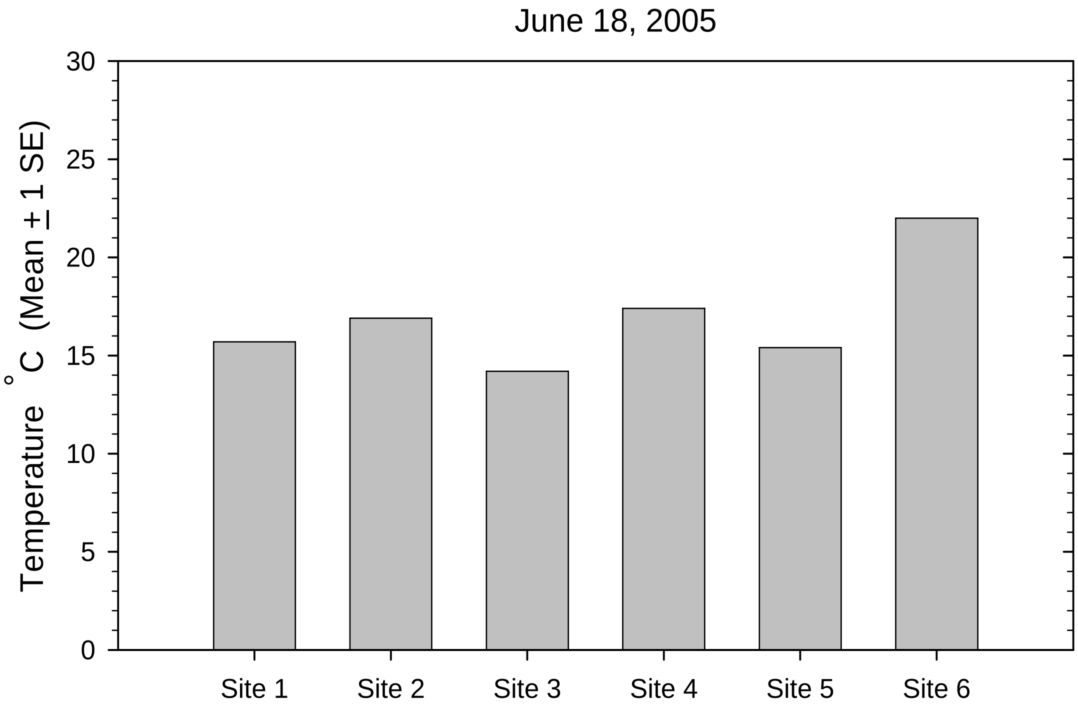
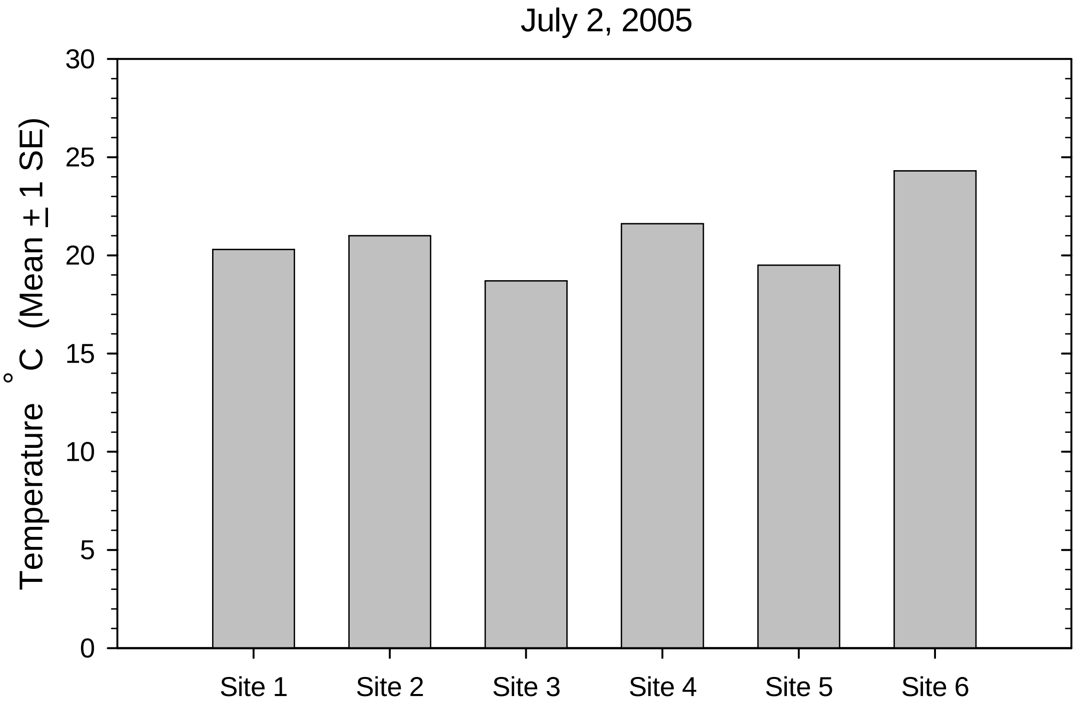


Figure C17. Temperature (° C, mean ± 1 SE) for collection dates July 2 and July 16, 2005, for all collection sites on the Eightmile River West Branch.



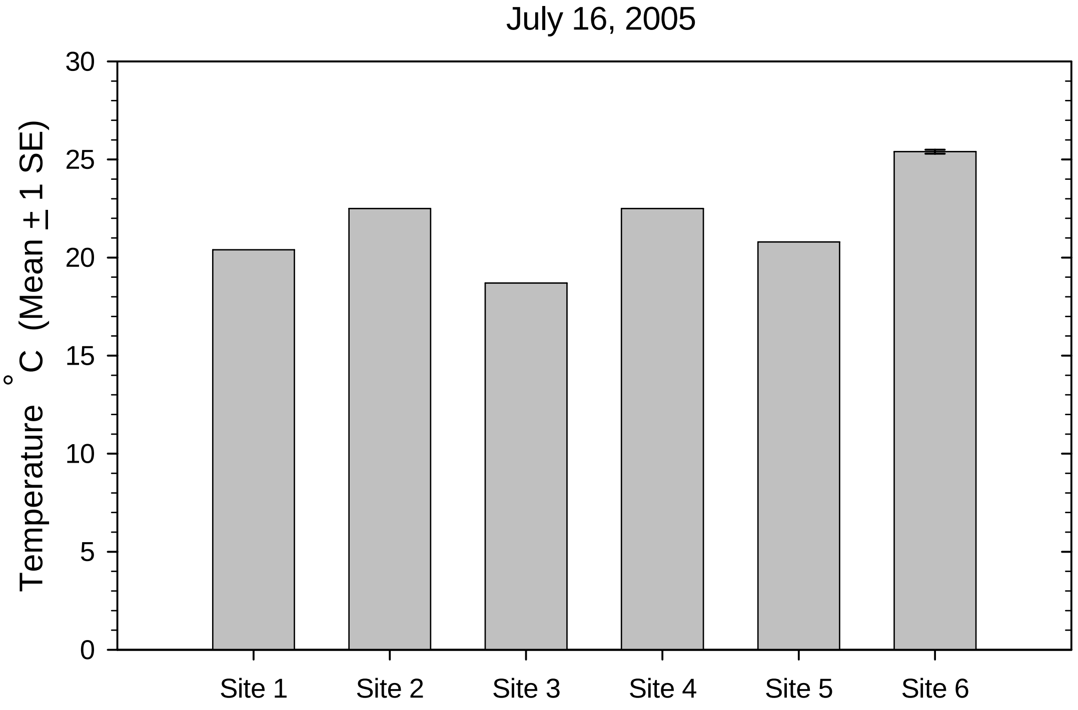
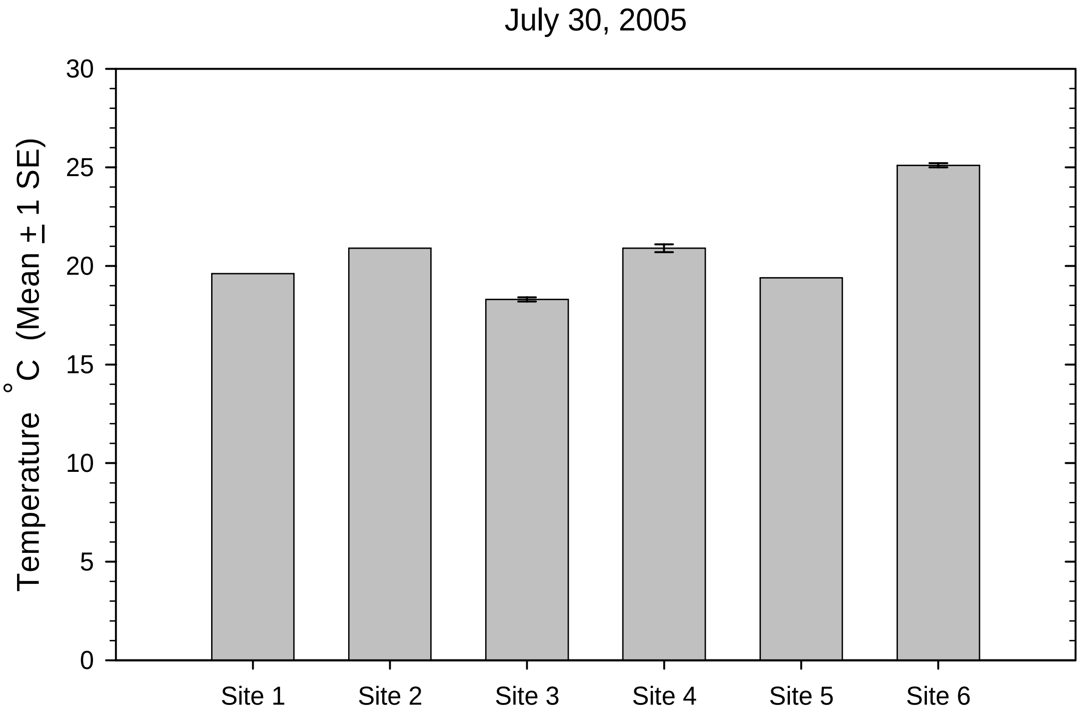


Figure C18. Temperature (° C, mean ± 1 SE) for collection dates July 30 and August 13, 2005, for all collection sites on the Eightmile River West Branch.


July 30, 2005

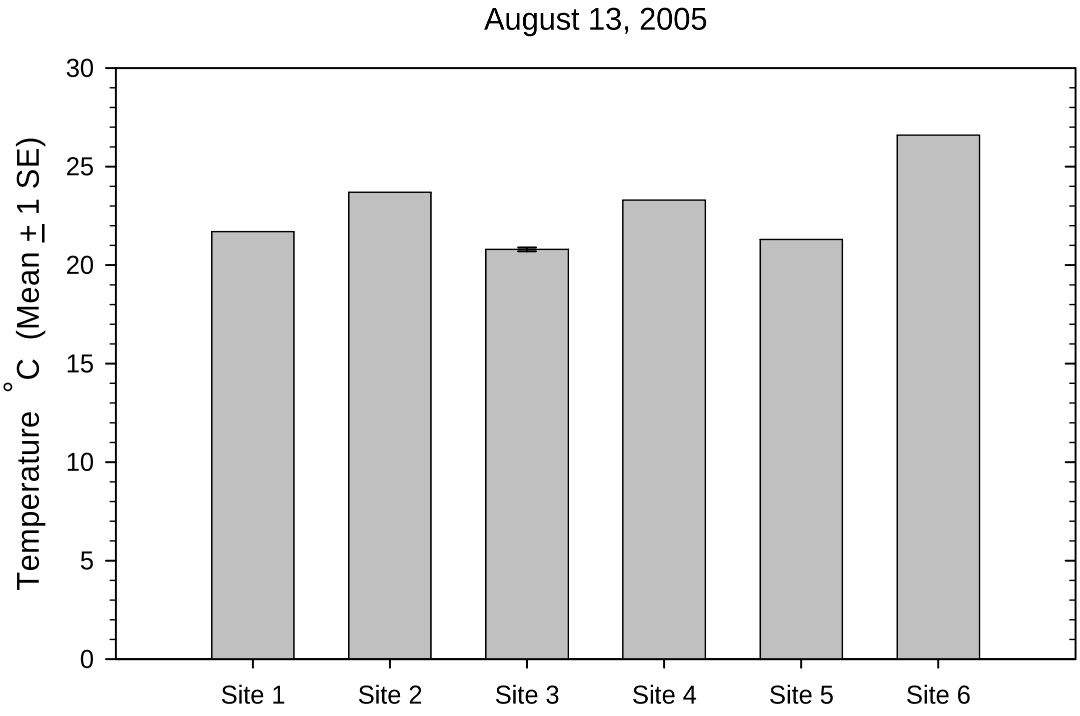

August 13, 2005

Figure C19. Temperature (° C, mean ± 1 SE) for collection dates August 27 and September 10, 2005, for all collection sites on the Eightmile River West Branch.

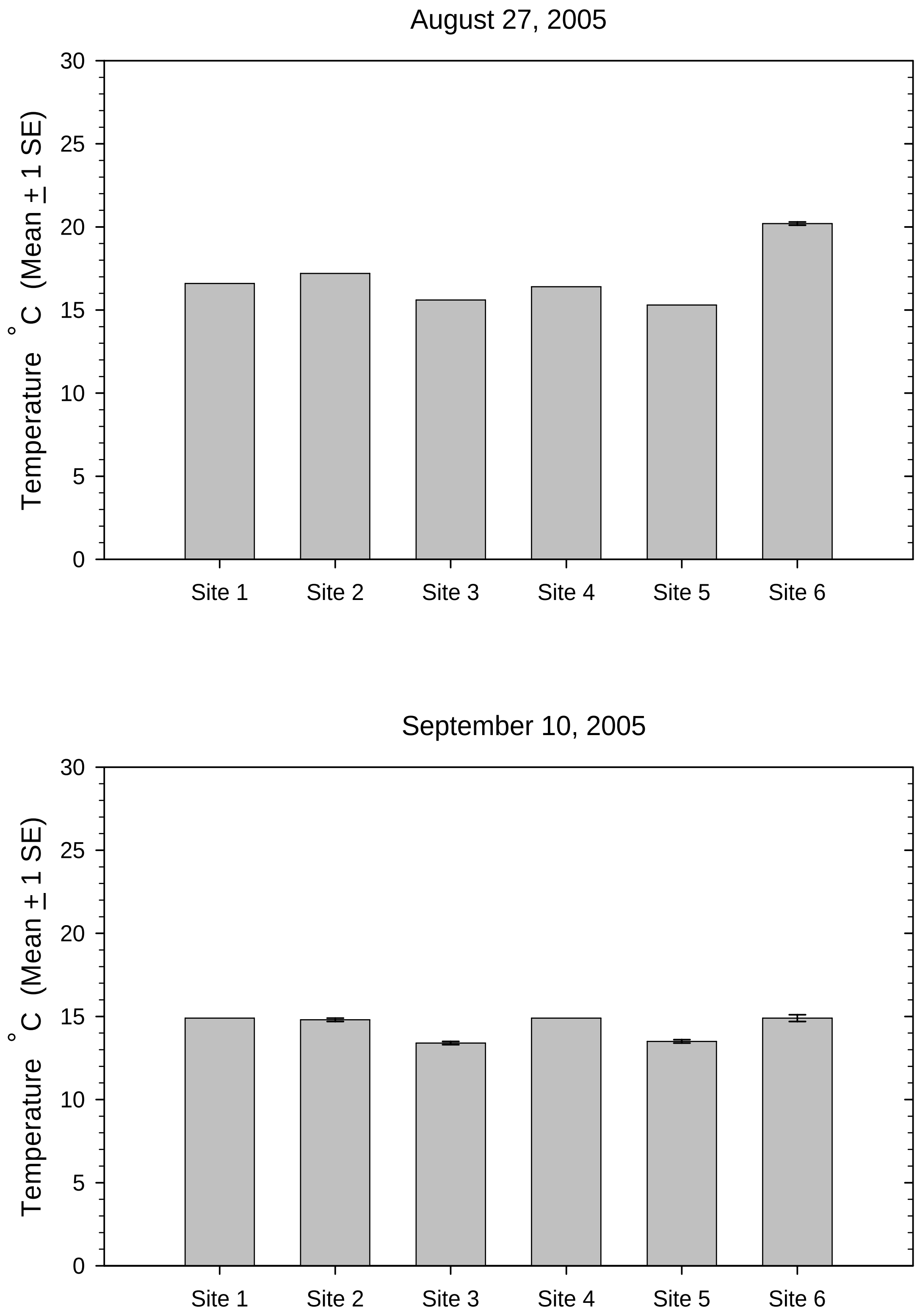
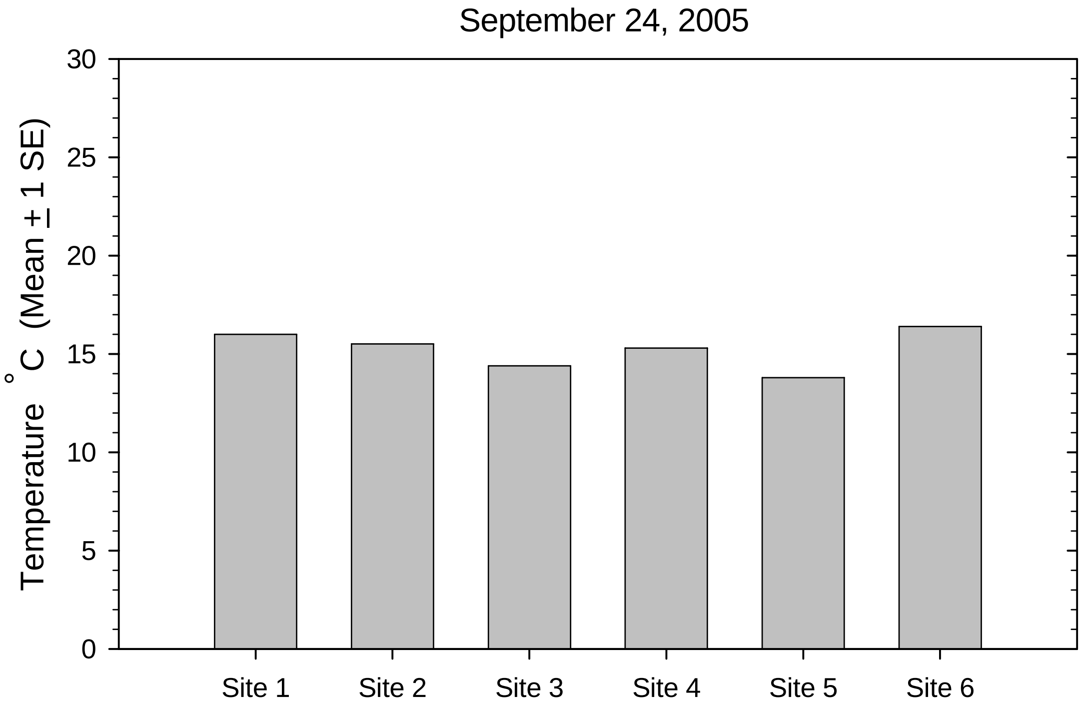


Figure C20. Temperature (° C, mean ± 1 SE) for collection dates September 24 and October 7, 2005, for all collection sites on the Eightmile River West Branch.



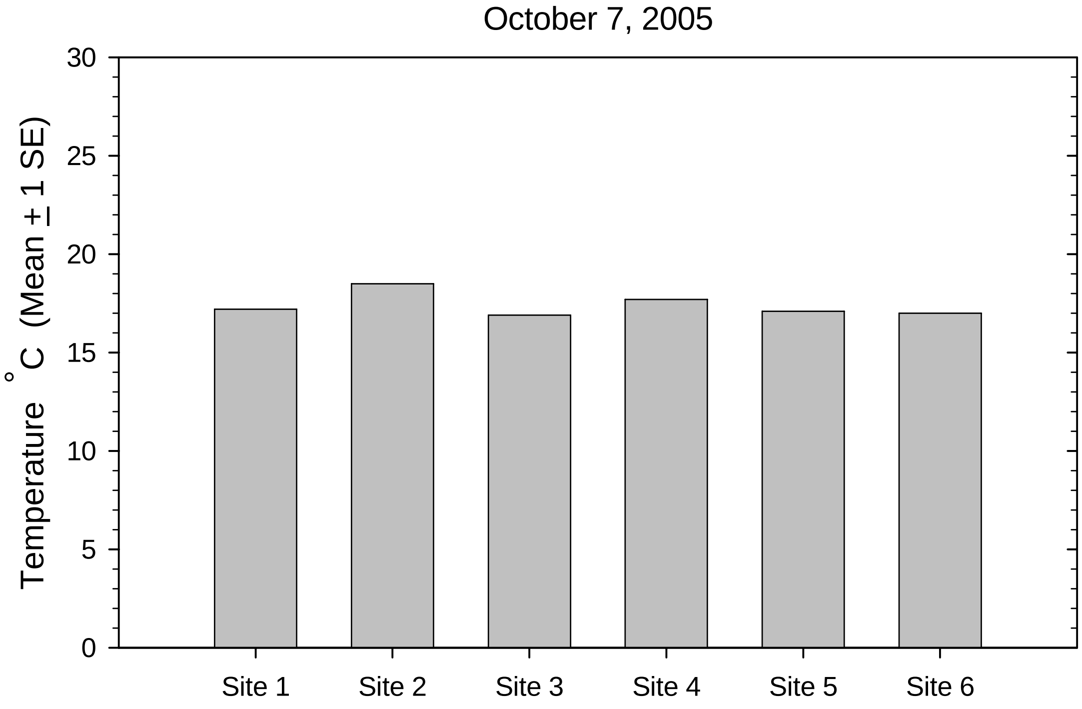


Figure C21. Temperature (° C, mean ± 1 SE) for collection date October 22, 2005, for all collection sites on the Eightmile River West Branch.

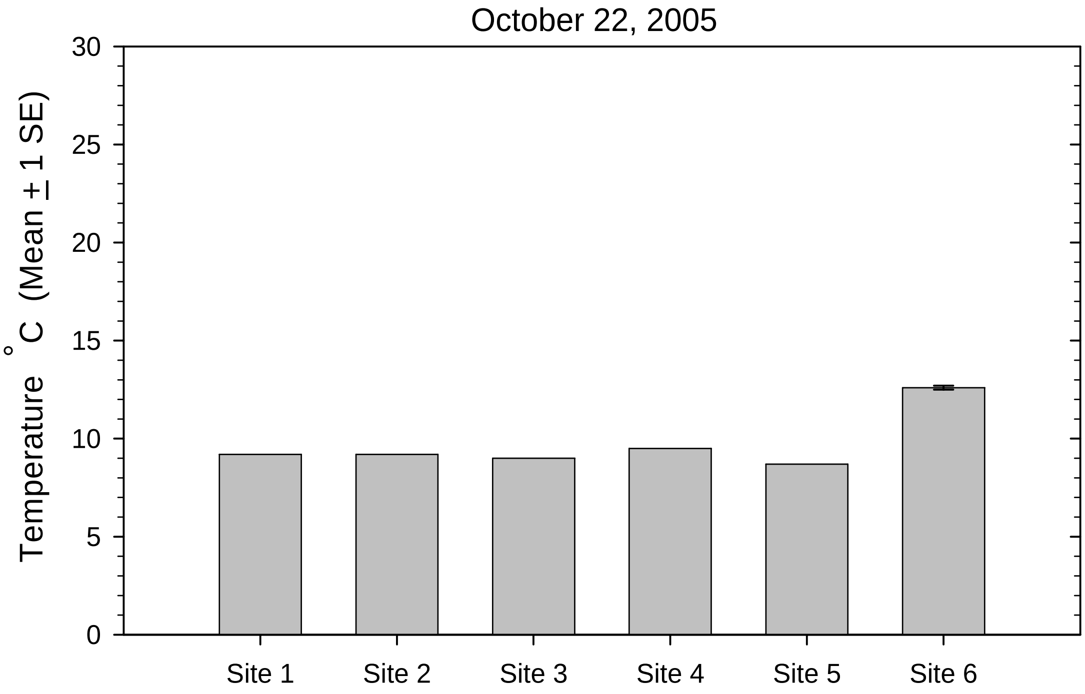
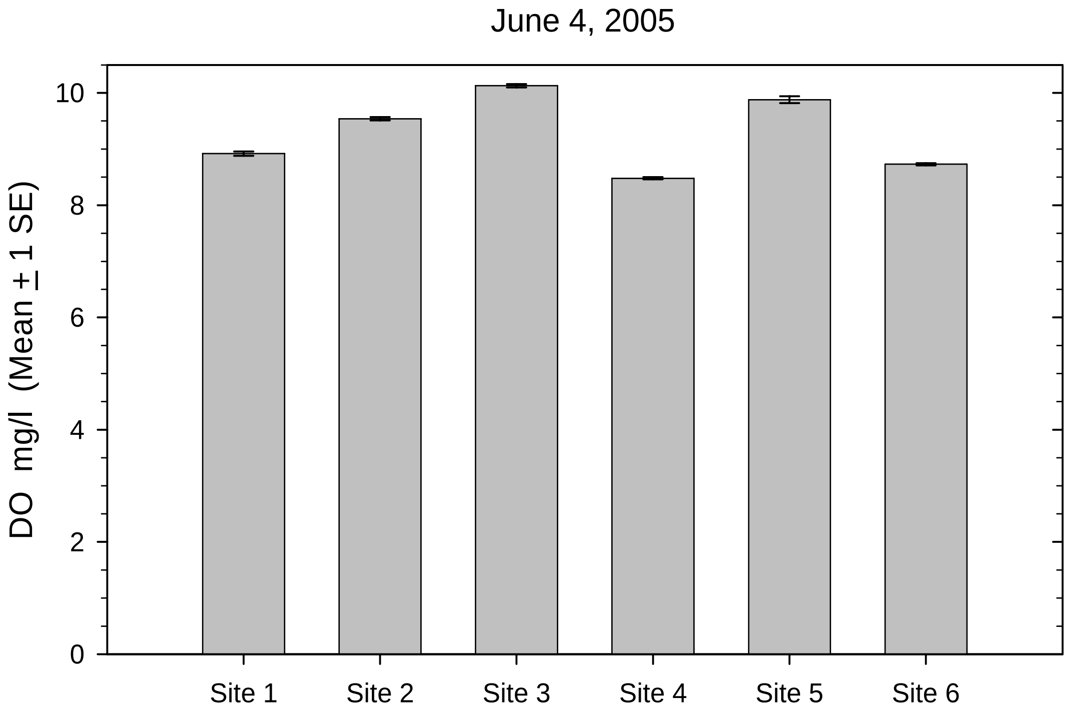


Figure C22. Dissolved oxygen (mg/l, mean ± 1 SE) for collection dates June 4 and June 18, 2005, for all collection sites on the Eightmile River West Branch.



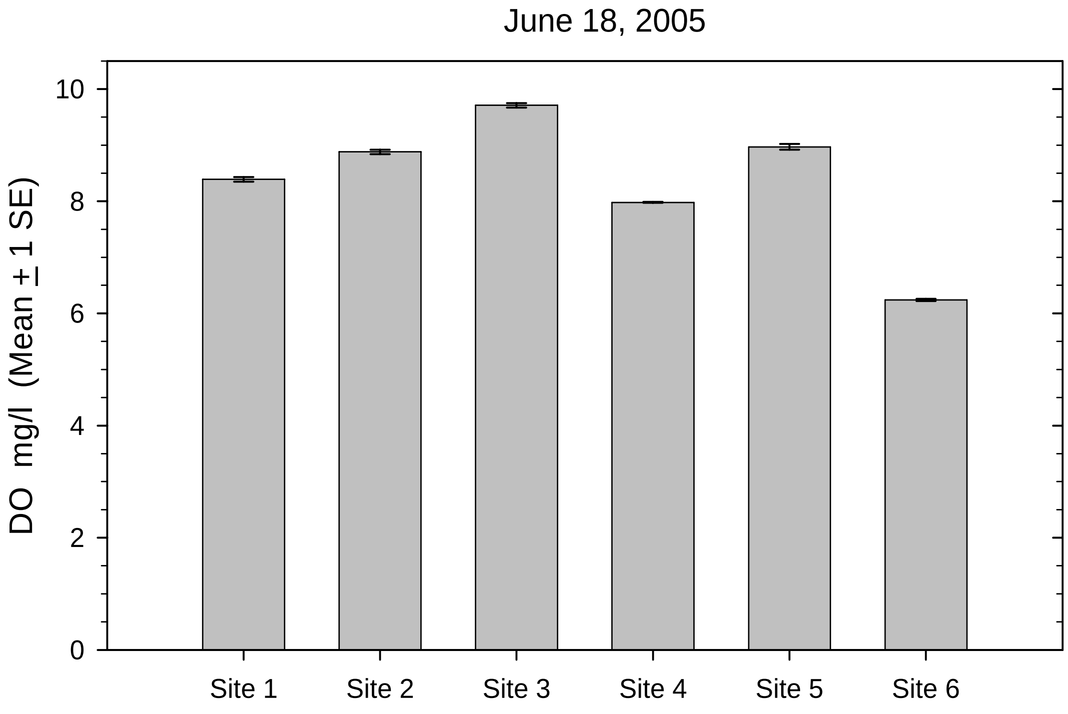
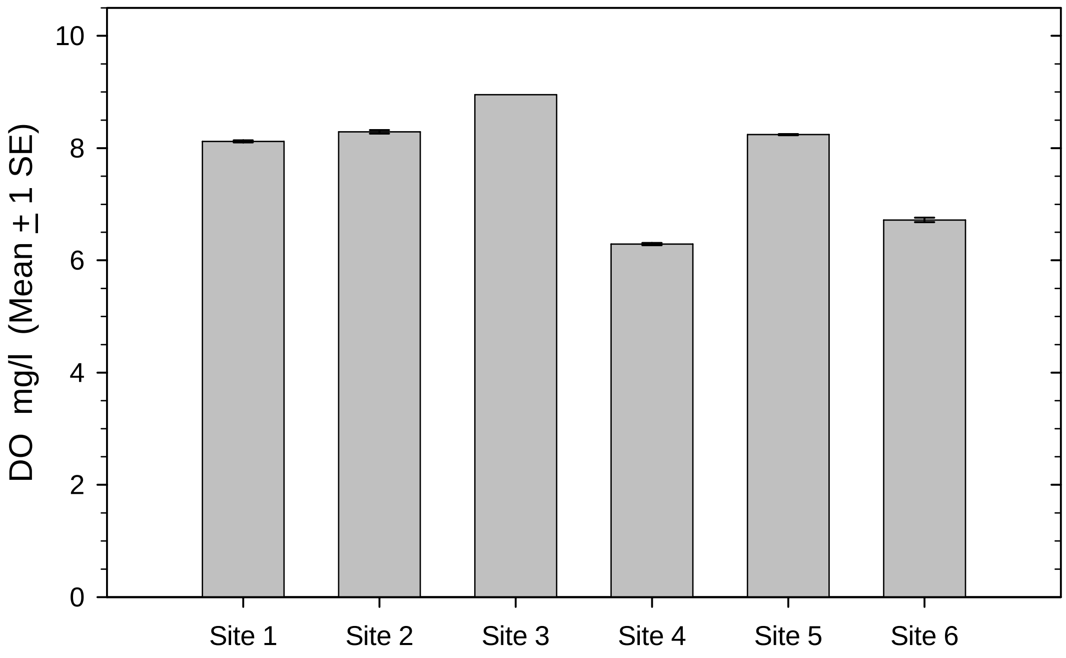


Figure C23. Dissolved oxygen (mg/l, mean ± 1 SE) for collection dates July 2 and July 16, 2005, for all collection sites on the Eightmile River West Branch.

July 2, 2005



July 16, 2005

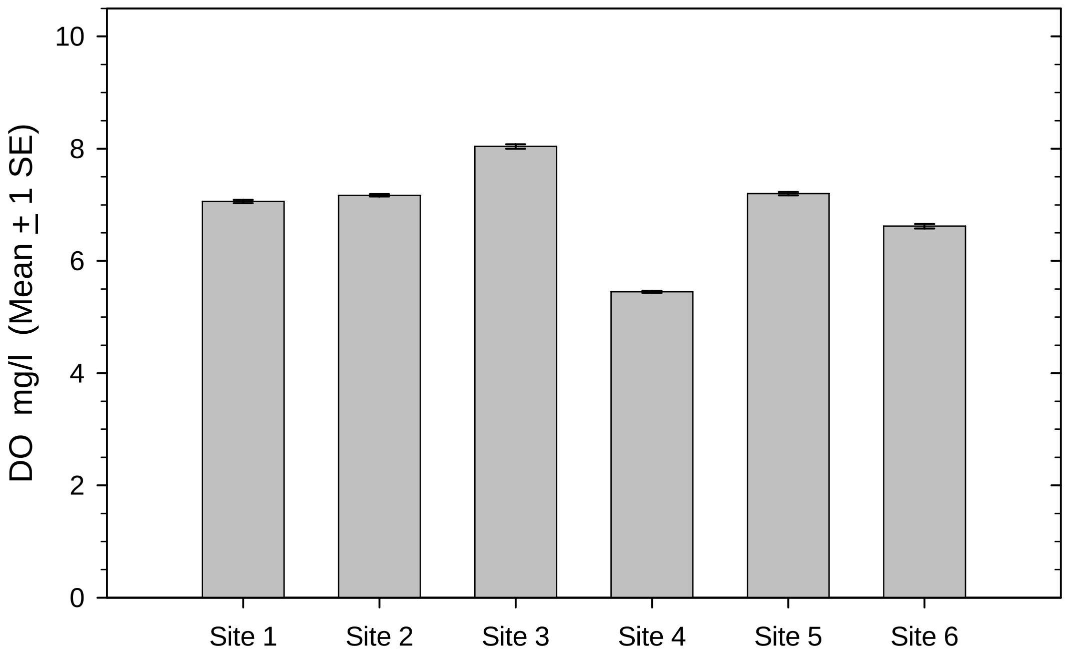
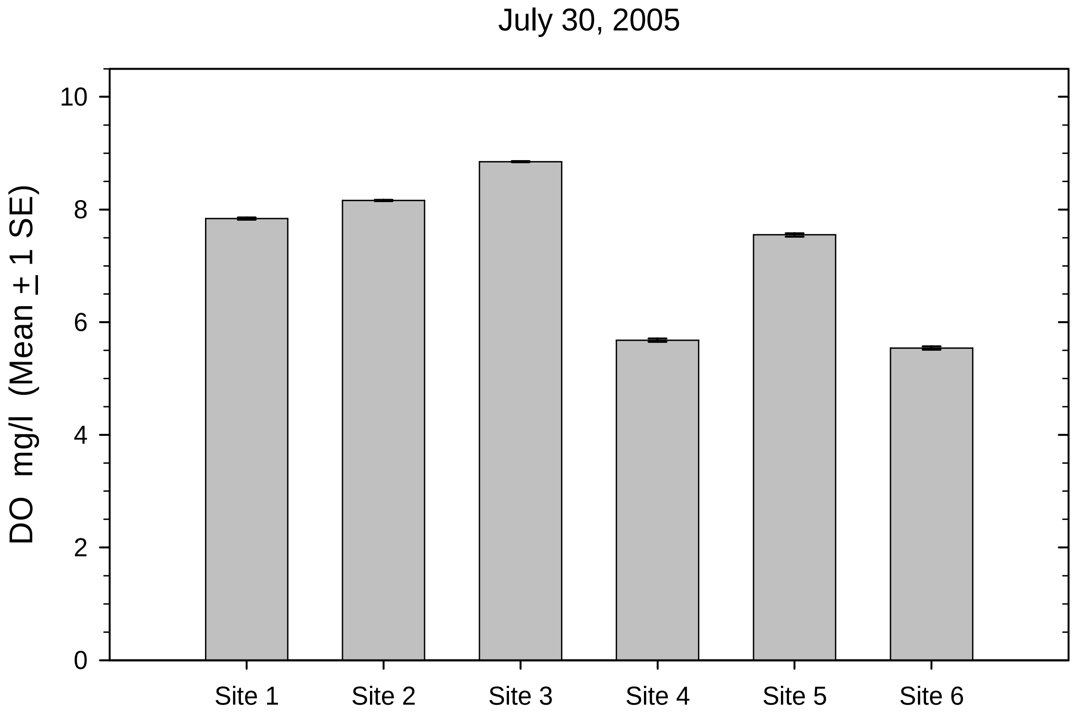


Figure C24. Dissolved oxygen (mg/l, mean ± 1 SE) for collection dates July 30 and August 13, 2005, for all collection sites on the Eightmile River West Branch.



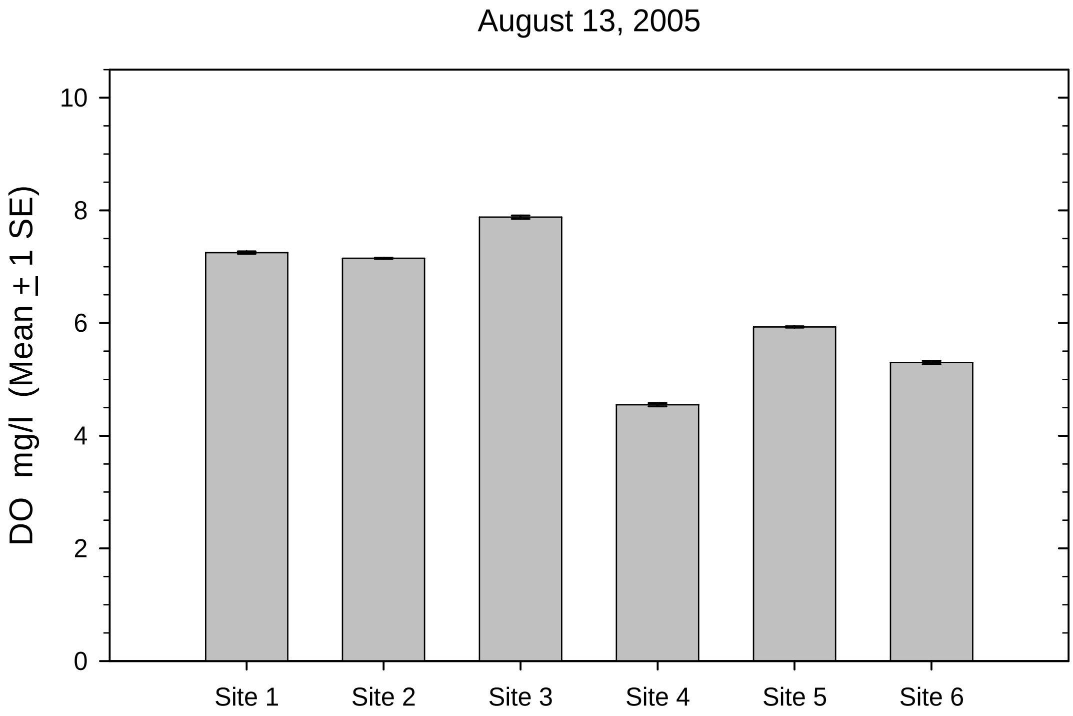
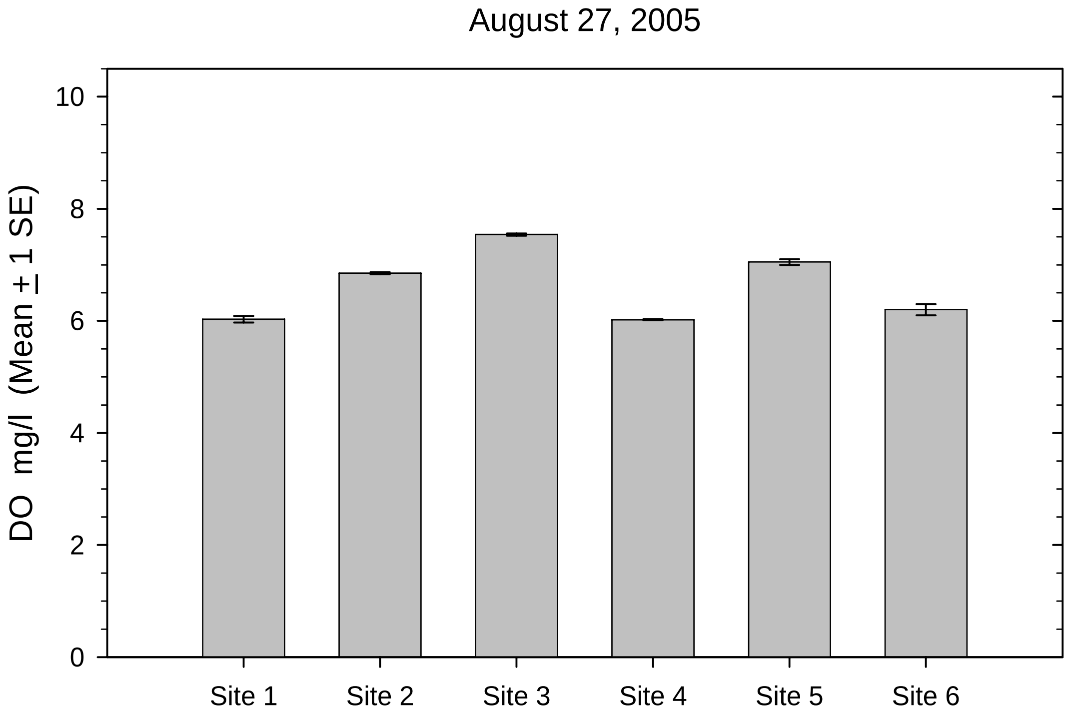


Figure C25. Dissolved oxygen (mg/l, mean ± 1 SE) for collection dates August 27 and September 10, 2005, for all collection sites on the Eightmile River West Branch.



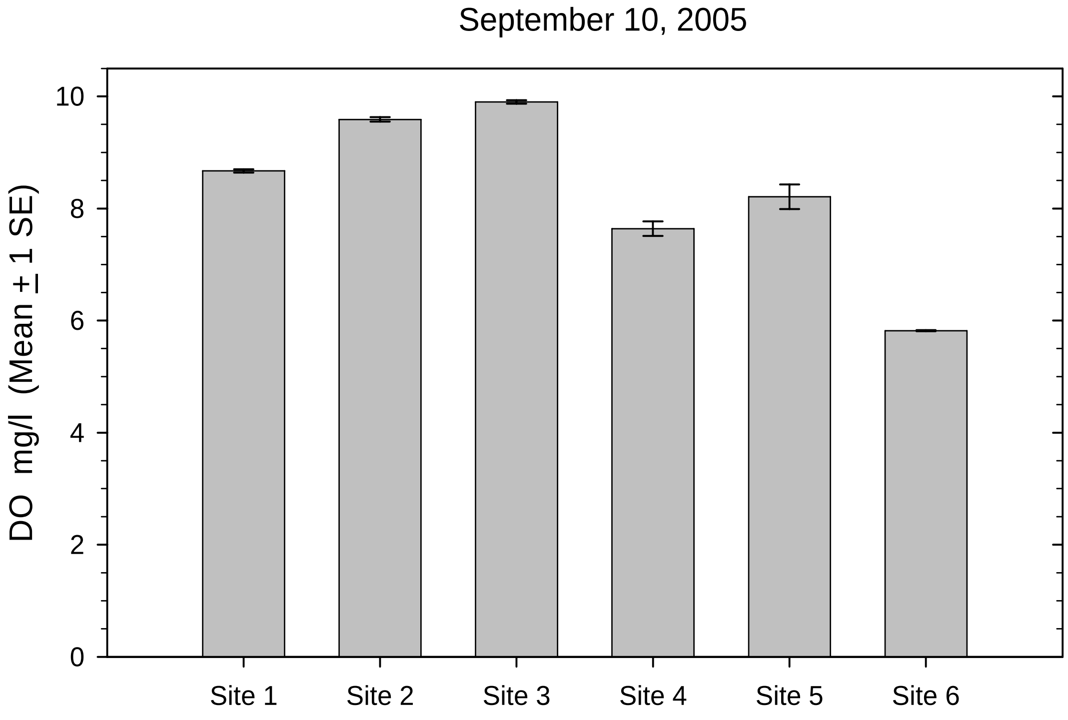
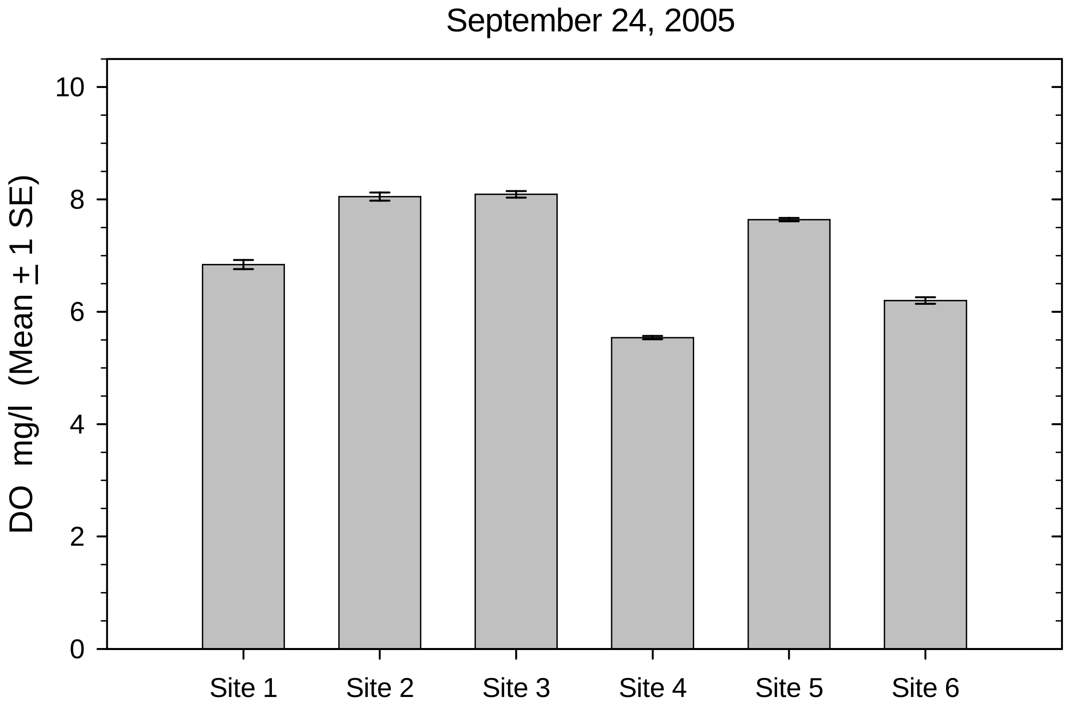


Figure C26. Dissolved oxygen (mg/l, mean ± 1 SE) for collection dates September 24 and October 7, 2005, for all collection sites on the Eightmile River West Branch.


September 24, 2005

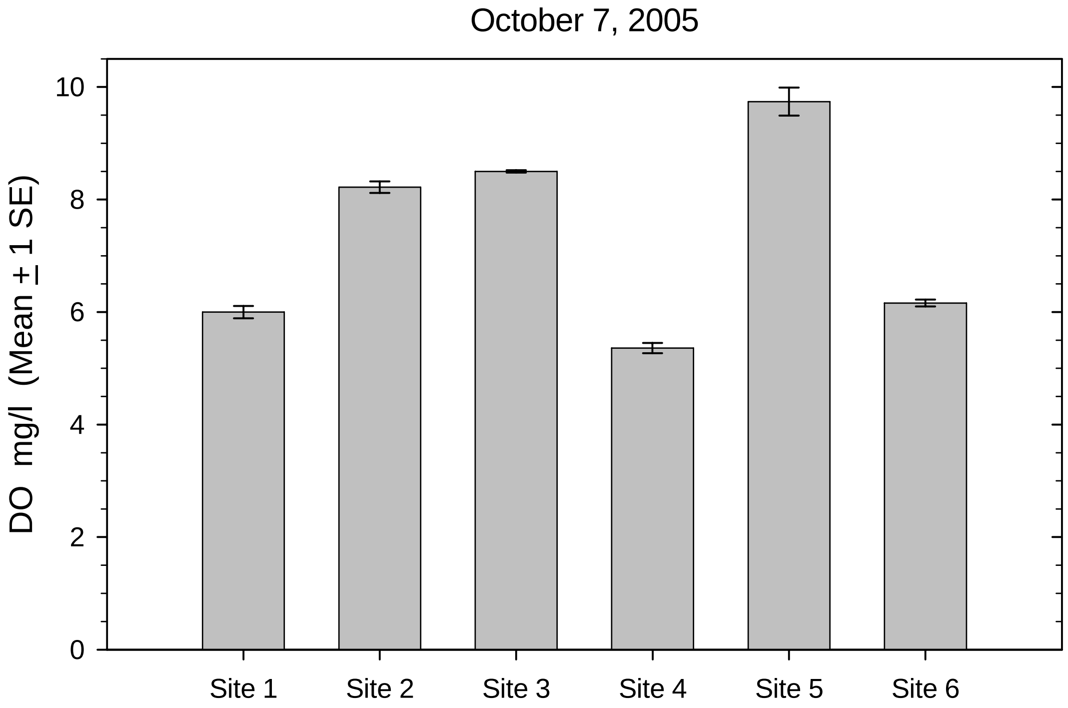

October 7, 2005

Figure C27. Dissolved oxygen (mg/l, mean ± 1 SE) for collection date October 22, 2005, for all collection sites on the Eightmile River West Branch.

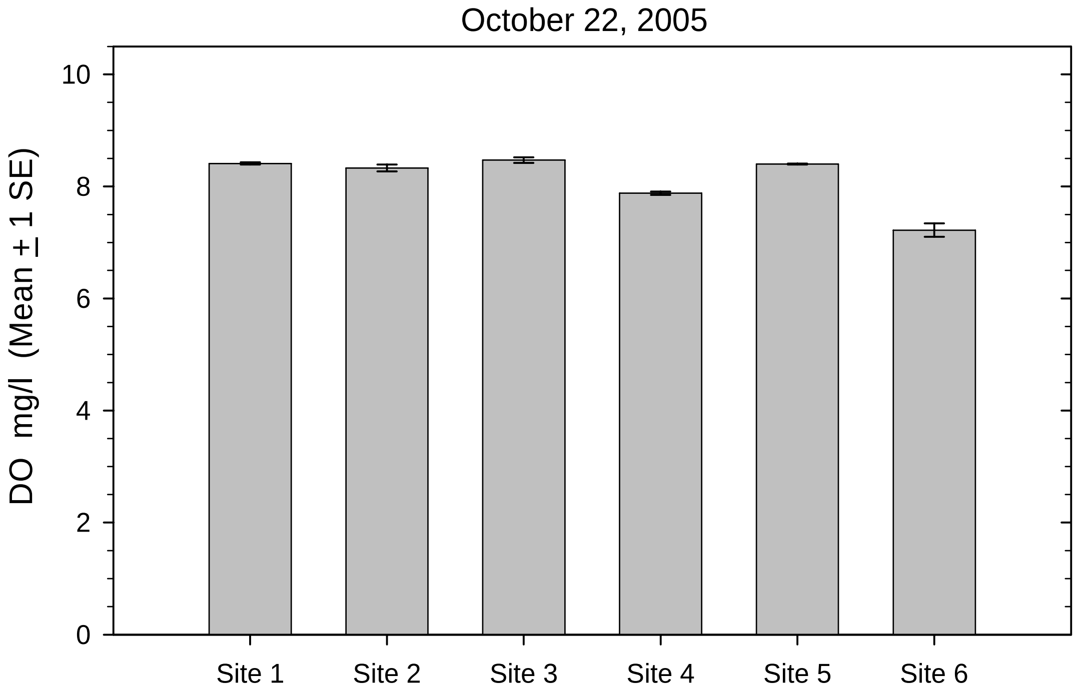
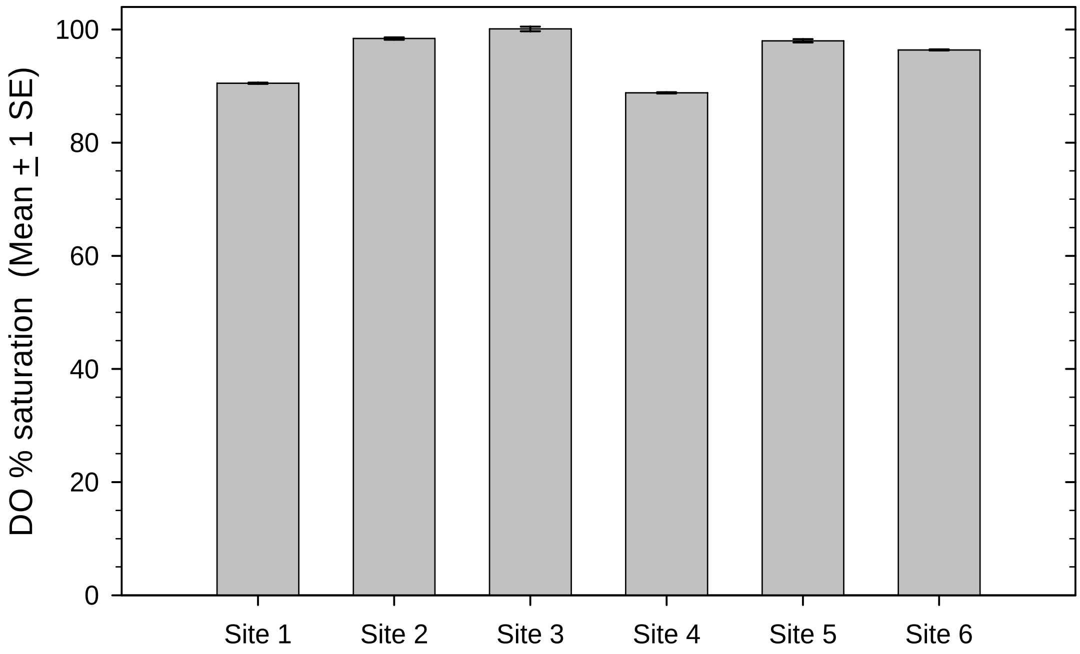
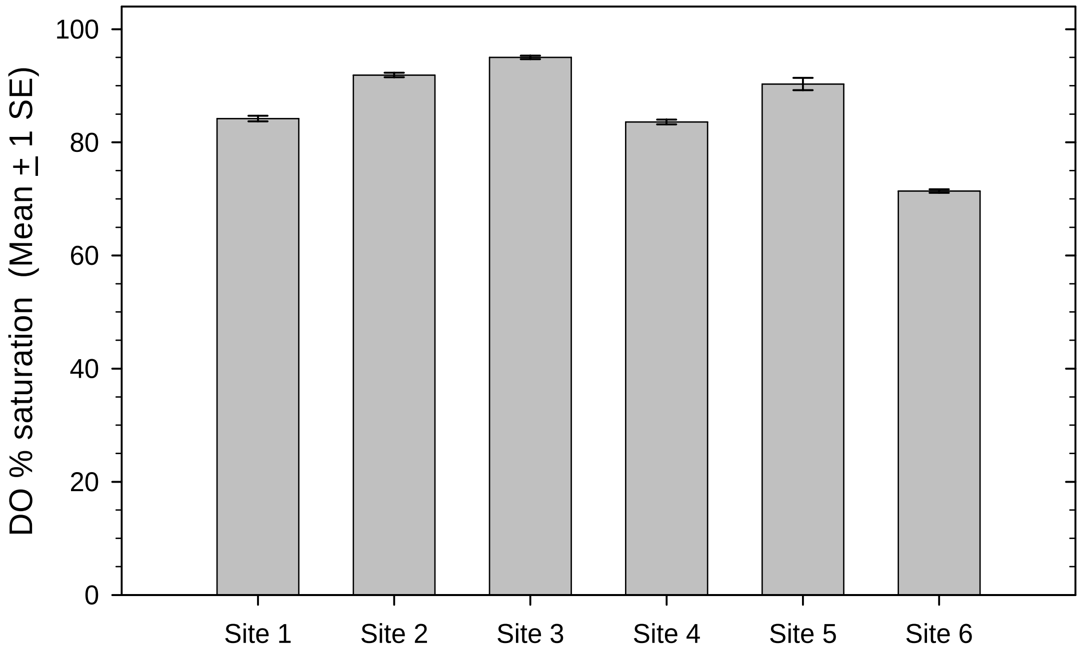


Figure C28. Dissolved oxygen (% saturation, mean + 1 SE) for collection dates June 4 and June 18, 2005, for all collection sites on the Eightmile River West Branch.

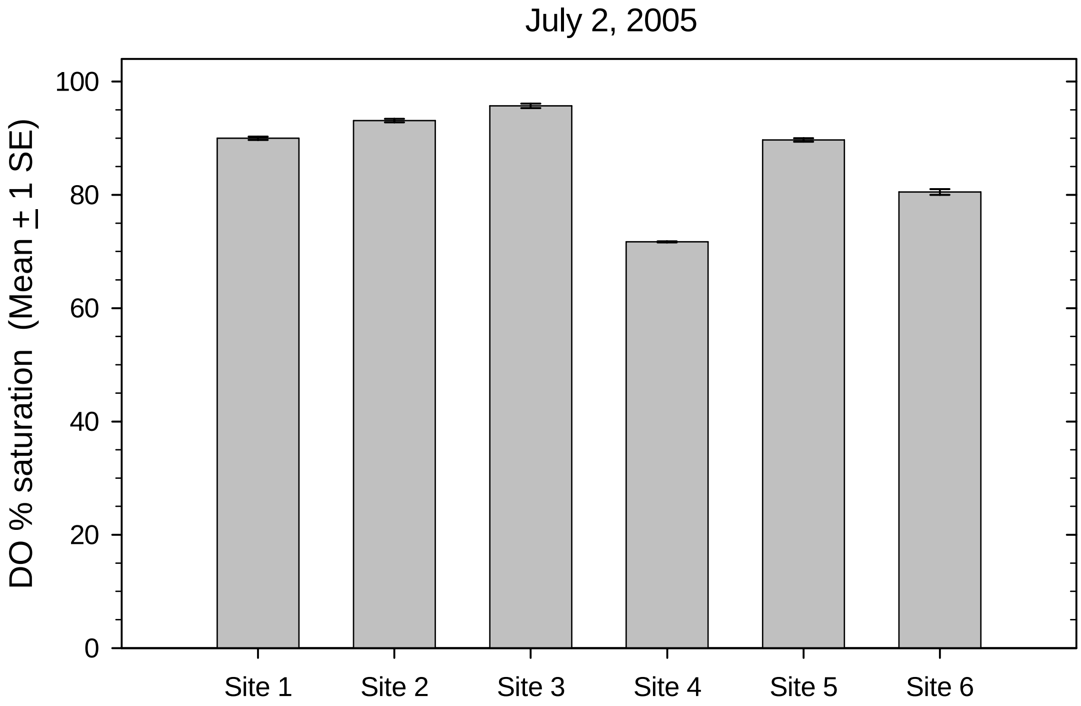


June 4, 2005



June 18, 2005

Figure C29. Dissolved oxygen (% saturation, mean ± 1 SE) for collection dates July 2 and July 16, 2005, for all collection sites on the Eightmile River West Branch.



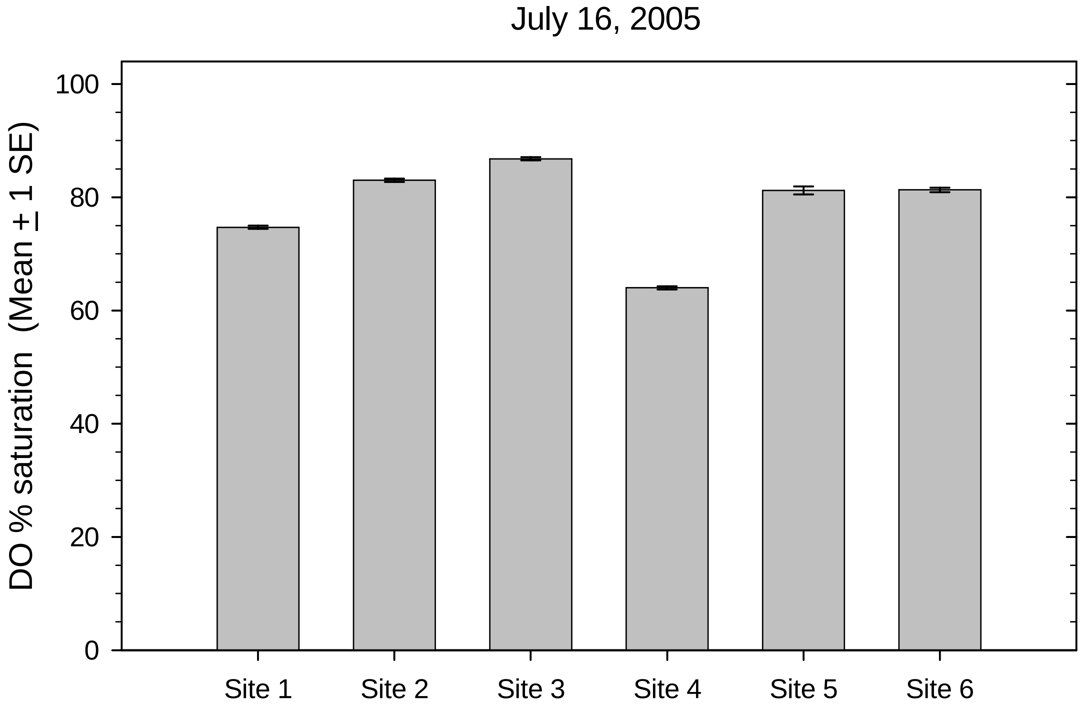
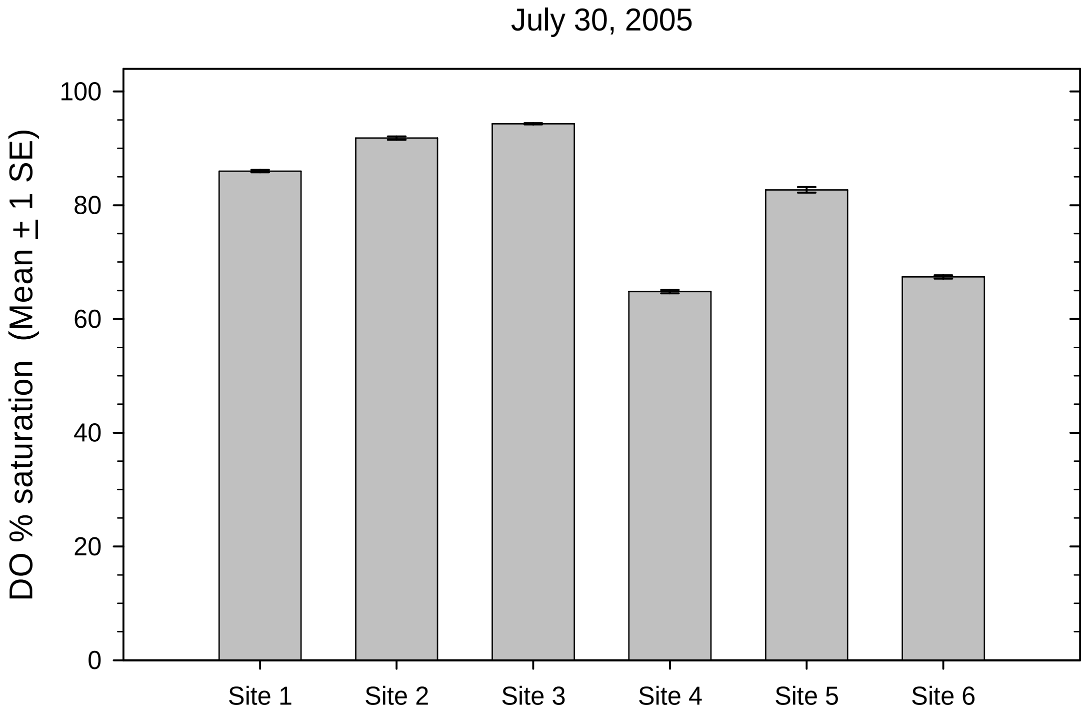


Figure C30. Dissolved oxygen (% saturation, mean ± 1 SE) for collection dates July 30 and August 13, 2005, for all collection sites on the Eightmile River West Branch.



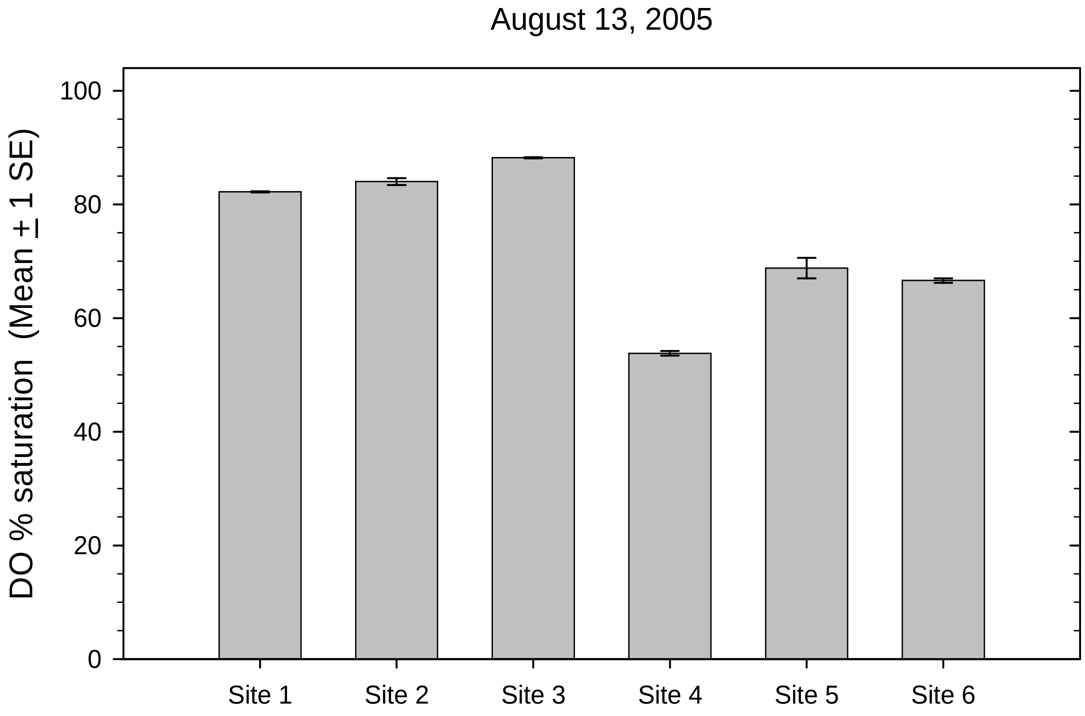
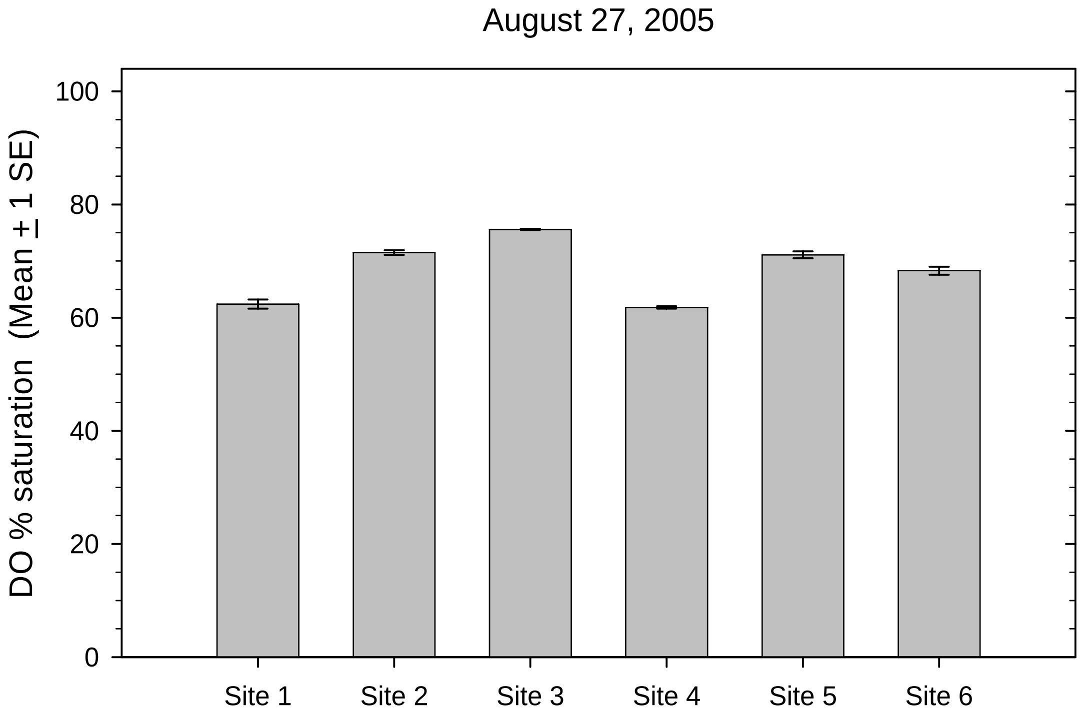


Figure C31. Dissolved oxygen (% saturation, mean ± 1 SE) for collection dates August 27 and September 10, 2005, for all collection sites on the Eightmile River West Branch.



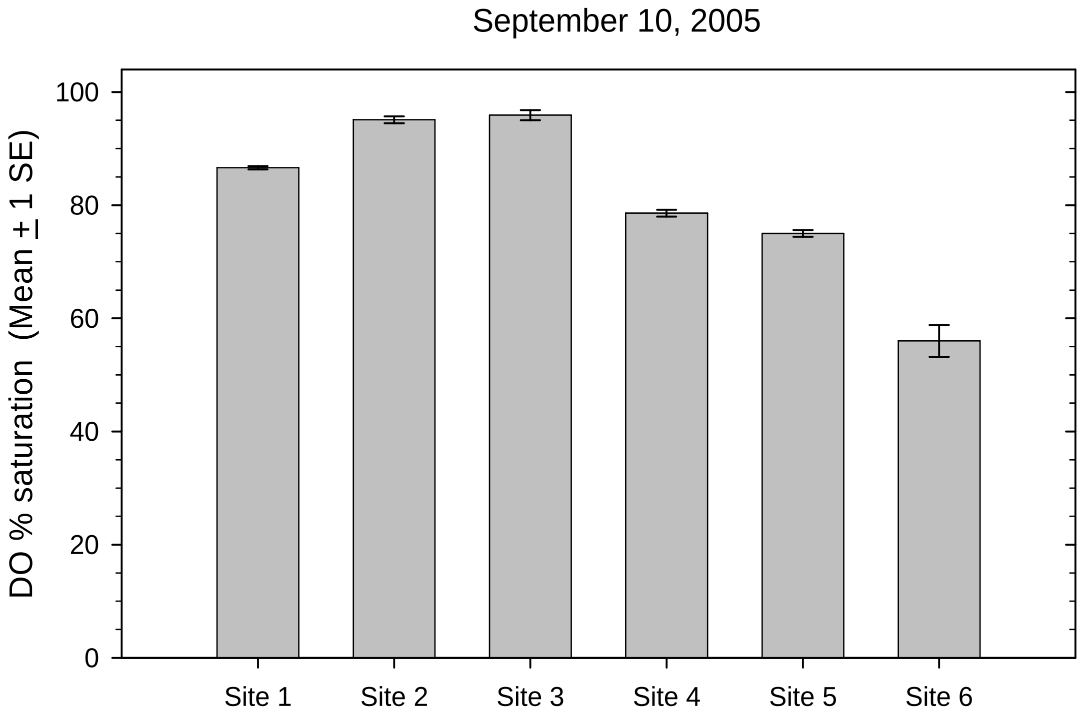


Figure C32. Dissolved oxygen (% saturation, mean ± 1 SE) for collection dates September 24 and October 7, 2005, for all collection sites on the Eightmile River West Branch.

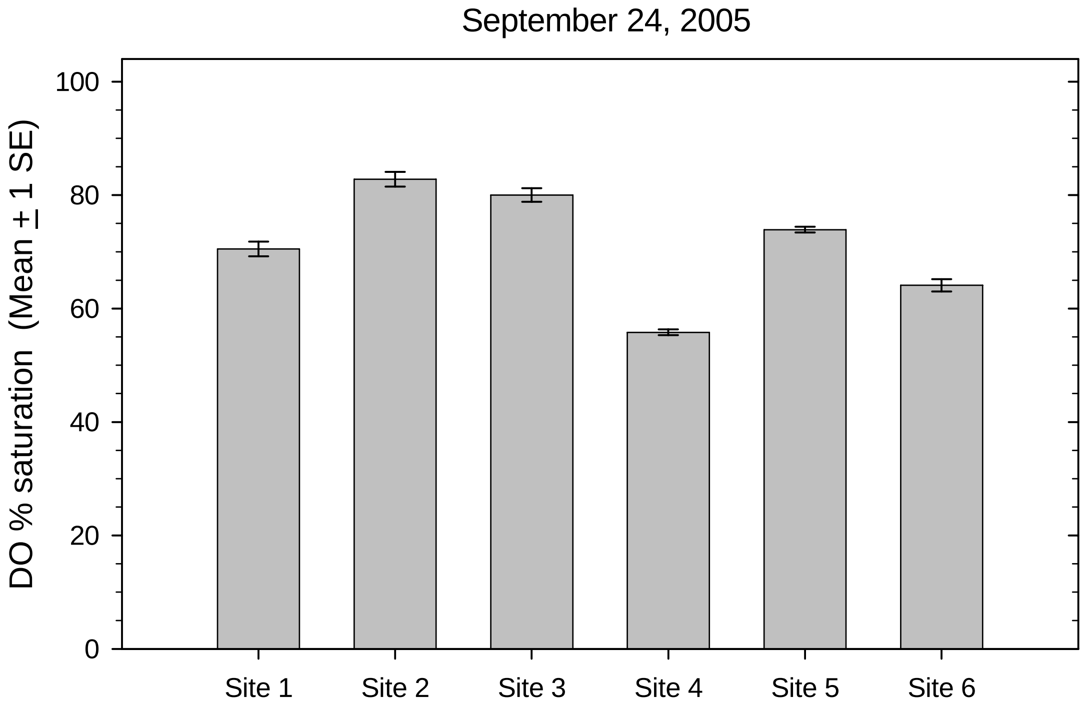


Figure C33. Dissolved oxygen (% saturation, mean ± 1 SE) for collection date October 22, 2005, for all collection sites on the Eightmile River West Branch.

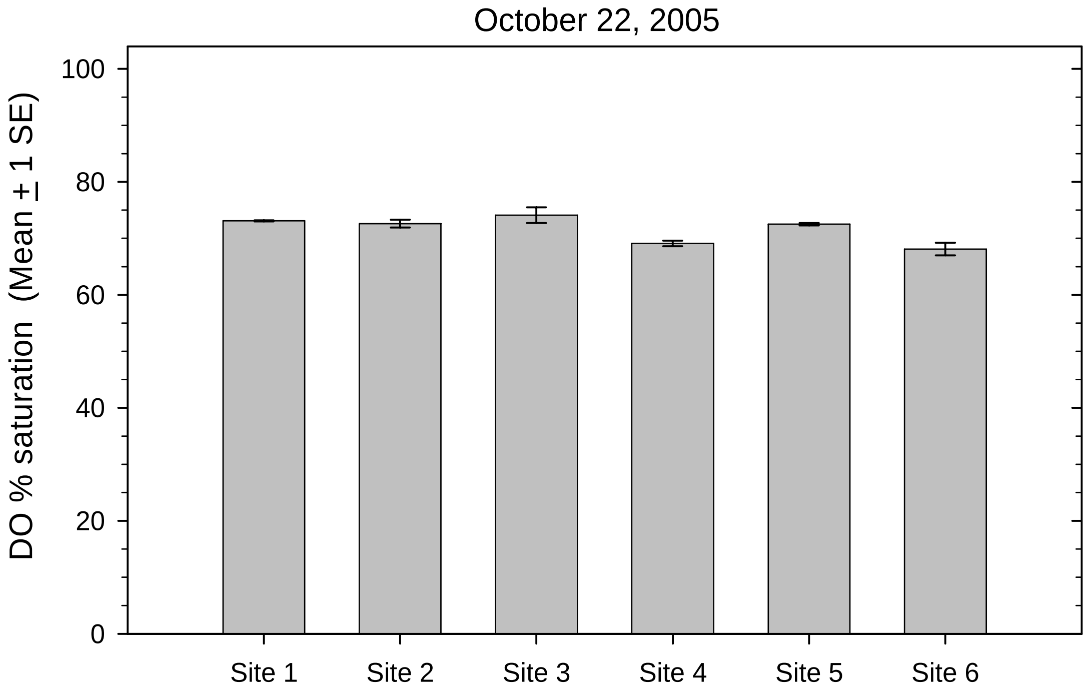
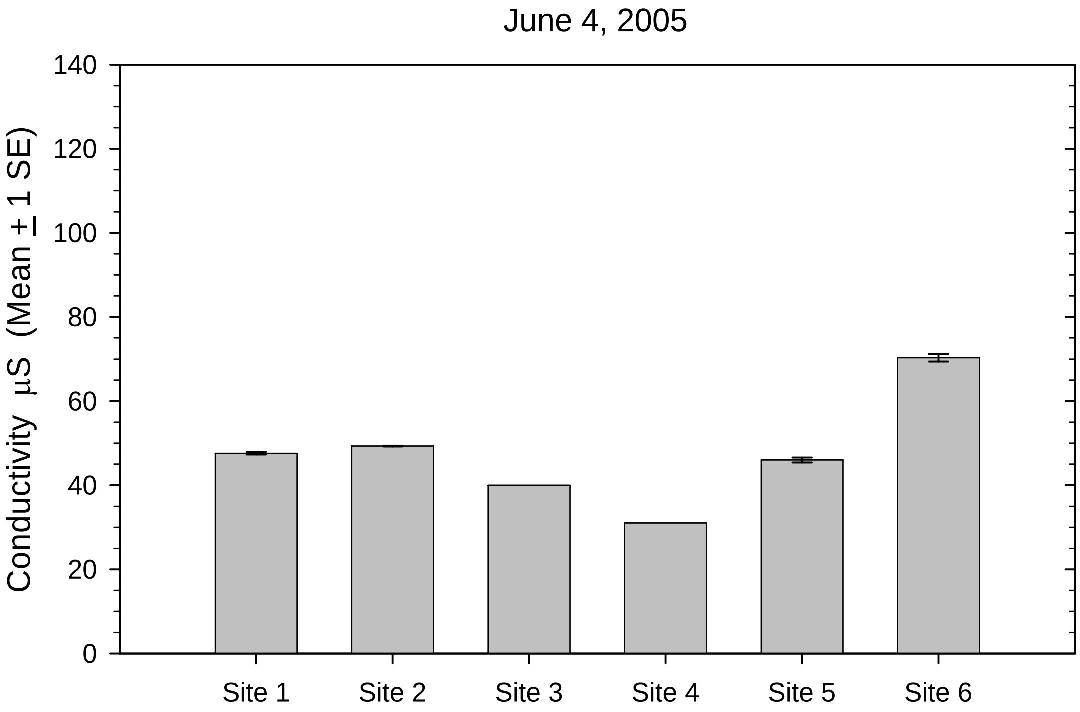


Figure C34. Conductivity (μS, mean ± 1 SE) for collection dates June 4 and June 18, 2005, for all collection sites on the Eightmile River West Branch.



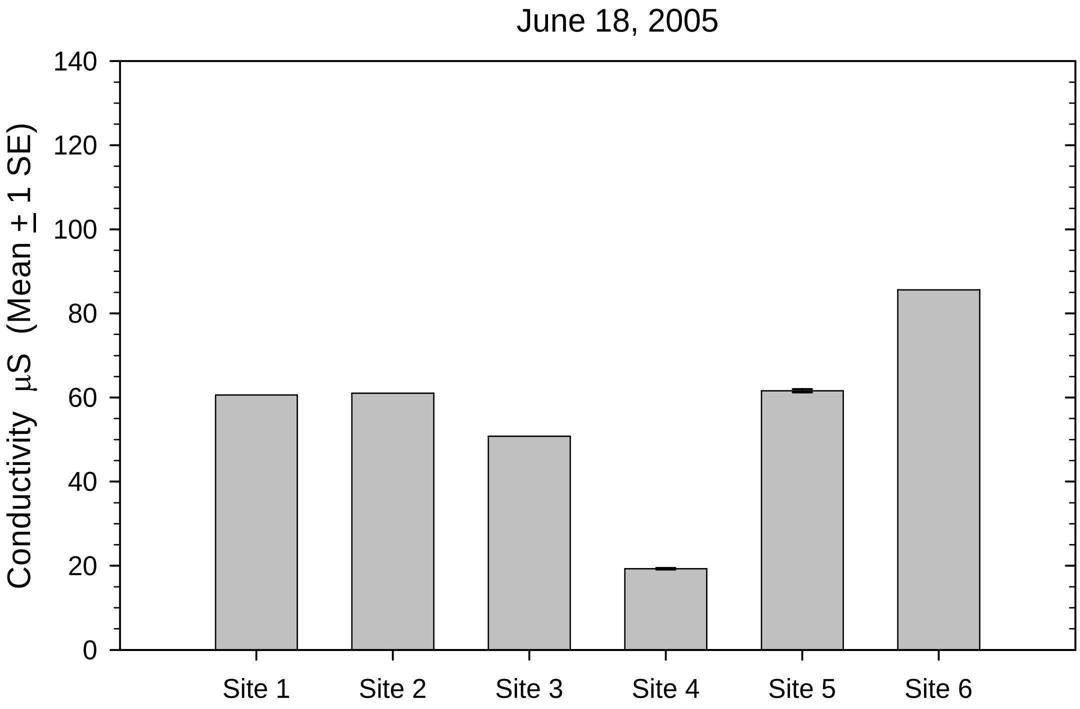
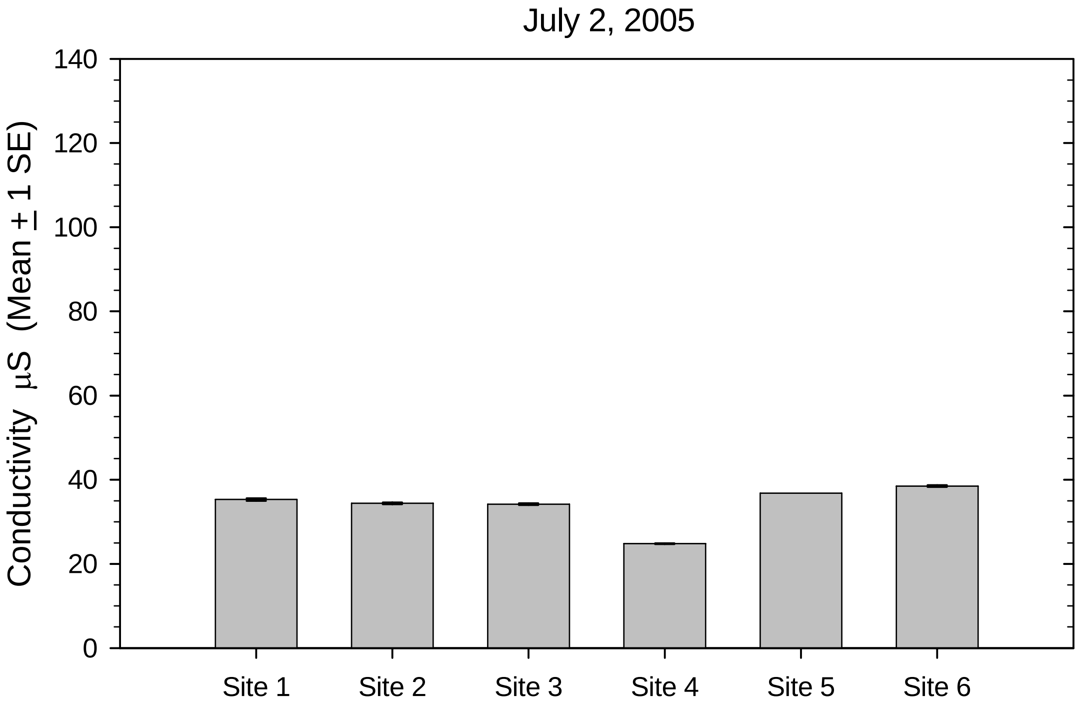


Figure C35. Conductivity (µS, mean ± 1 SE) for collection dates July 2 and July 16, 2005, for all collection sites on the Eightmile River West Branch.



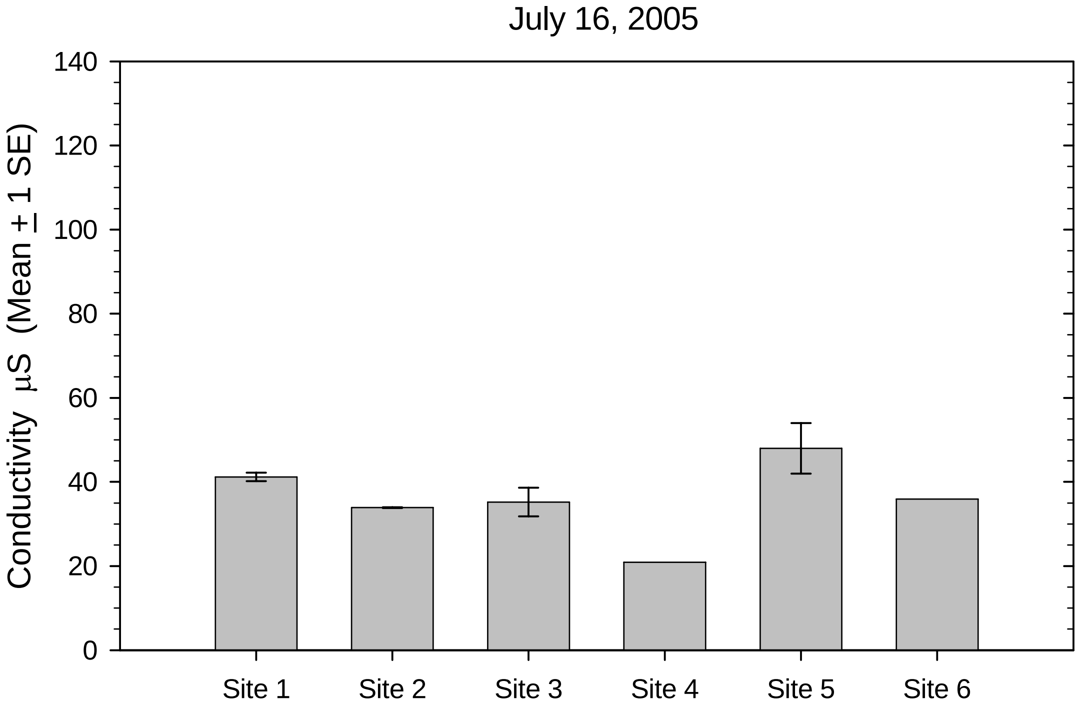
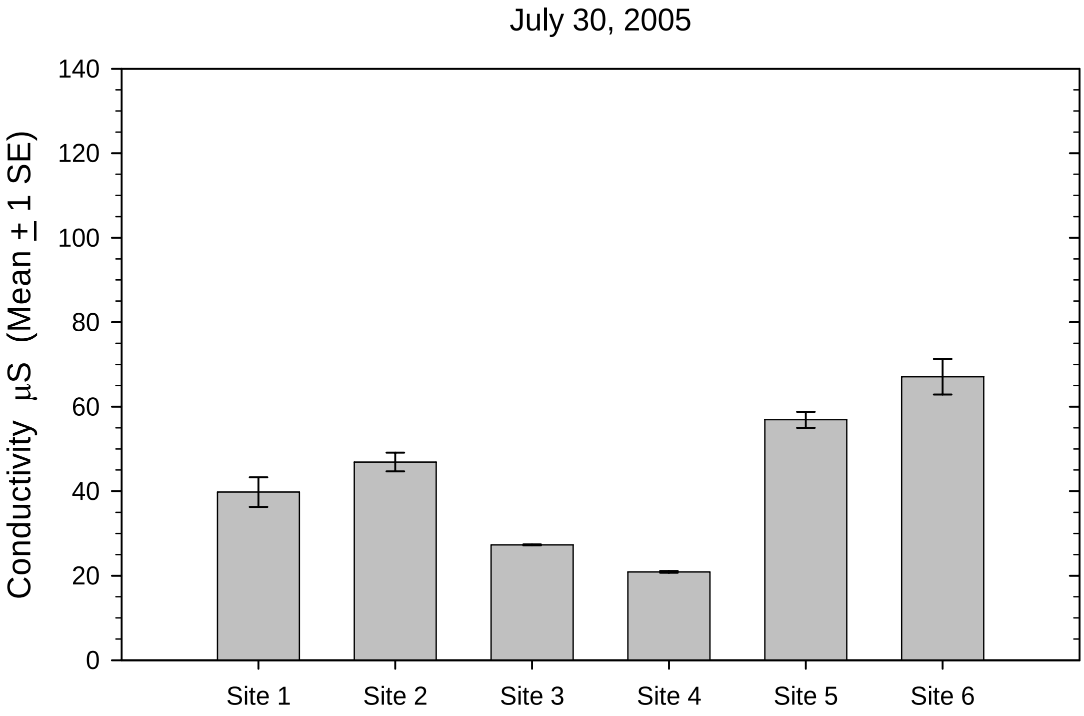


Figure C36. Conductivity (µS, mean + 1 SE) for collection dates July 30 and August 13, 2005, for all collection sites on the Eightmile River West Branch.



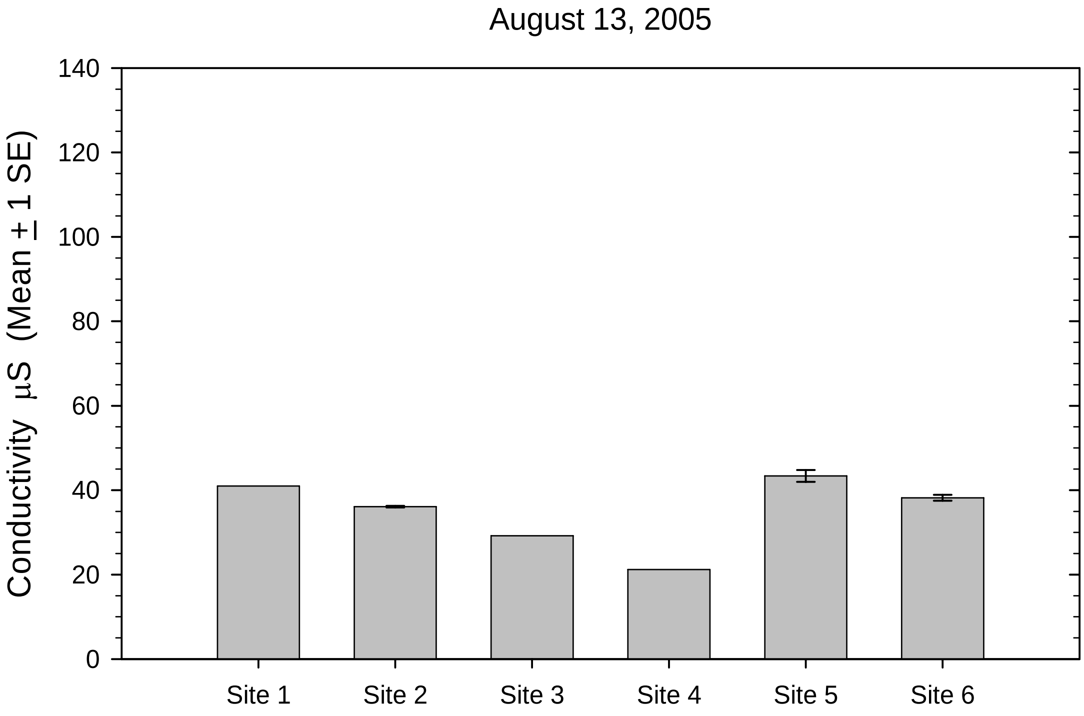
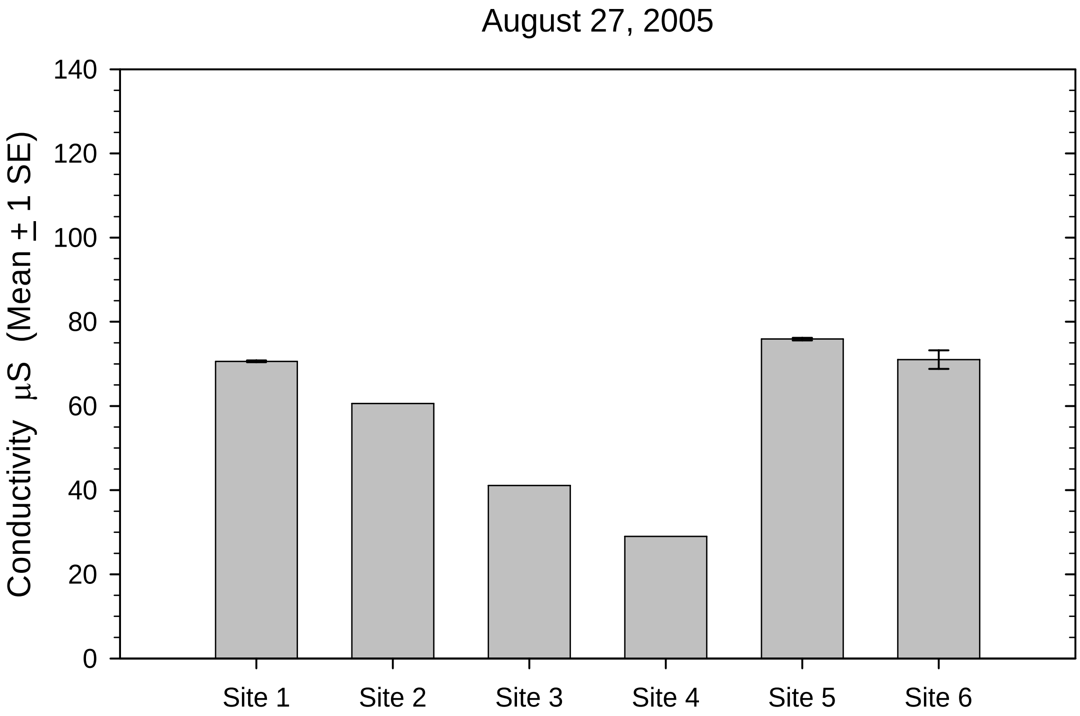


Figure C37. Conductivity (µS, mean ± 1 SE) for collection dates August 27 and September 10, 2005, for all collection sites on the Eightmile River West Branch.



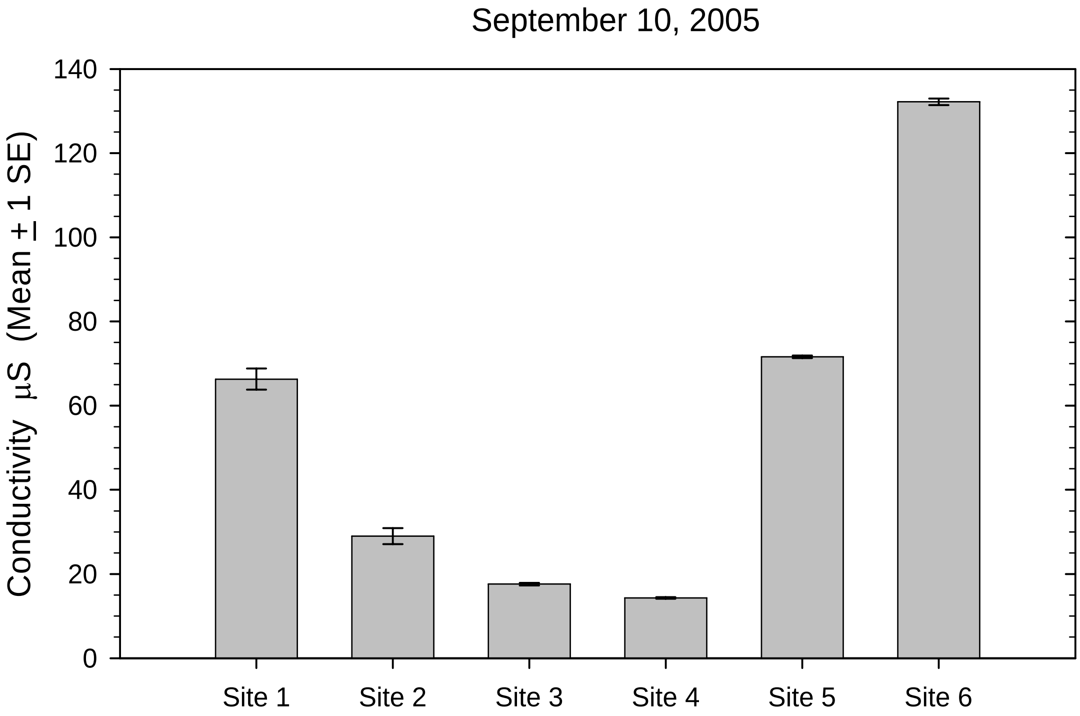
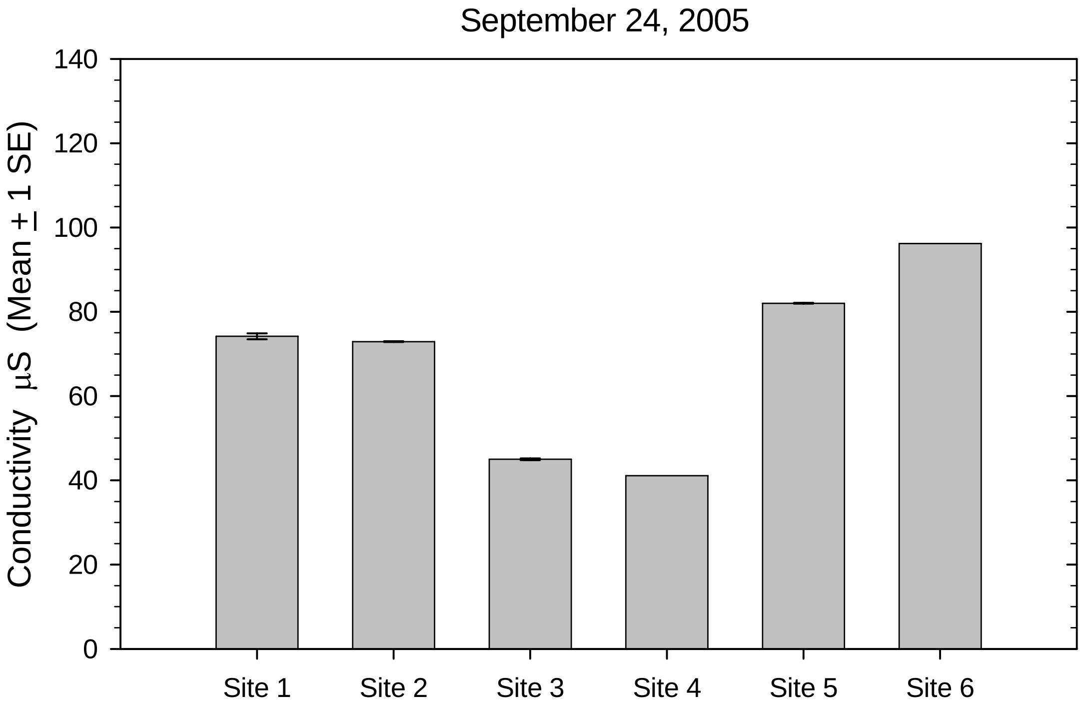


Figure C38. Conductivity (µS, mean ± 1 SE) for collection dates September 24 and October 7, 2005, for all collection sites on the Eightmile River West Branch.



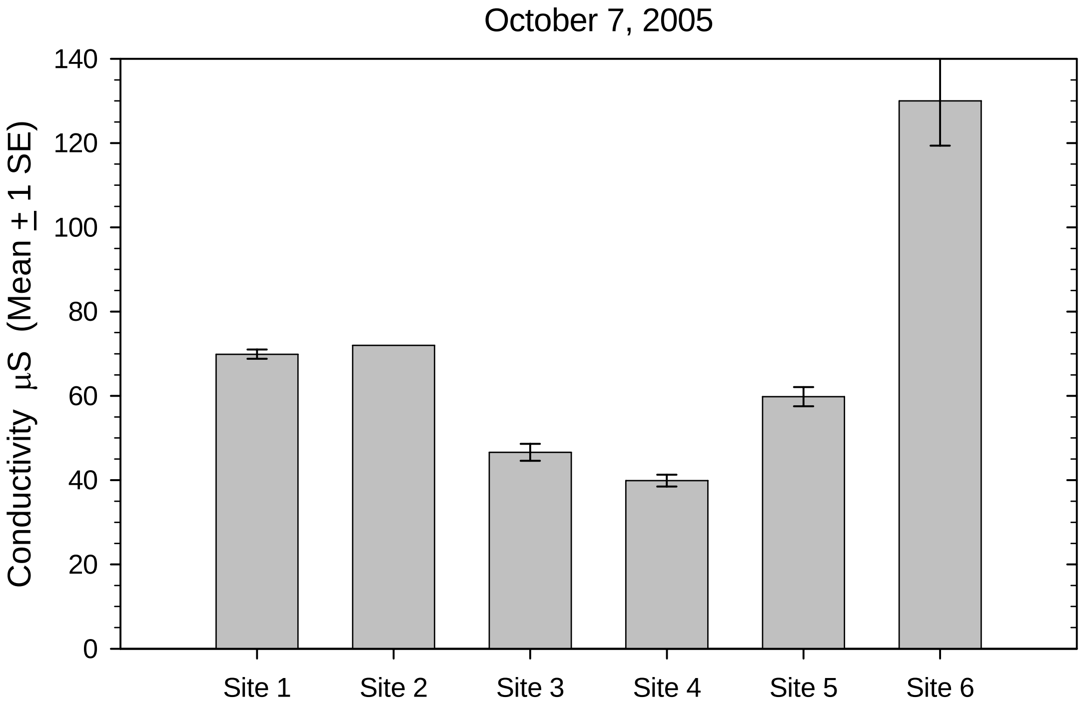


Figure C39. Conductivity (µS, mean ± 1 SE) for collection date October 22, 2005, for all collection sites on the Eightmile River West Branch.

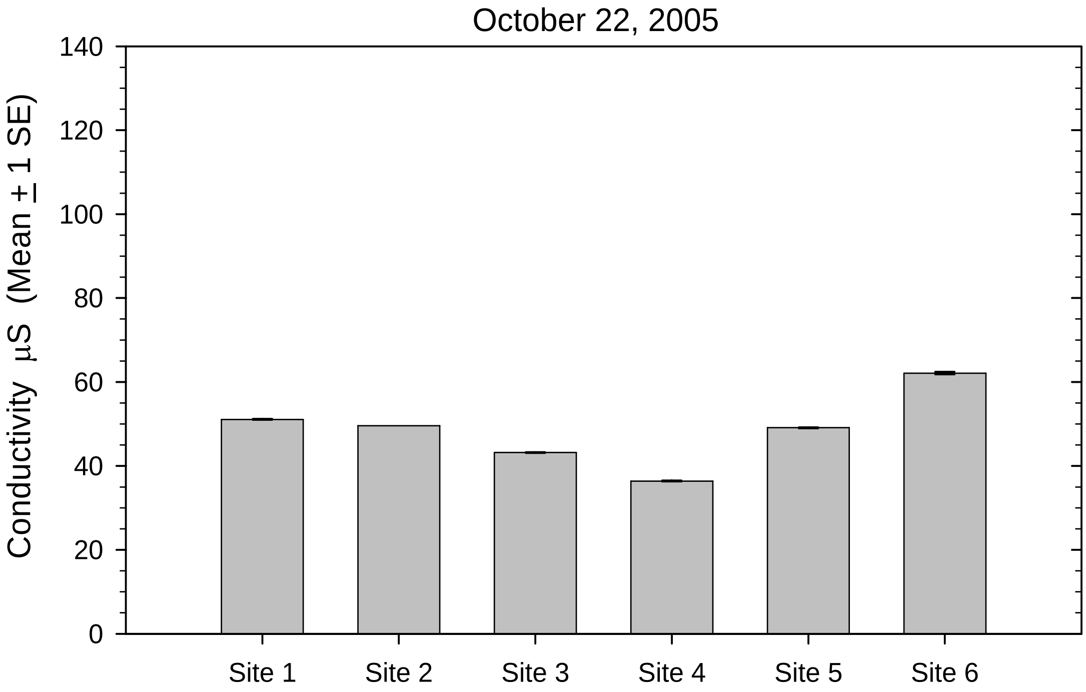
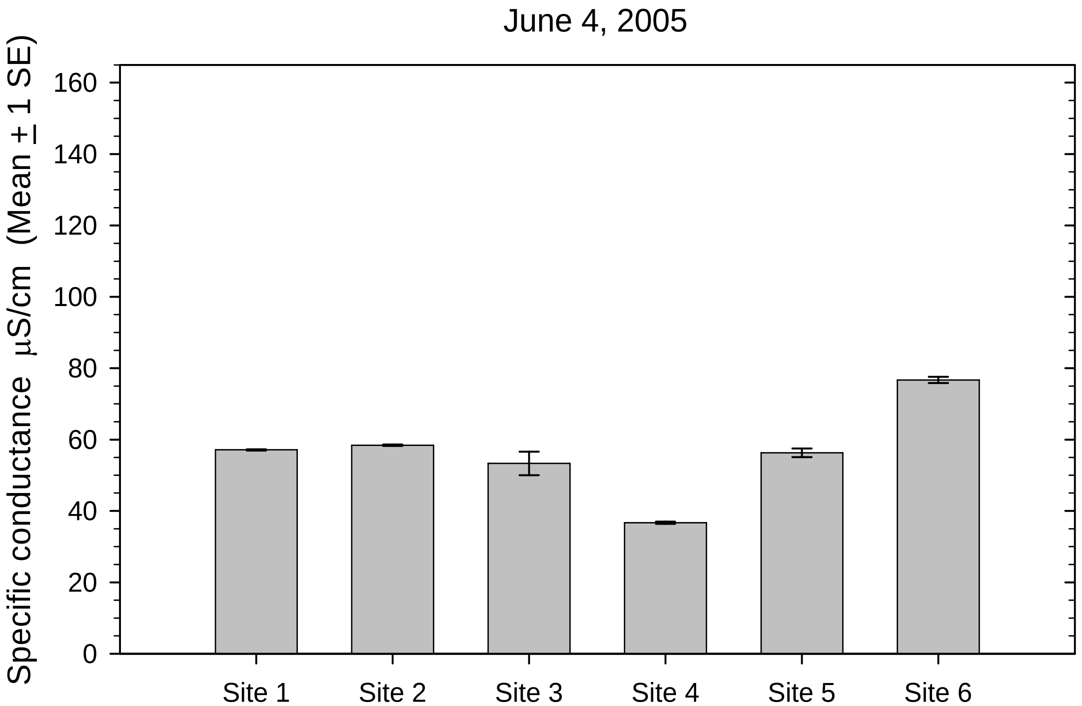


Figure C40. Specific conductance (μS/cm, mean + 1 SE) for collection dates June 4 and June 18, 2005, for all collection sites on the Eightmile River West Branch.



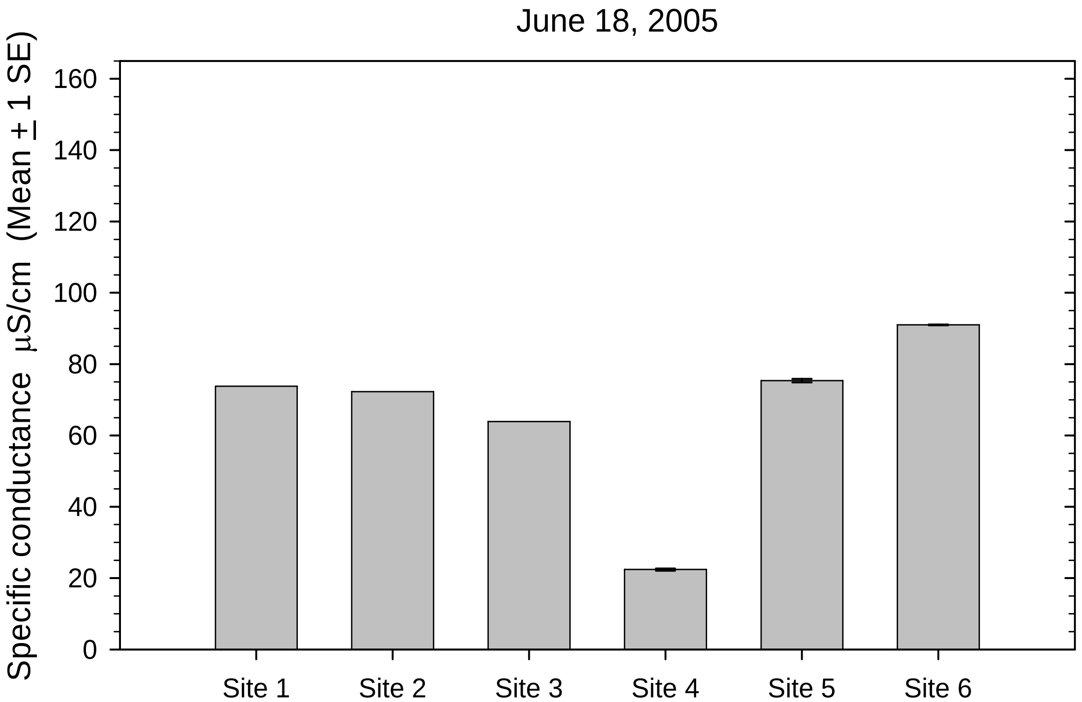
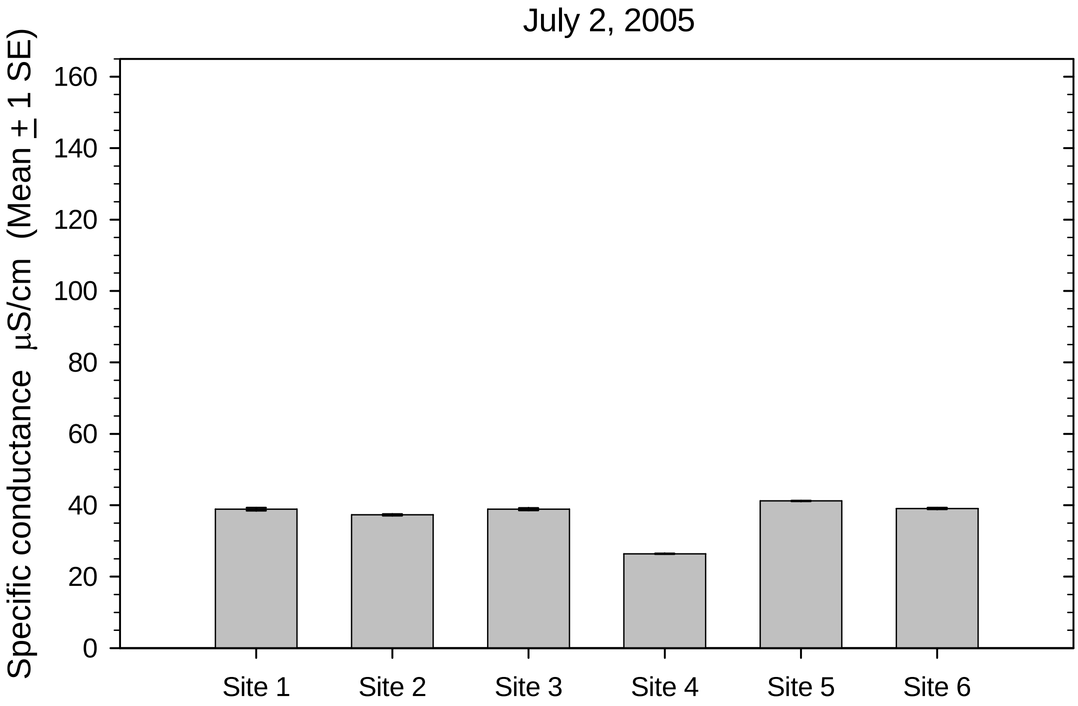


Figure C41. Specific conductance (μS/cm, mean + 1 SE) for collection dates July 2 and July 16, 2005, for all collection sites on the Eightmile River West Branch.



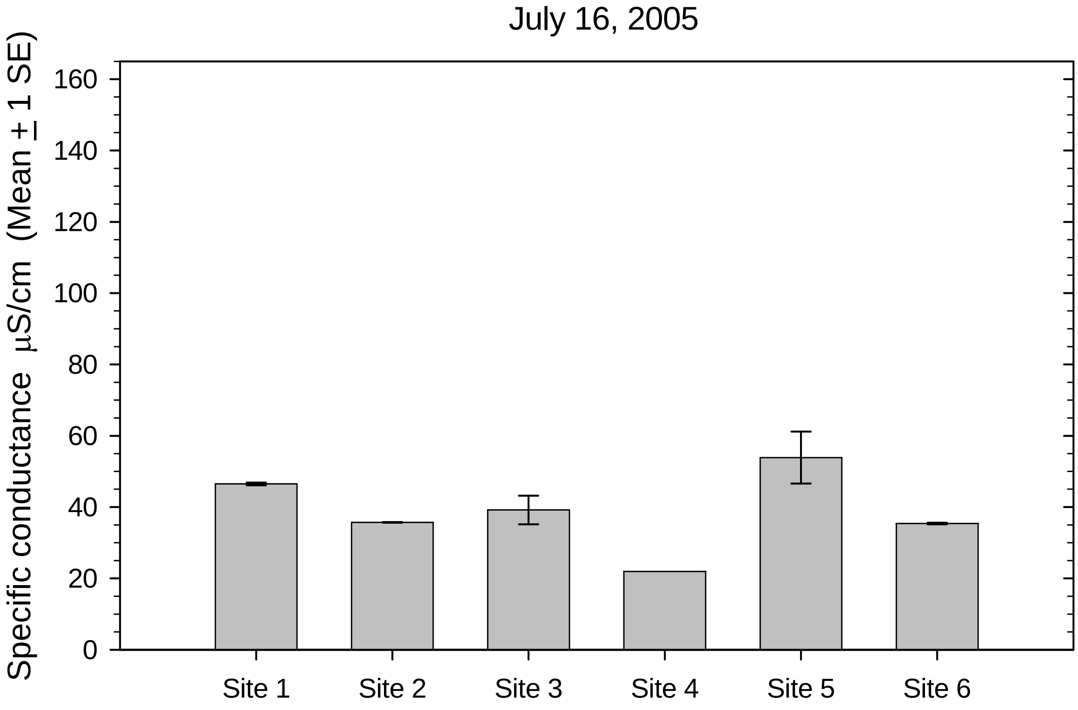
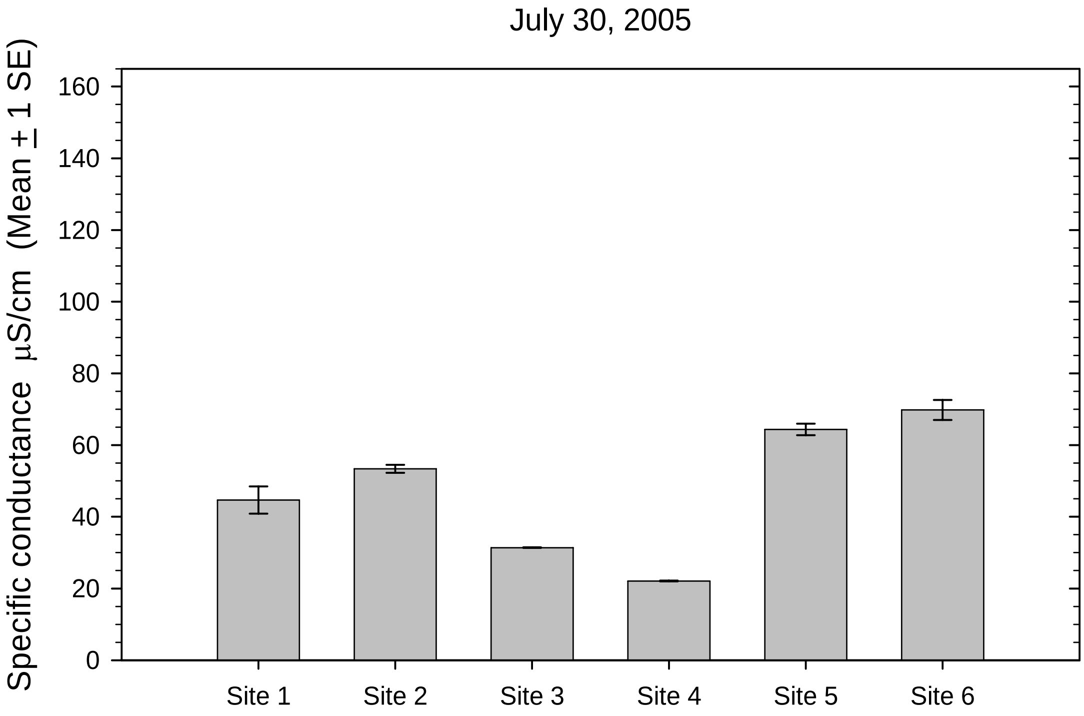


Figure C42. Specific conductance (µS/cm, mean ± 1 SE) for collection dates July 30 and August 13, 2005, for all collection sites on the Eightmile River West Branch.



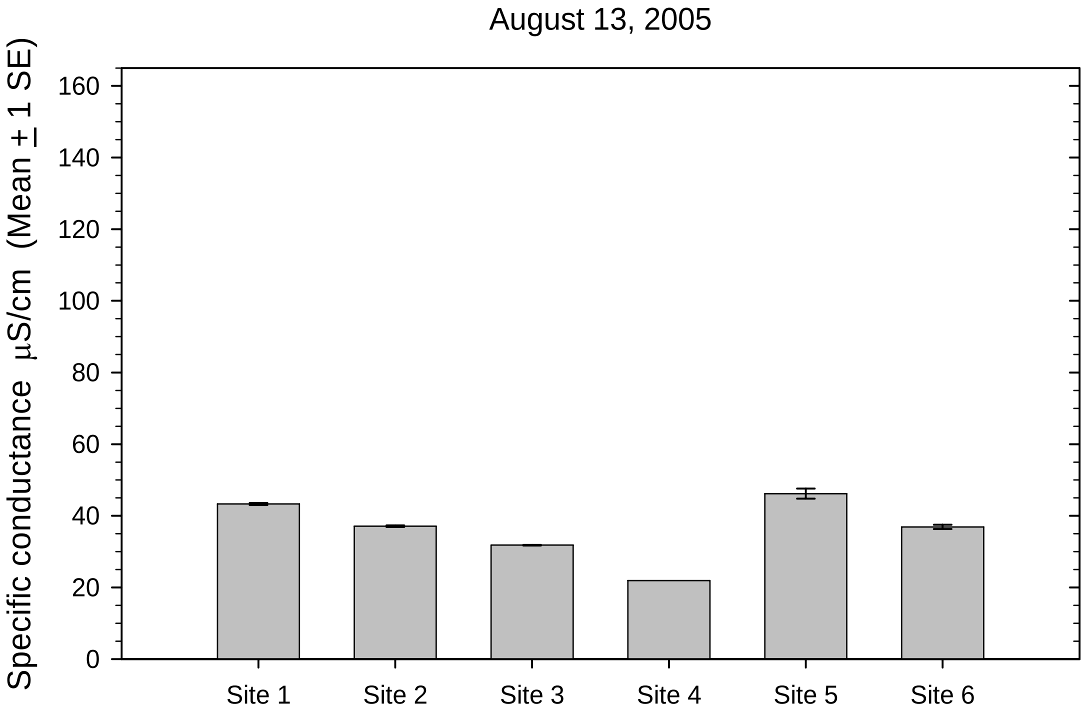


Figure C43. Specific conductance (µS/cm, mean + 1 SE) for collection dates August 27 and September 10, 2005, for all collection sites on the Eightmile River West Branch.

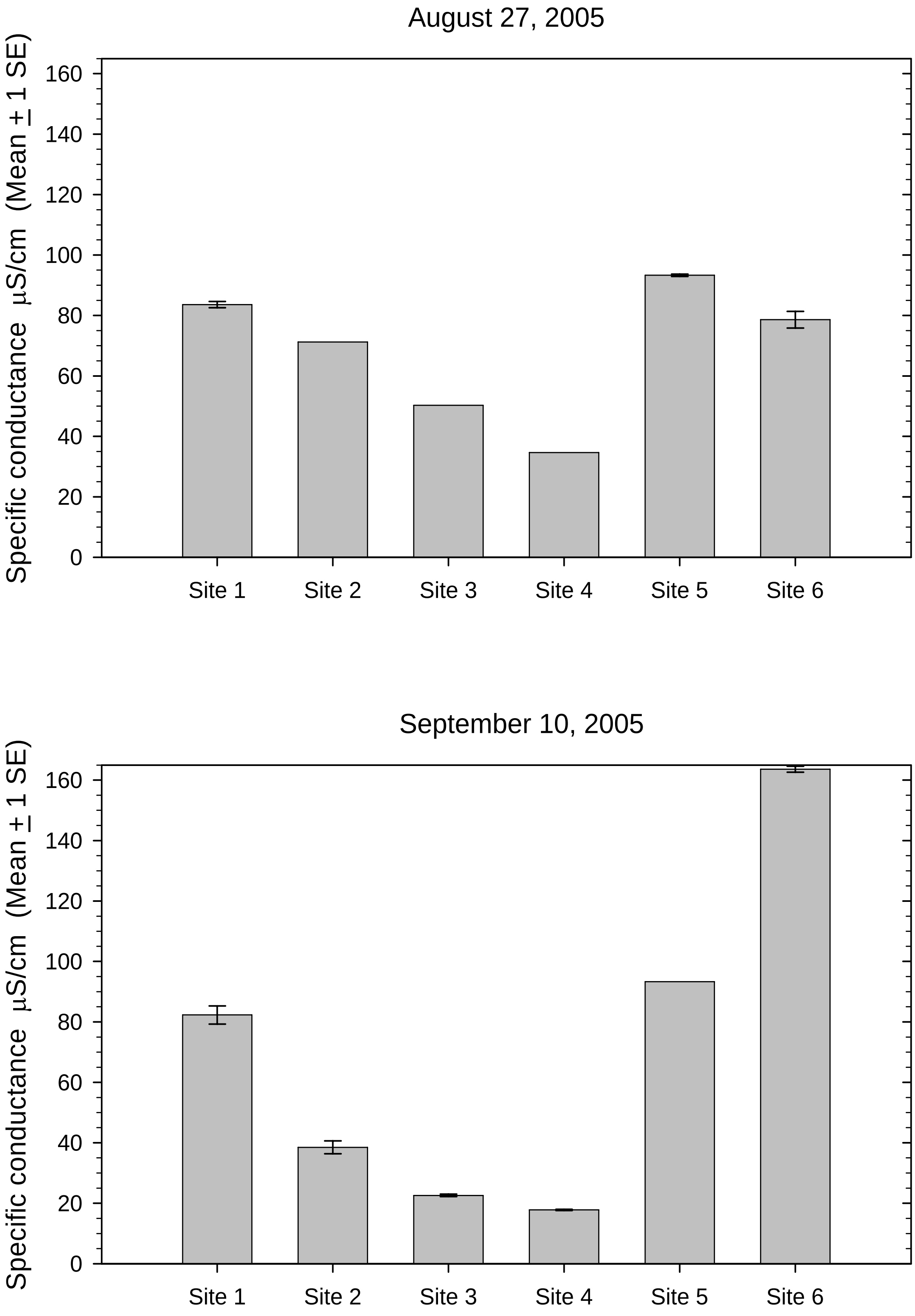
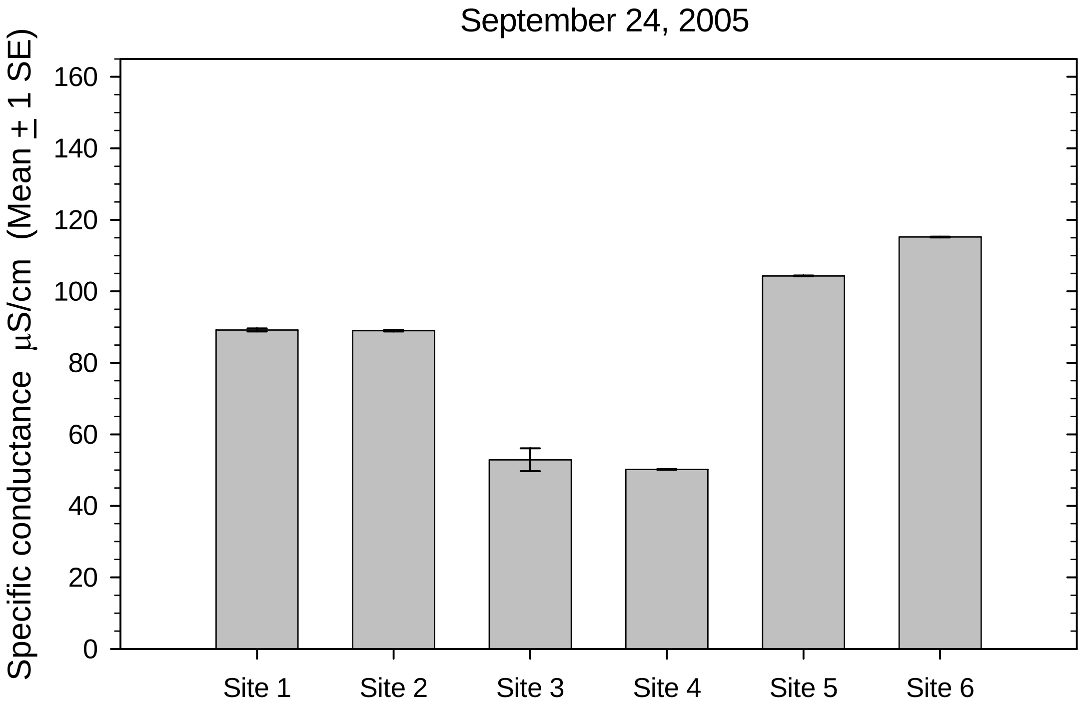


Figure C44. Specific conductance (μS/cm, mean + 1 SE) for collection dates September 24 and October 7, 2005, for all collection sites on the Eightmile River West Branch.



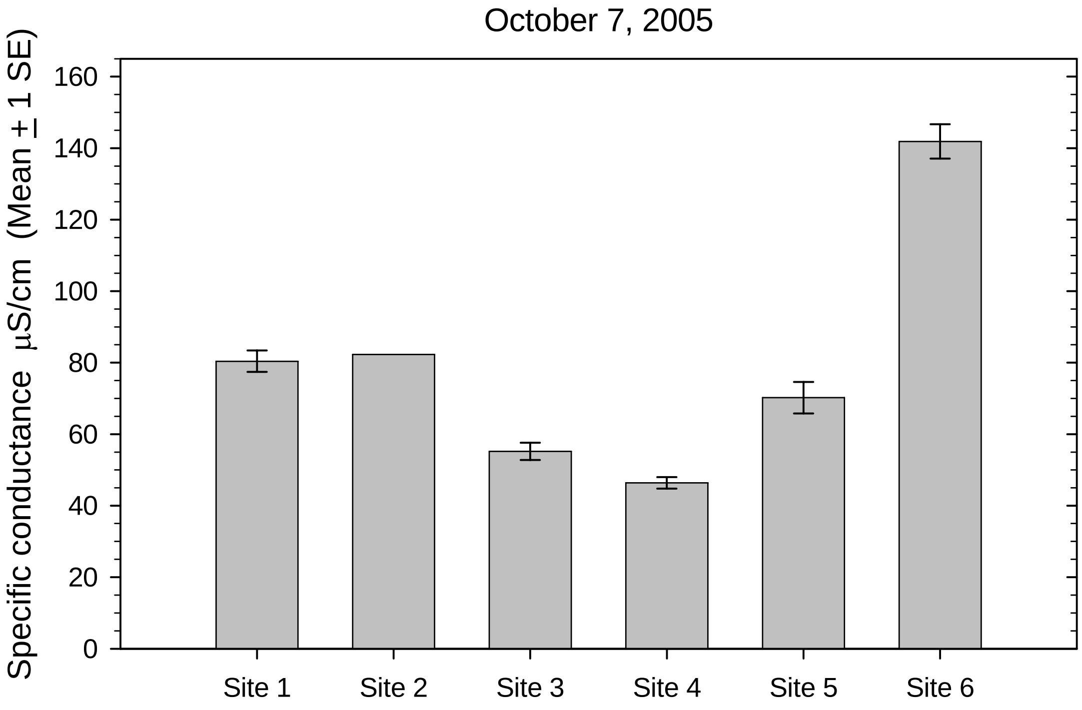


Figure C45. Specific conductance (μS/cm, mean ± 1 SE) for collection date October 22, 2005, for all collection sites on the Eightmile River West Branch.

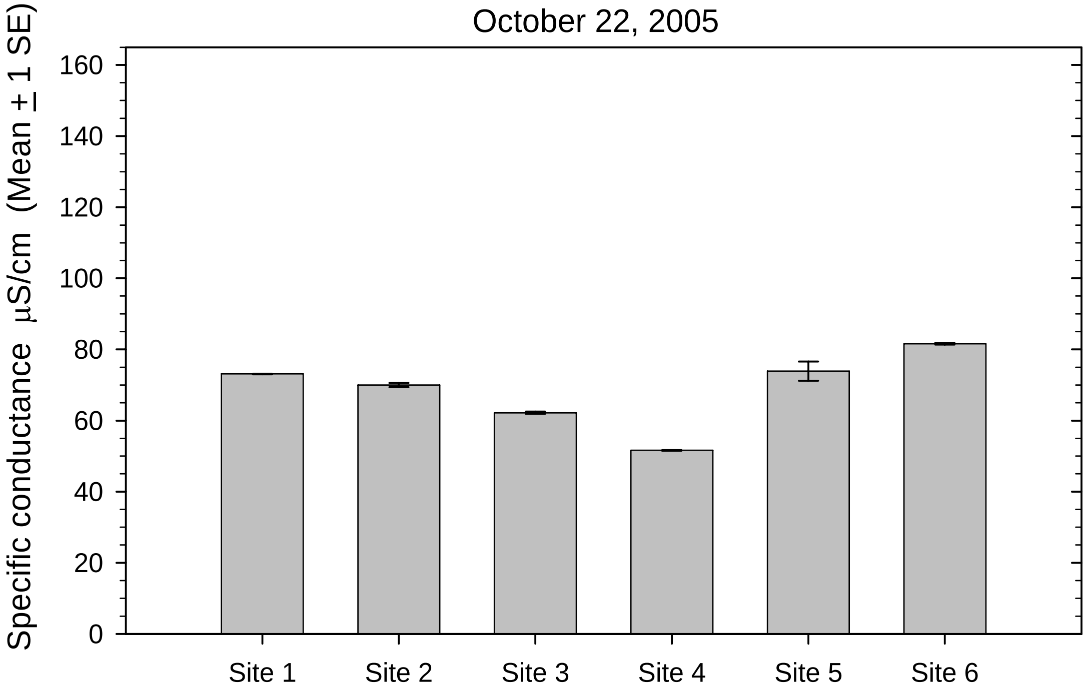
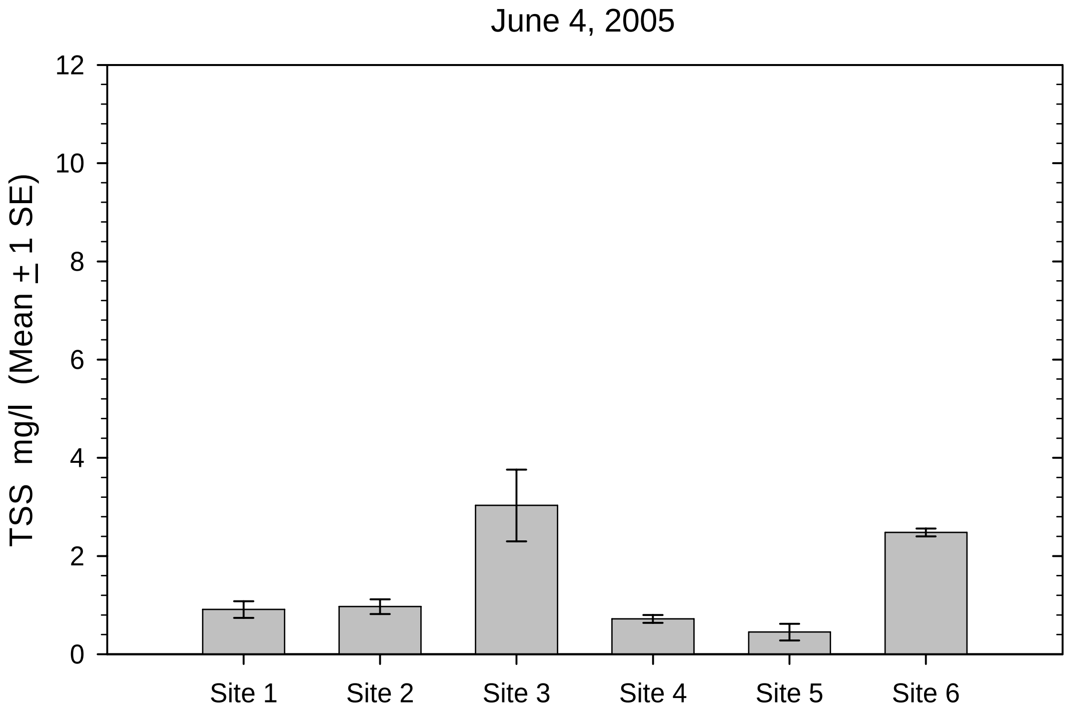


Figure C46. TSS (mg/l, mean + 1 SE) for collection dates June 4 and June 18, 2005, for all collection sites on the Eightmile River West Branch.



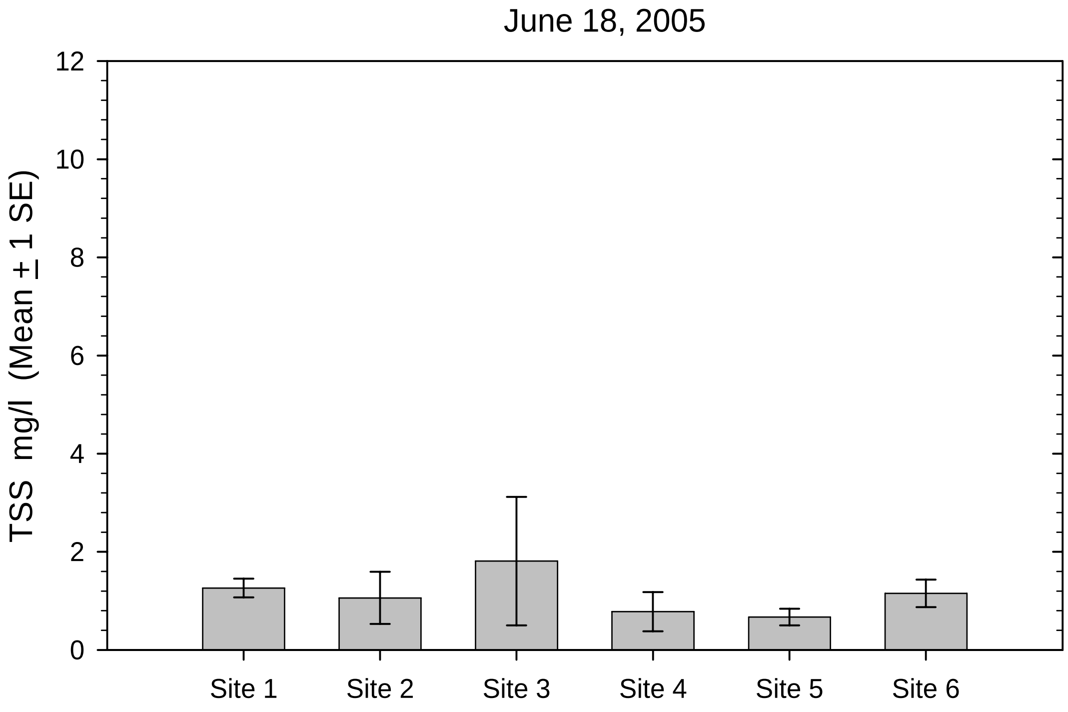
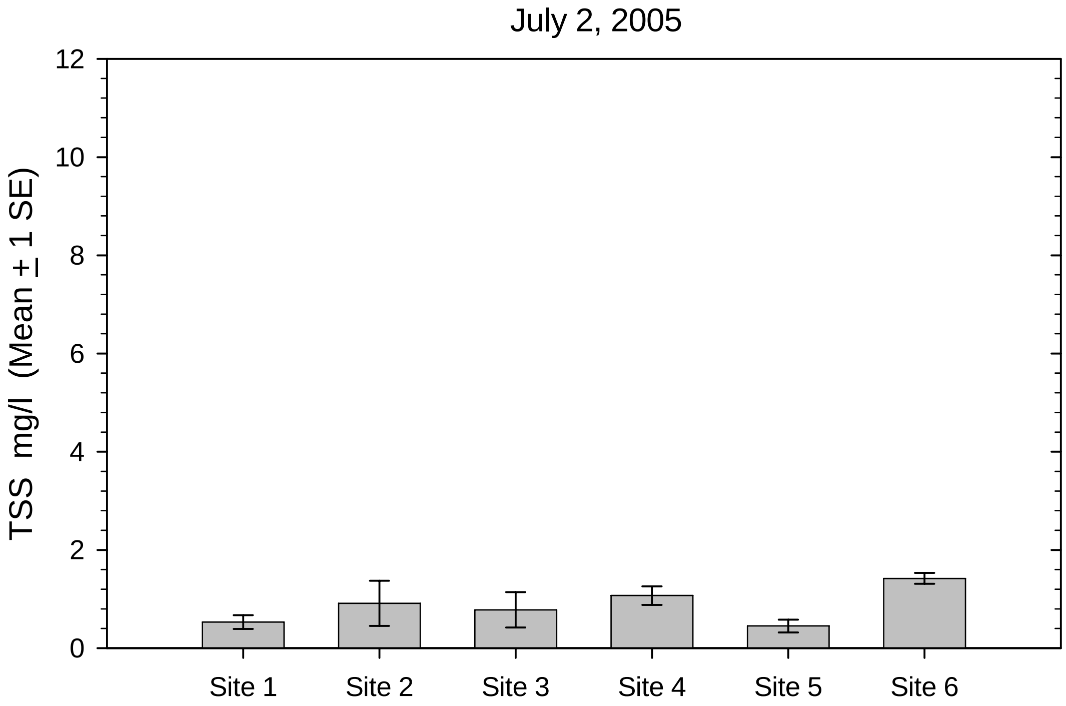


Figure C47. TSS (mg/l, mean ± 1 SE) for collection dates July 2 and July 16, 2005, for all collection sites on the Eightmile River West Branch.



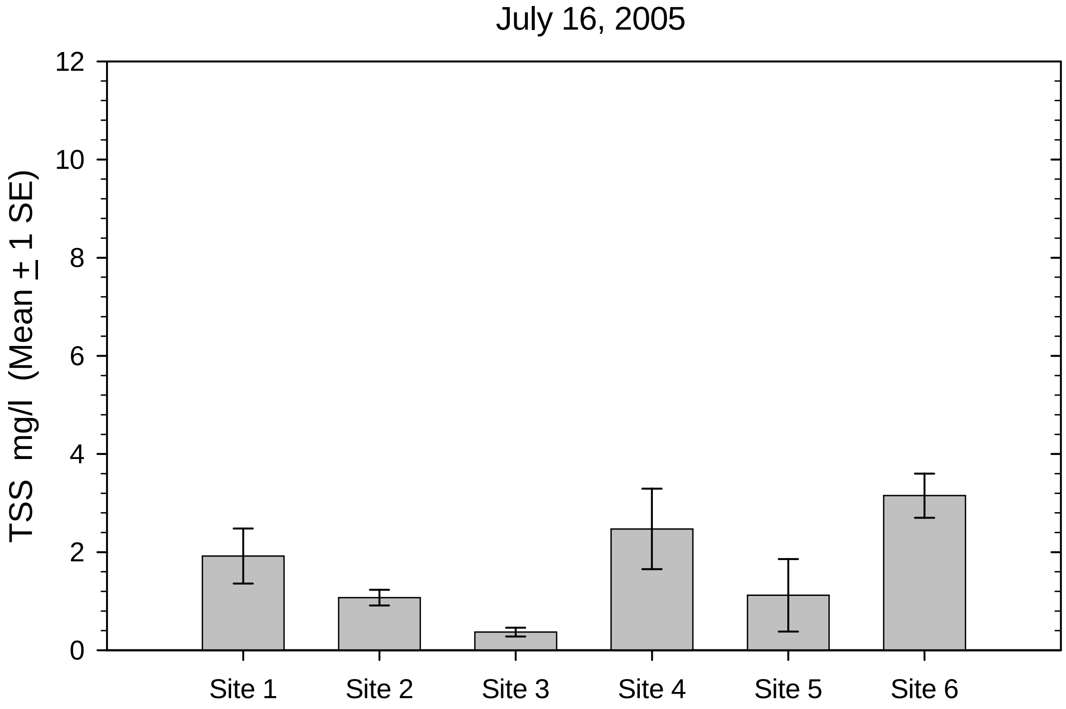
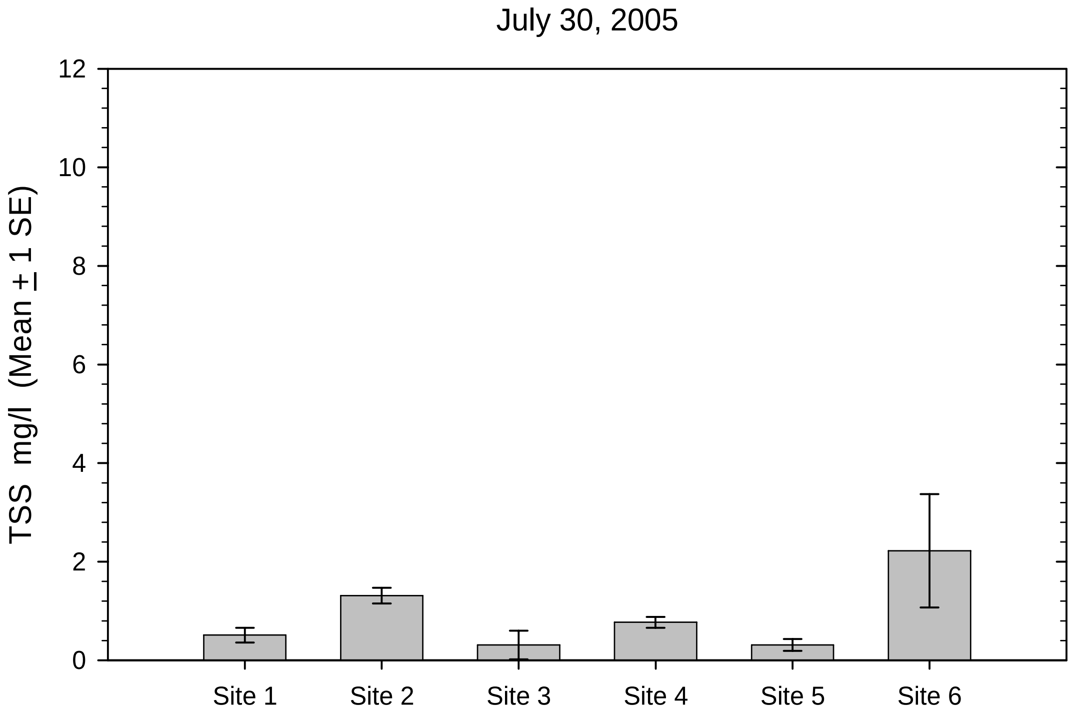


Figure C48. TSS (mg/l, mean + 1 SE) for collection dates July 30 and August 13, 2005, for all collection sites on the Eightmile River West Branch.


July 30, 2005

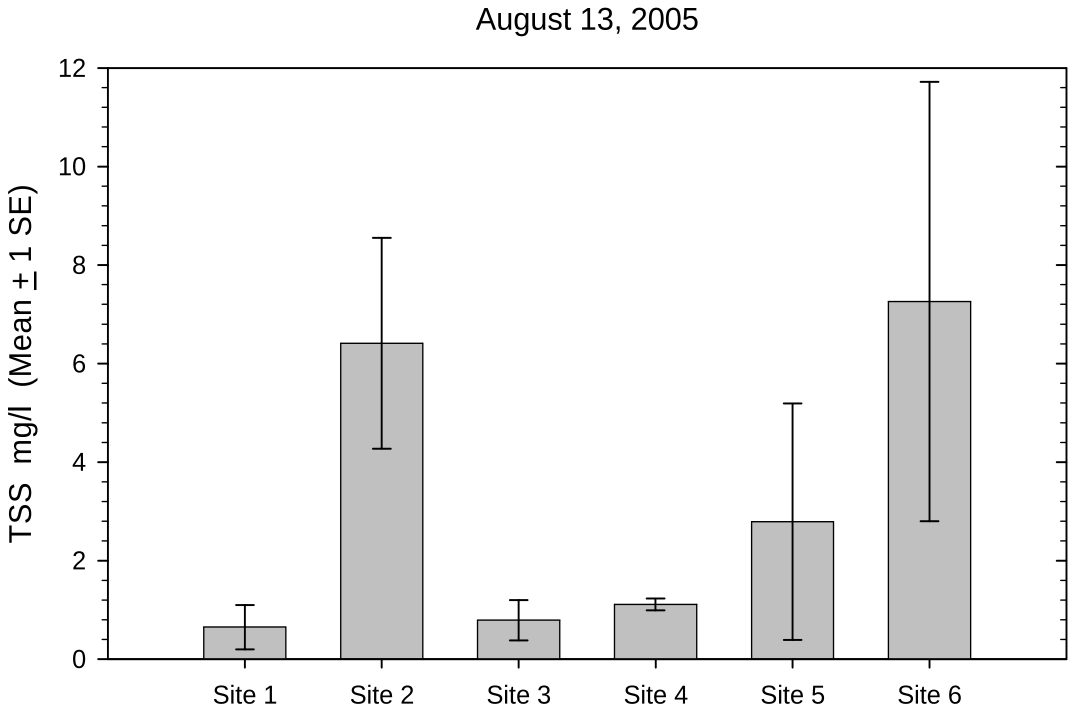
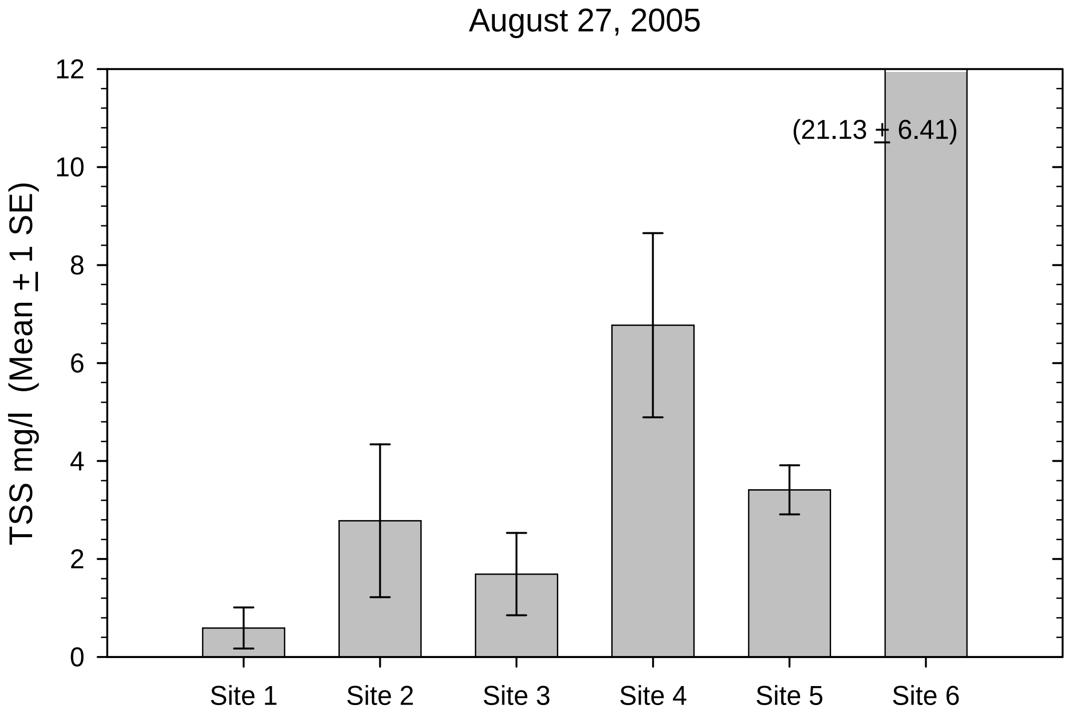

August 13, 2005

Figure C49. TSS (mg/l, mean ± 1 SE) for collection dates August 27 and September 10, 2005, for all collection sites on the Eightmile River West Branch.



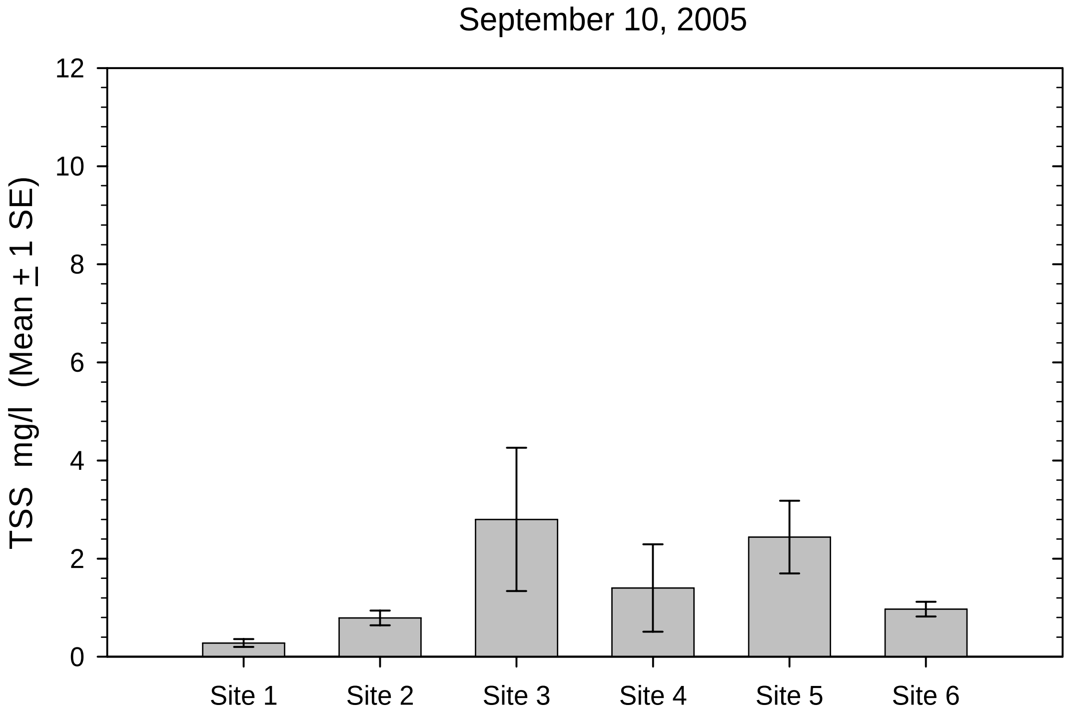
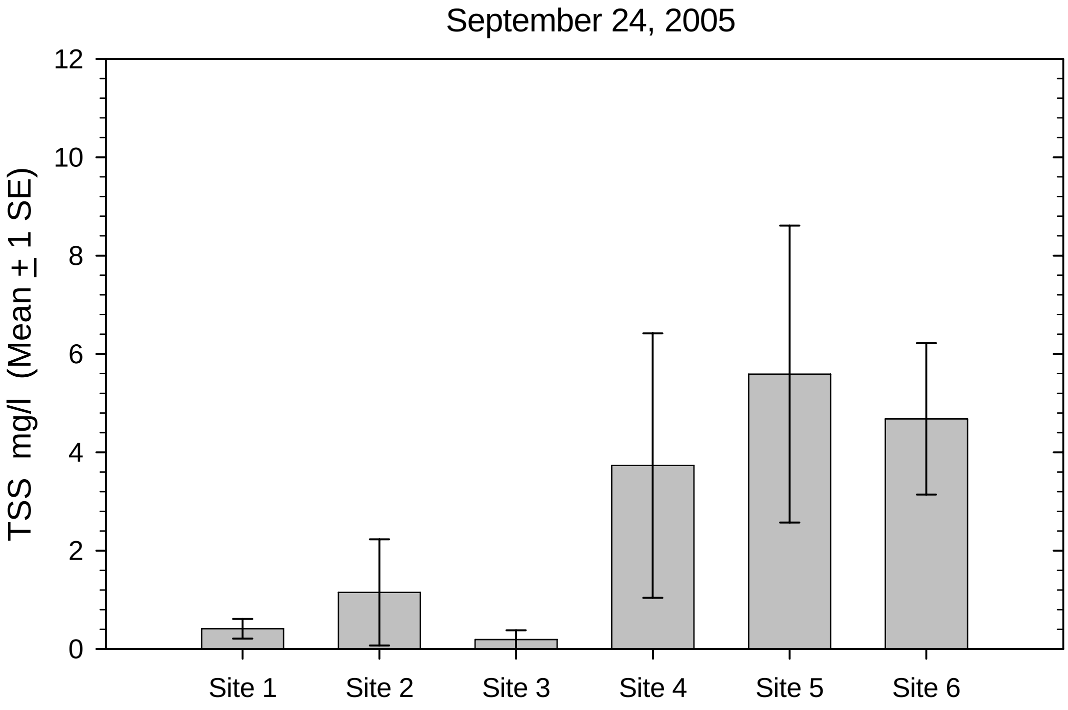


Figure C50. TSS (mg/l, mean ± 1 SE) for collection dates September 24 and October 7, 2005, for all collection sites on the Eightmile River West Branch.



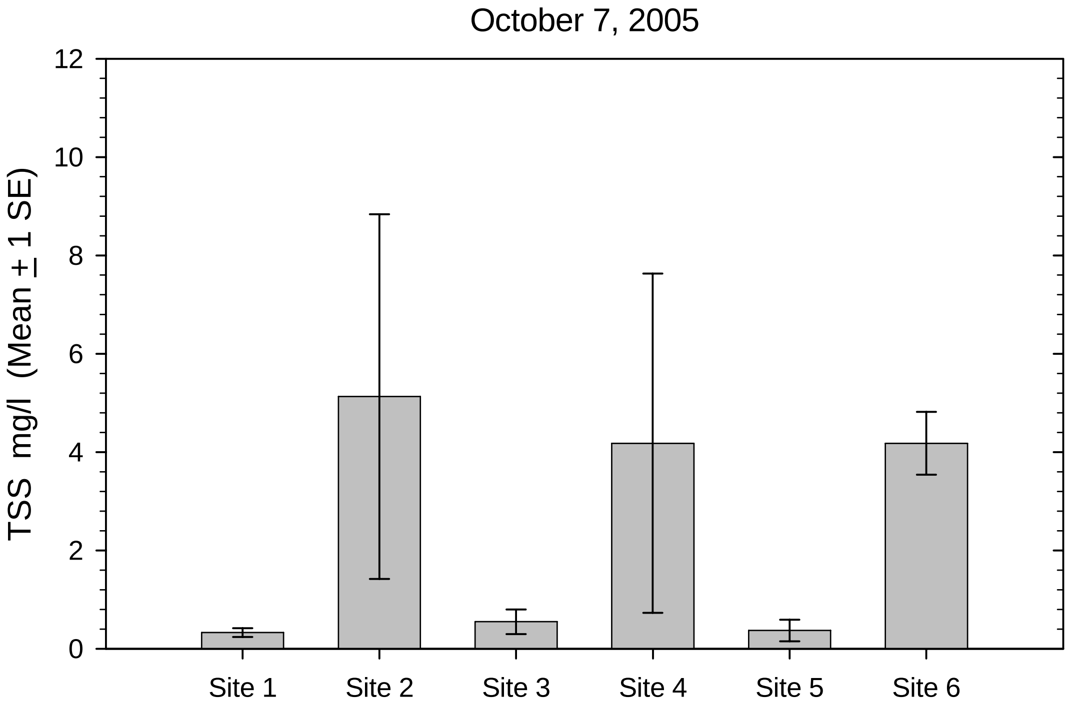


Figure C51. TSS (mg/l, mean ± 1 SE) for collection date October 22, 2005, for all collection sites on the Eightmile River West Branch.

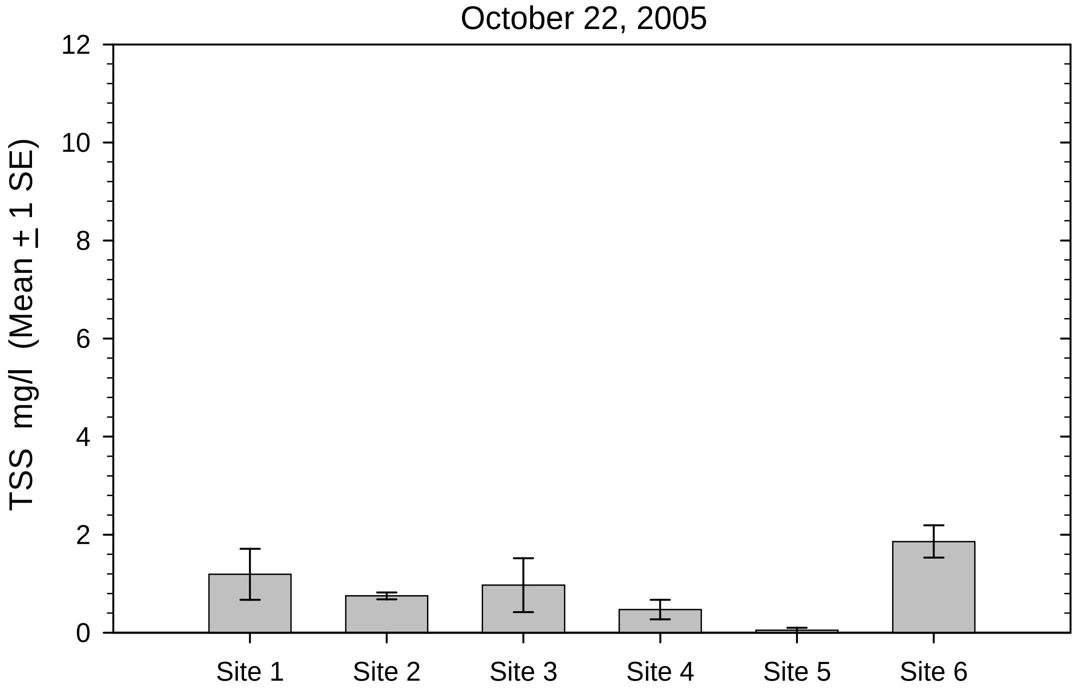
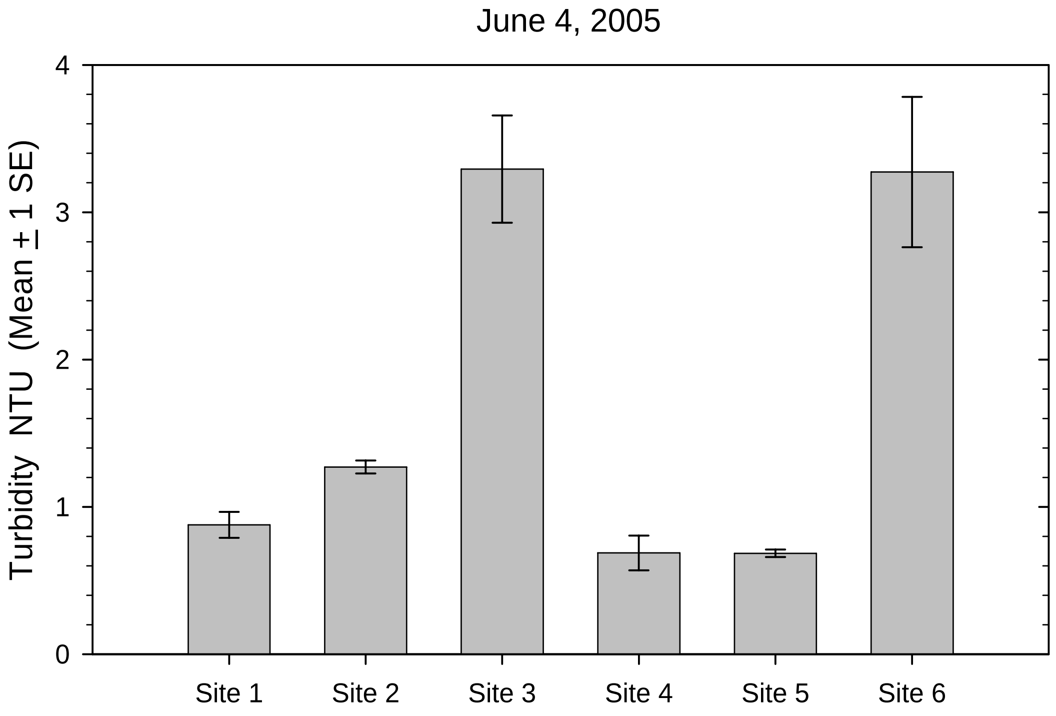


Figure C52. Turbidity (NTU, mean ± 1 SE) for collection dates June 4 and June 18, 2005, for all collection sites on the Eightmile River West Branch.



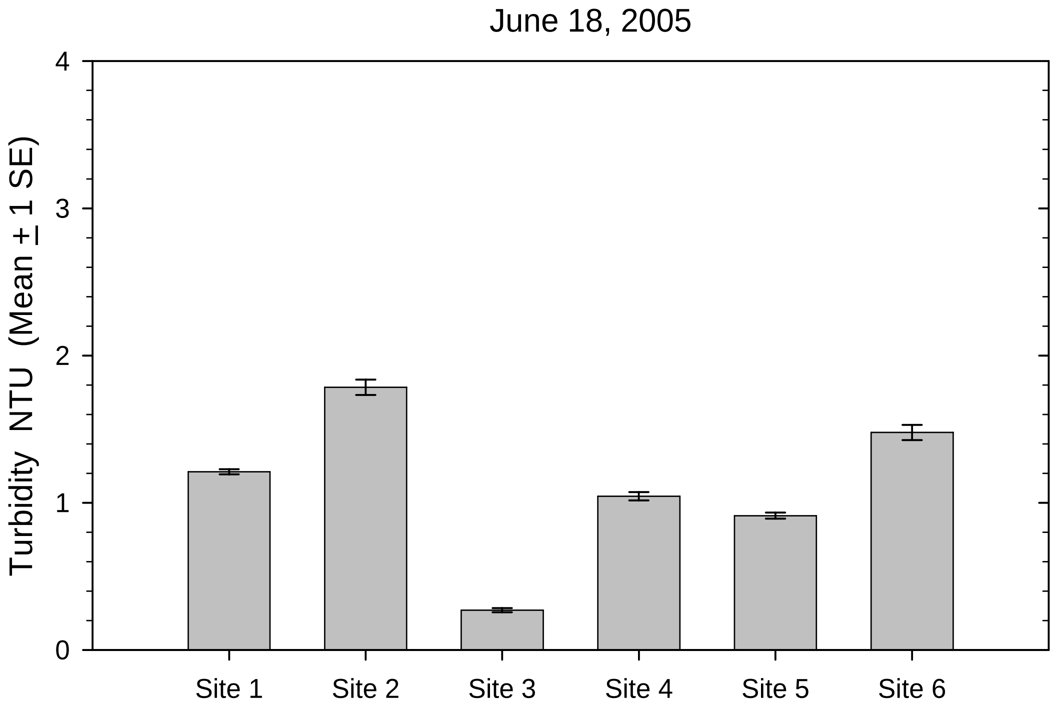
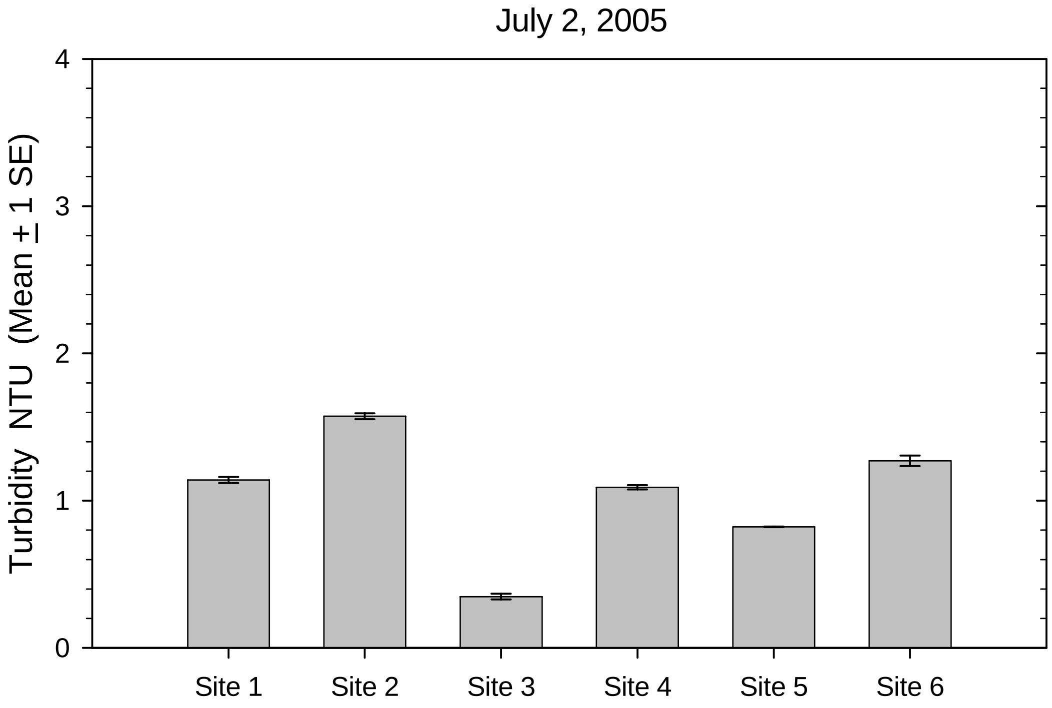


Figure C53. Turbidity (NTU, mean ± 1 SE) for collection dates July 2 and July 16, 2005, for all collection sites on the Eightmile River West Branch.



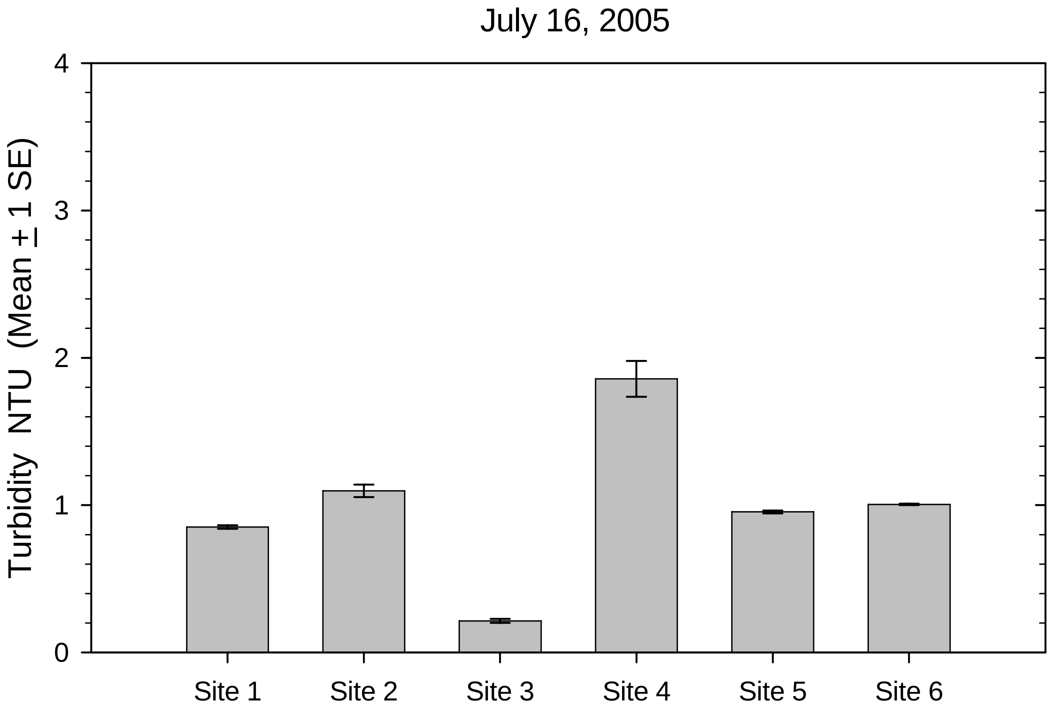
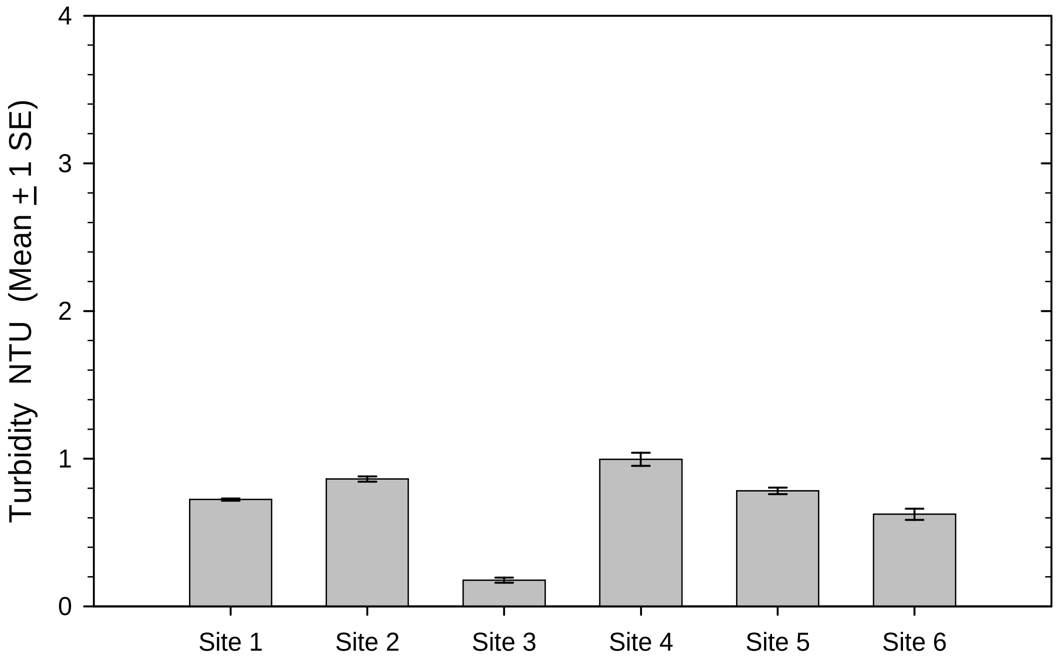


Figure C54. Turbidity (NTU, mean ± 1 SE) for collection dates July 30 and August 13, 2005, for all collection sites on the Eightmile River West Branch.

July 30, 2005



August 13, 2005

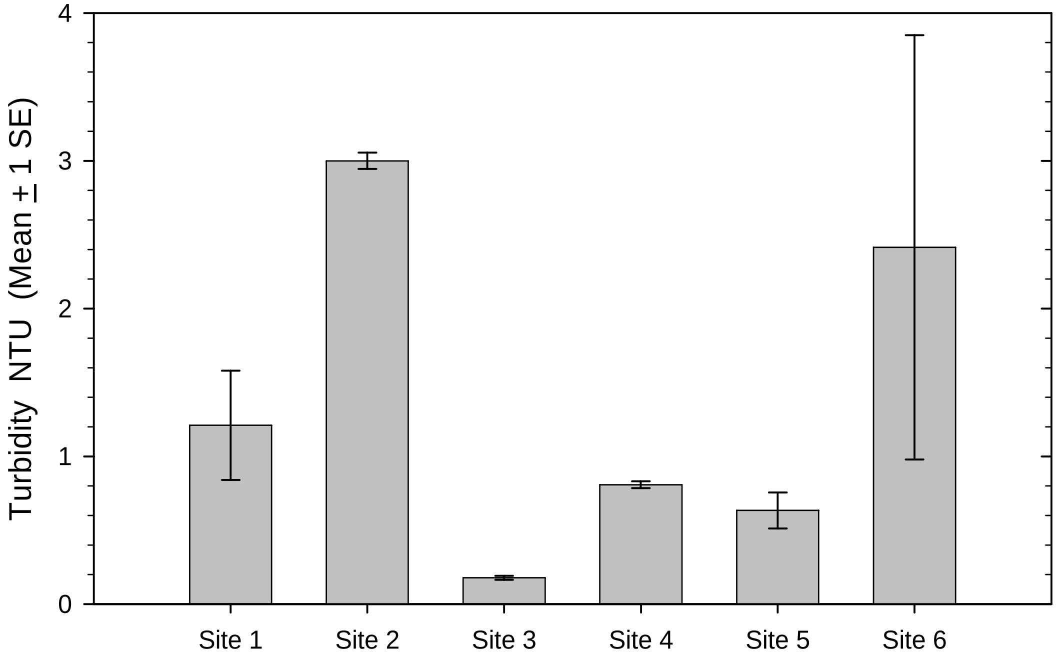
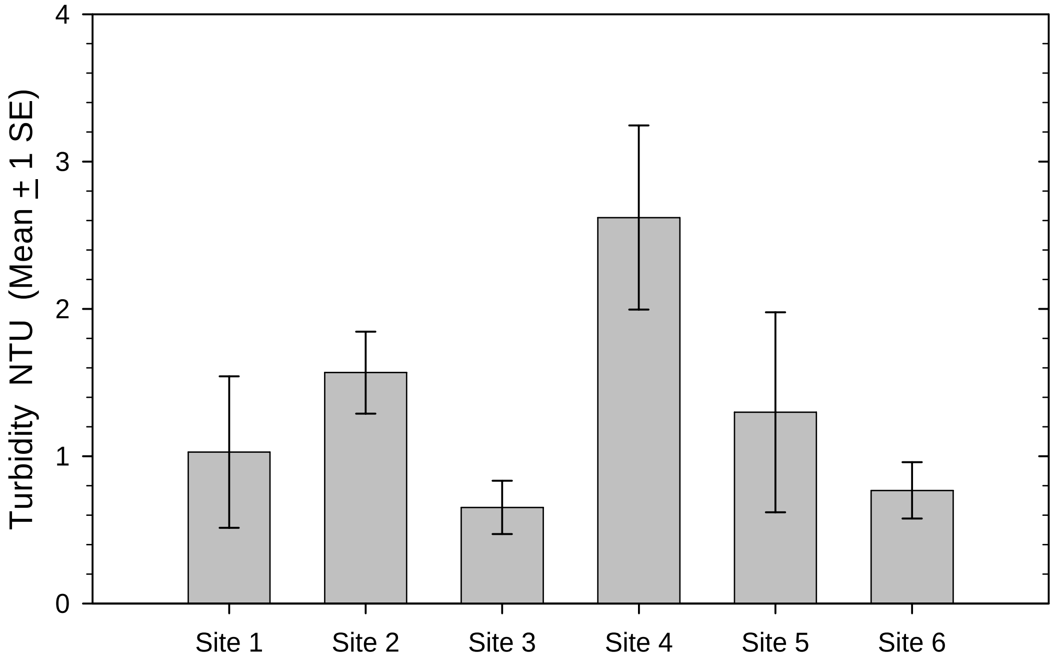


Figure C55. Turbidity (NTU, mean ± 1 SE) for collection dates August 27 and September 10, 2005, for all collection sites on the Eightmile River West Branch.

August 27, 2005



September 10, 2005

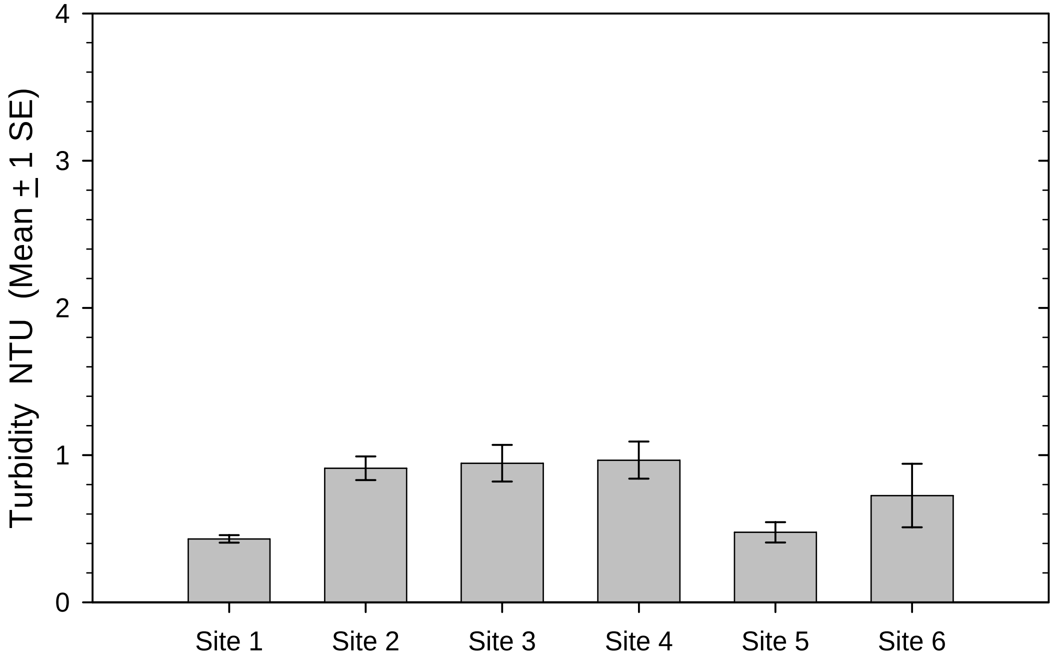
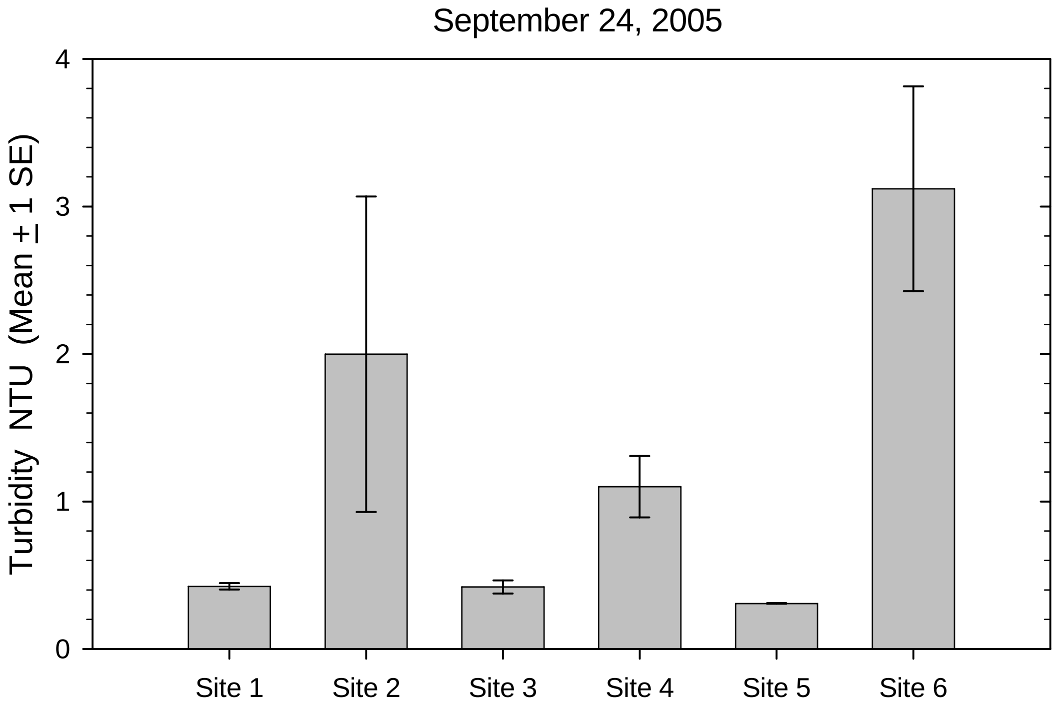


Figure C56. Turbidity (NTU, mean + 1 SE) for collection dates September 24 and October 7, 2005, for all collection sites on the Eightmile River West Branch.



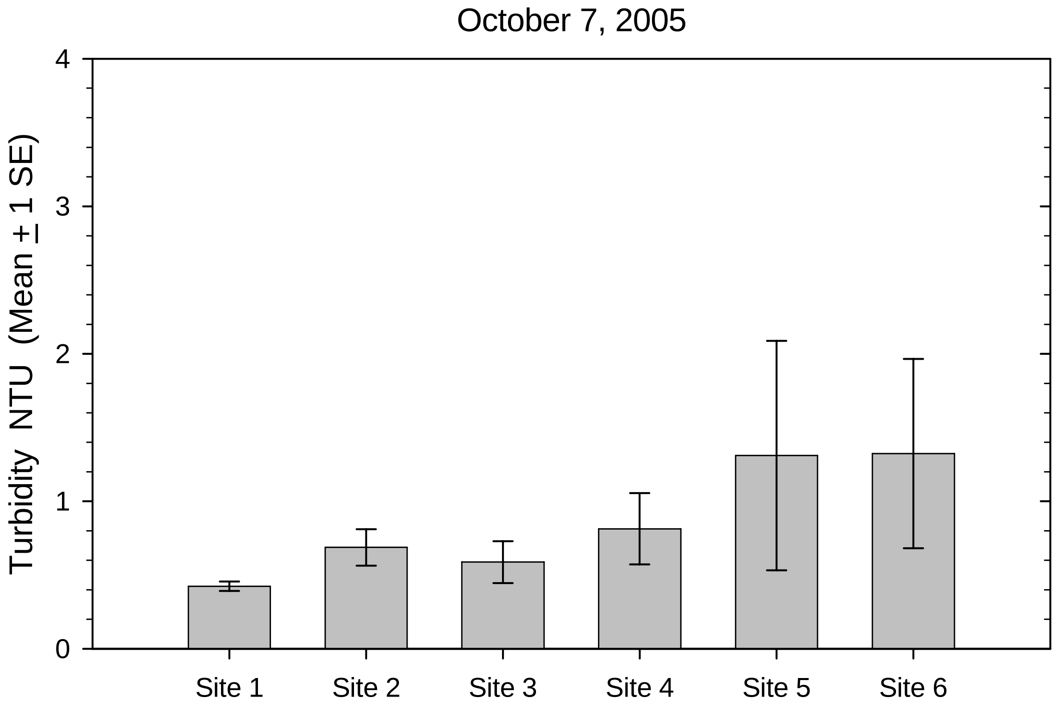
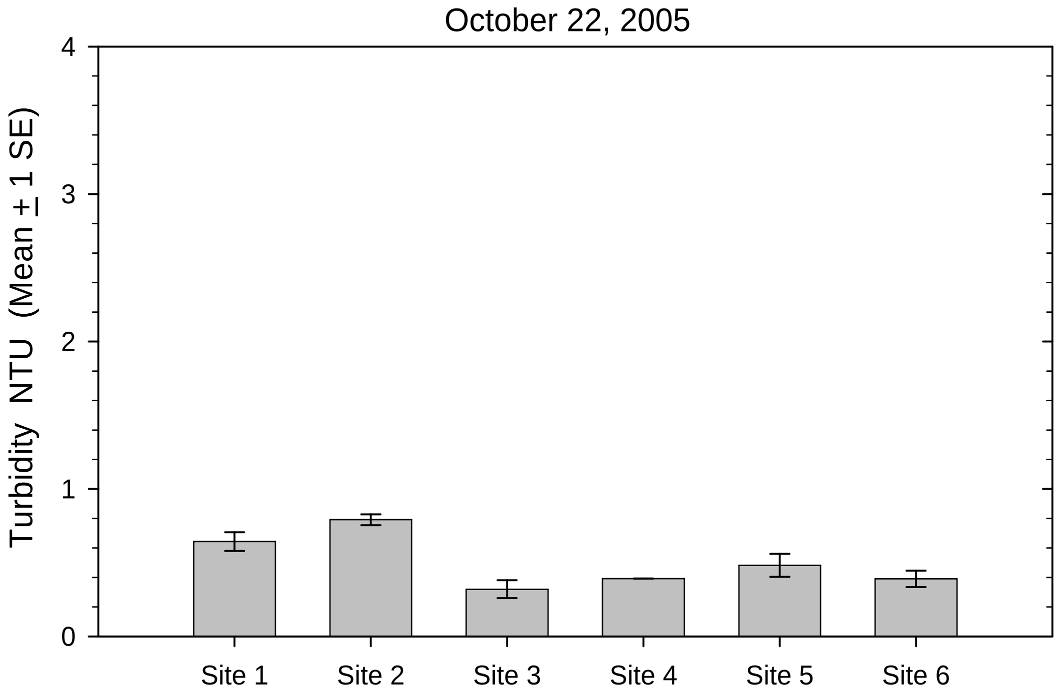


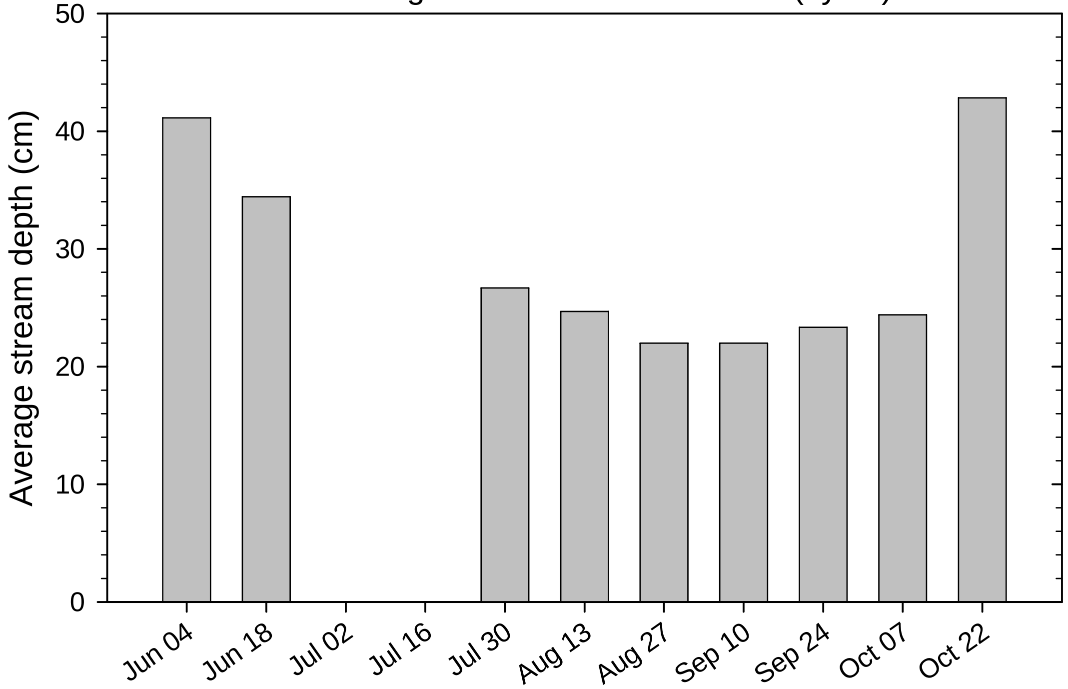
Figure C57. Turbidity (NTU, mean ± 1 SE) for collection date October 22, 2005, for all collection sites on the Eightmile River West Branch.



Appendix D

Figure D1. Average stream depth (cm) at Site 1, Eightmile River at Route 156 (Lyme) and Site 2, West Branch of Eightmile River at Hopyard Road (East Haddam) for all collection dates.

Site 1 - Eightmile River at Route 156 (Lyme)



Site 2 - West Branch of Eightmile River at Hopyard Road (East Haddam)

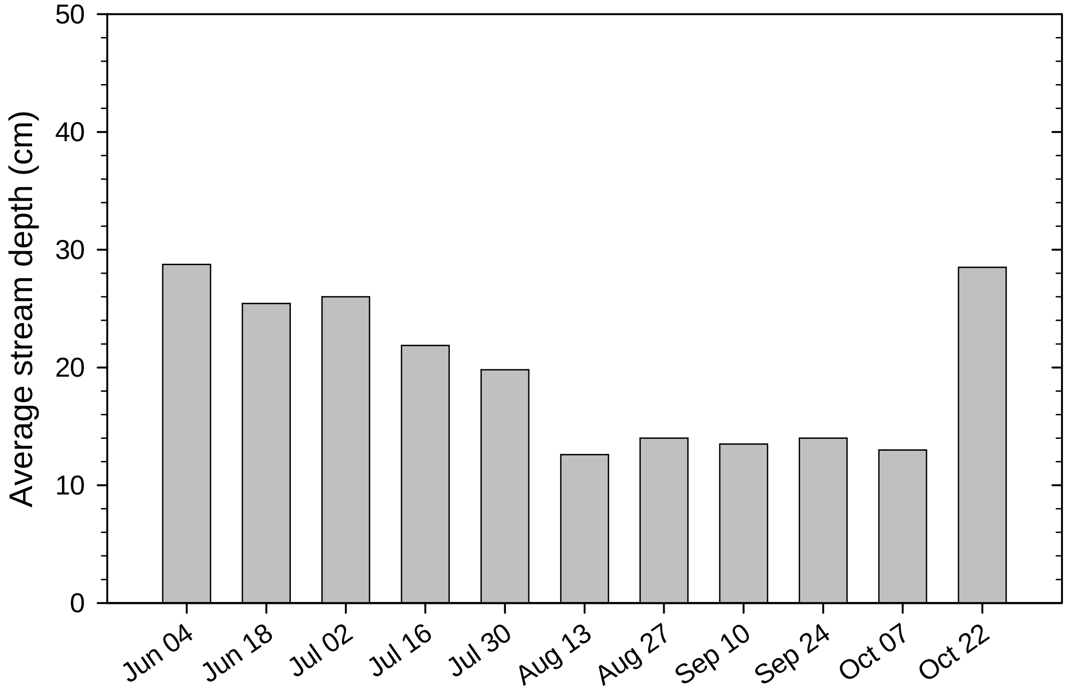
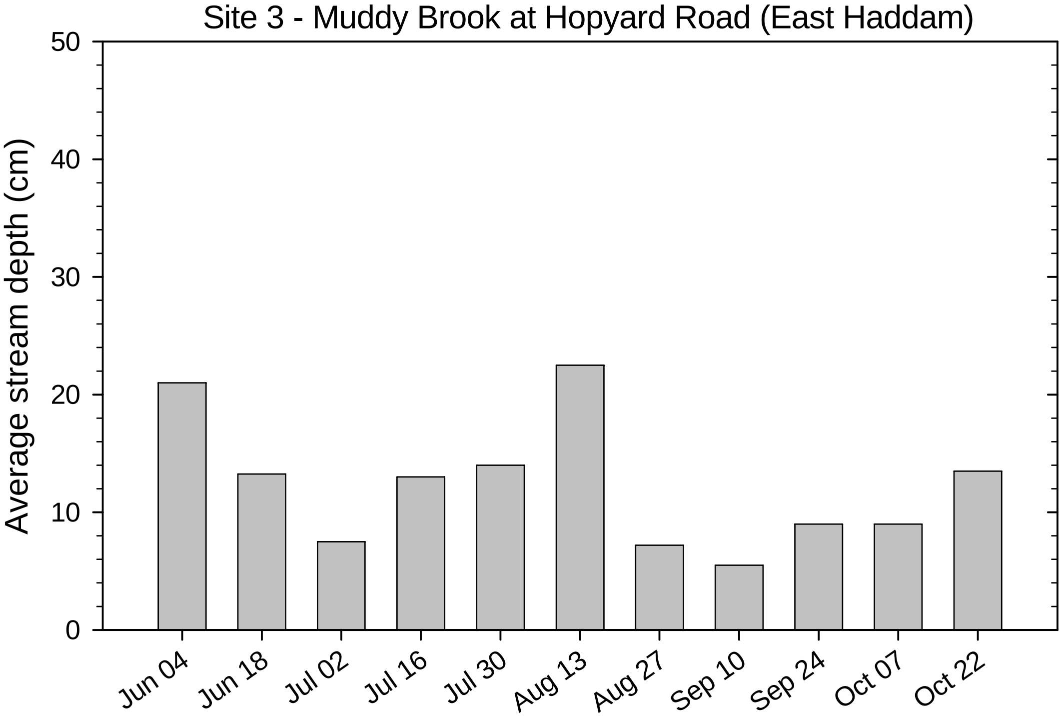


Figure D2. Average stream depth (cm) at Site 3, Muddy Brook at Hopyard Road (East Haddam) and Site 4, West Branch of Eightmile River at Haywardville Road (East Haddam) for all collection dates.



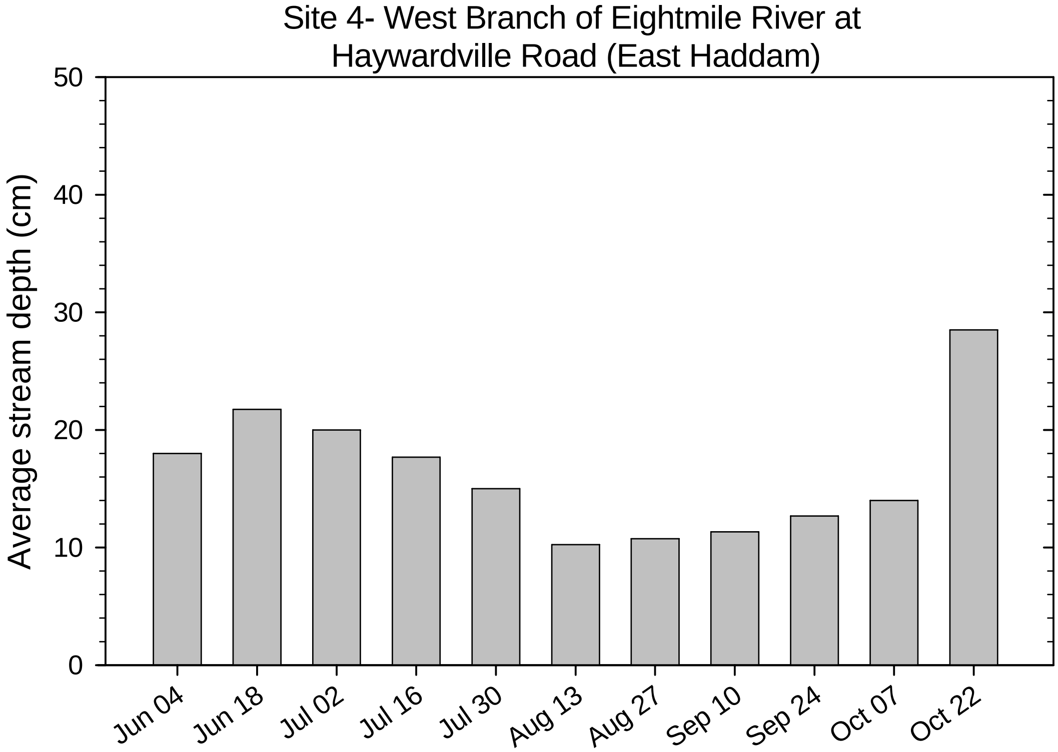
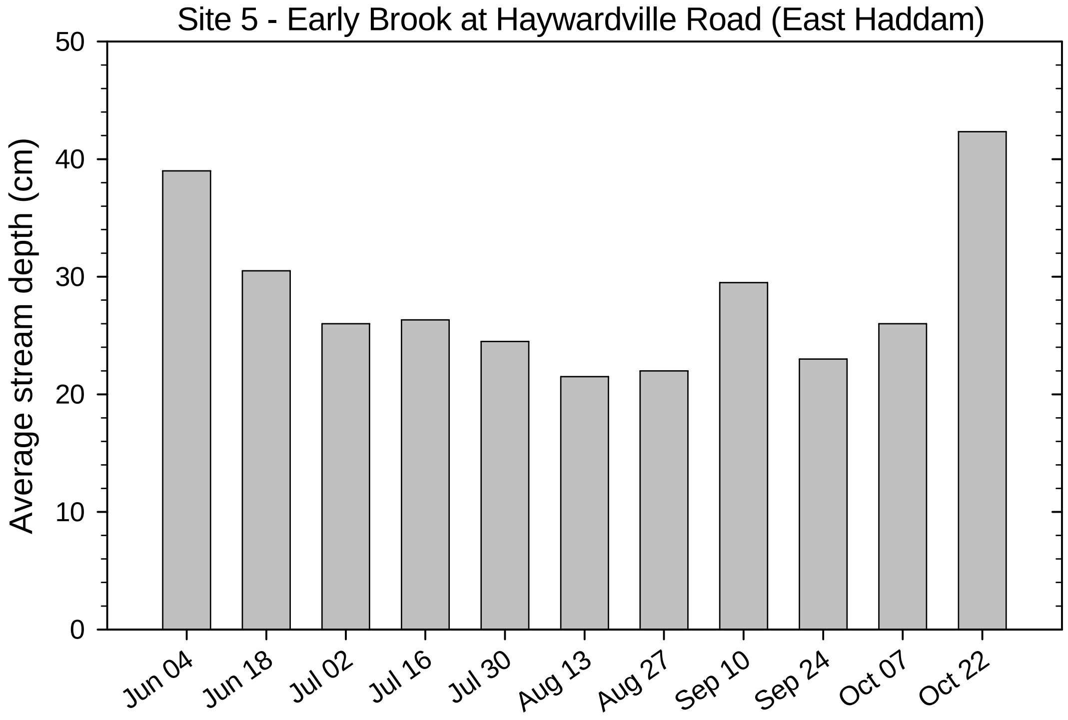
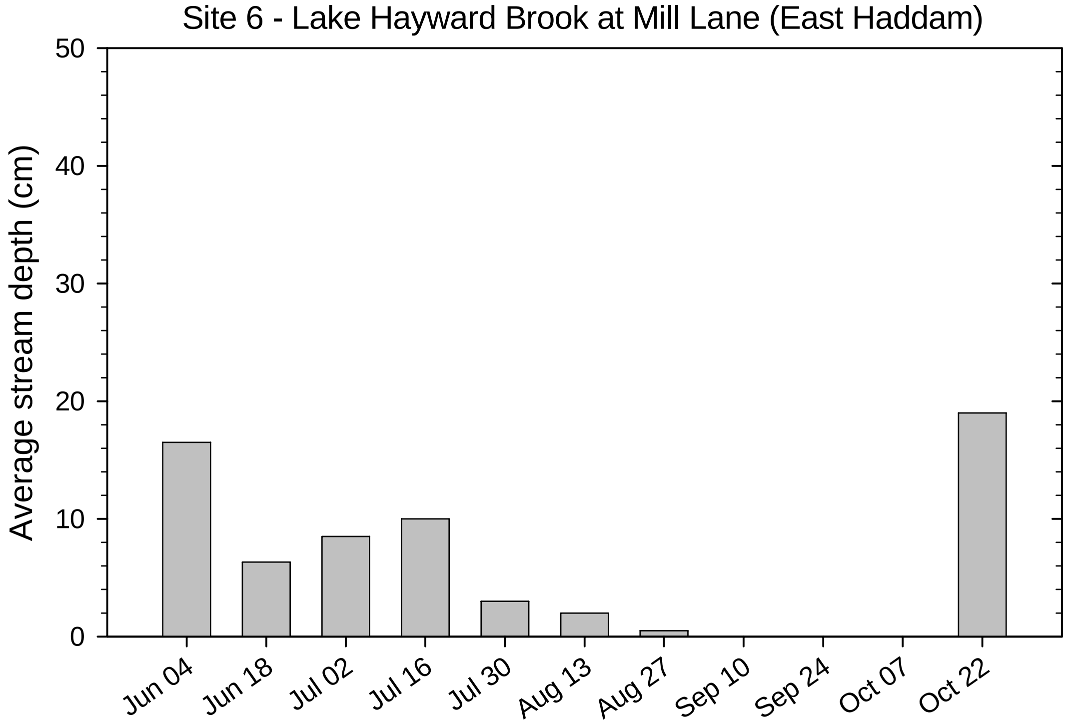


Figure D3. Average stream depth (cm) at Site 5, Early Brook at Haywardville Road (East Haddam) and Site 6, Lake Hayward Brook at Mill Lane for all collection dates.

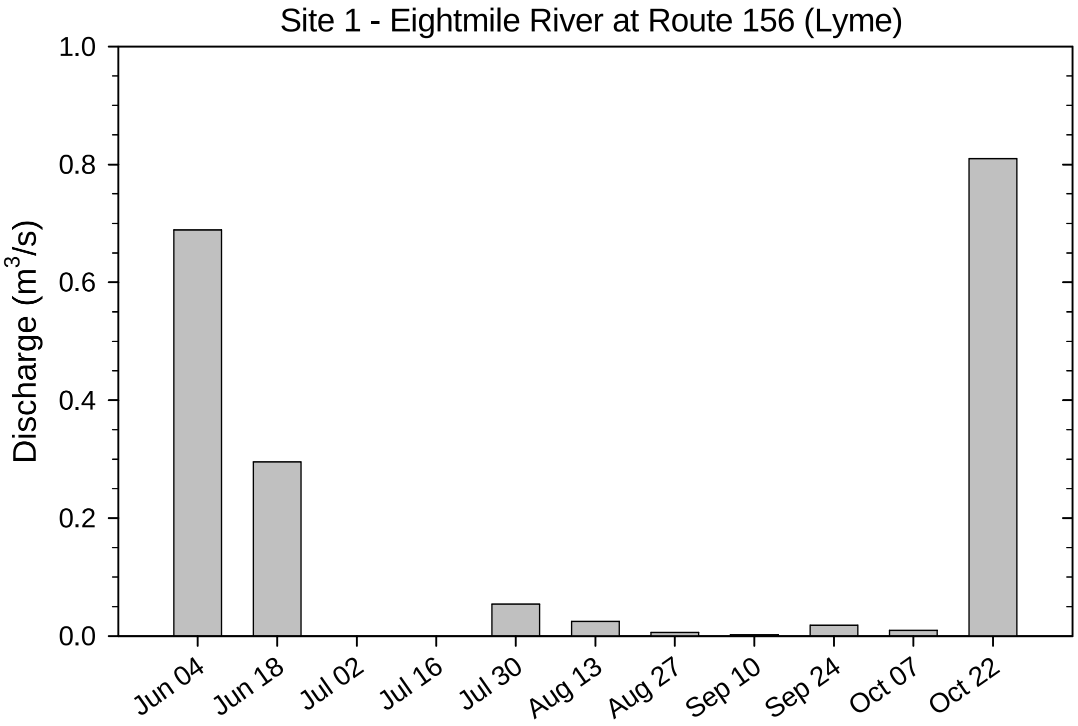


Site 5 - Early Brook at Haywardville Road (East Haddam)



Site 6 - Lake Hayward Brook at Mill Lane (East Haddam)

Figure D4. Discharge (m^3/s) at Site 1, Eightmile River at Route 156 (Lyme) and Site 2, West Branch of Eightmile River at Hopyard Road (East Haddam) for all collection dates.



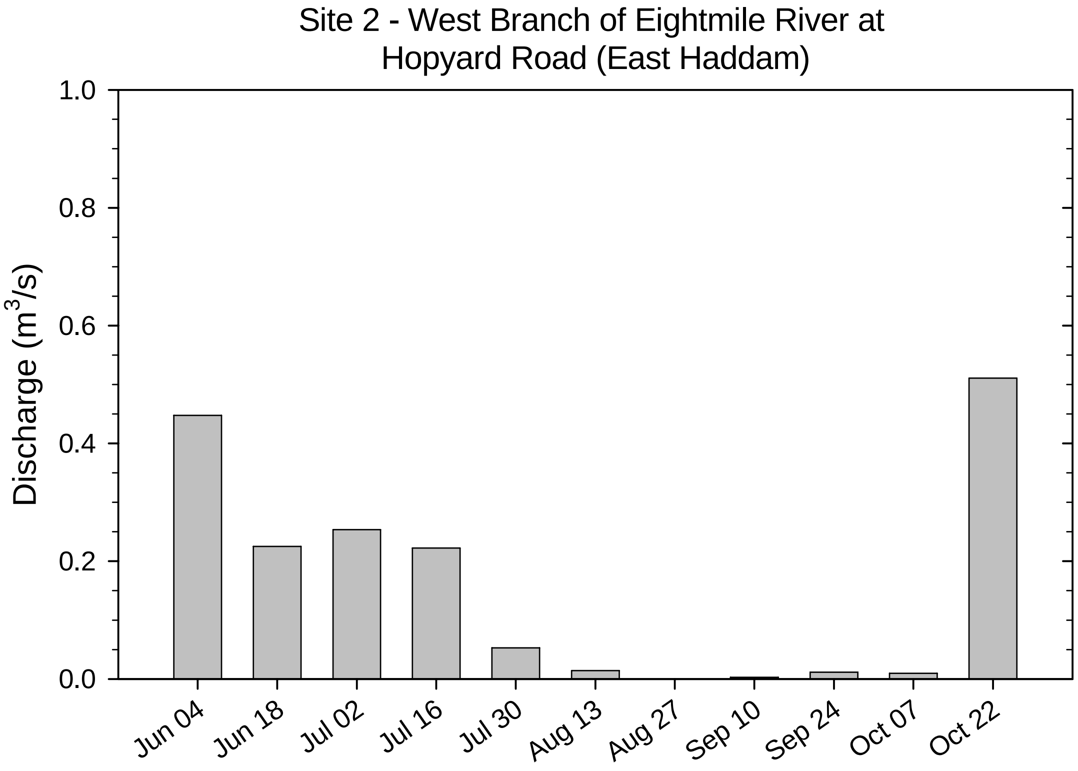
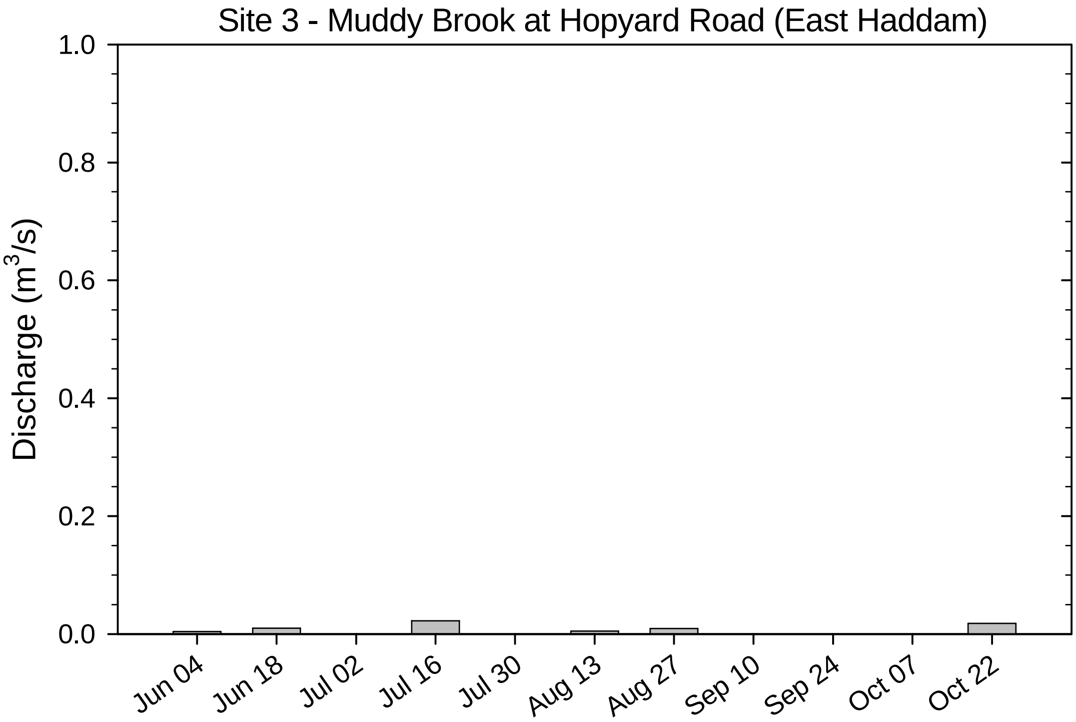


Figure D5. Discharge (m^3/s) at Site 3, Muddy Brook at Hopyard Road (East Haddam) and Site 4, West Branch of Eightmile River at Haywardville Road (East Haddam) for all collection dates.



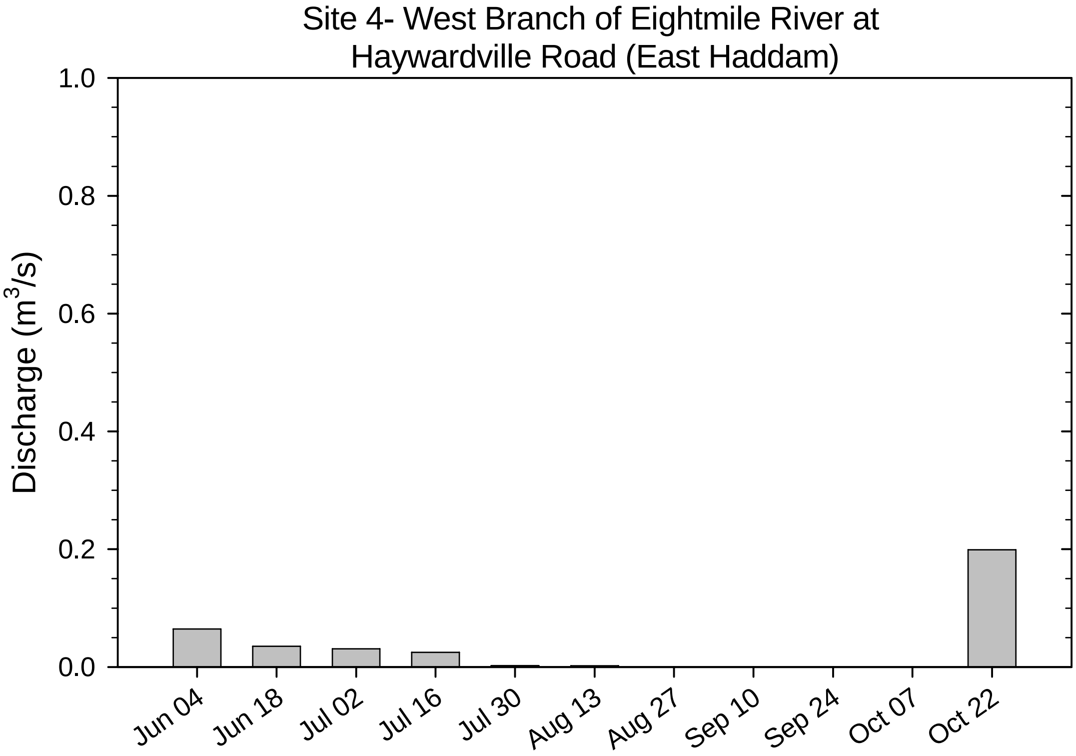
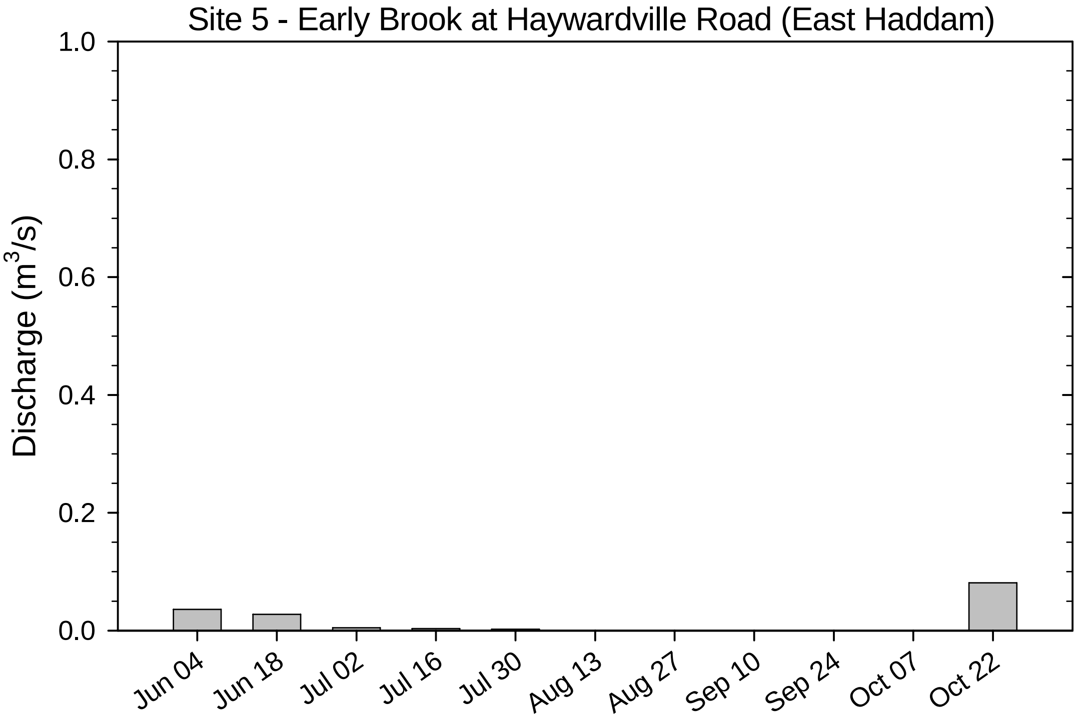


Figure D6. Discharge (m^3/s) at Site 5, Early Brook at Haywardville Road (East Haddam) and Site 6, Lake Hayward Brook at Mill Lane for all collection dates.



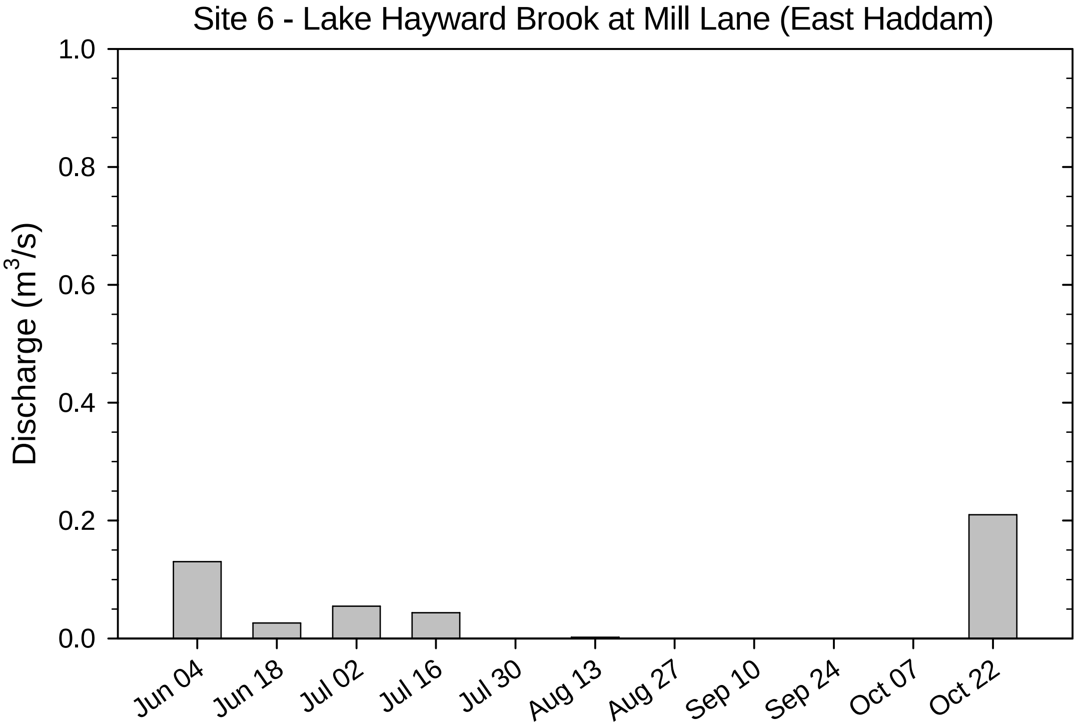
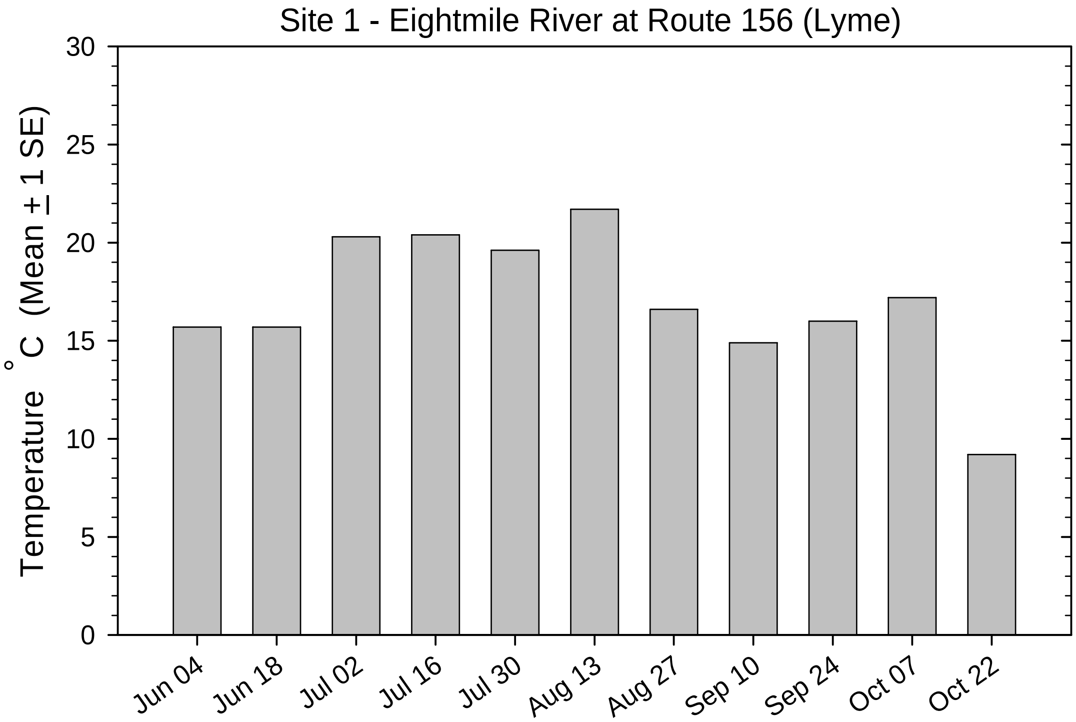


Figure D7. Temperature (° C, mean ± 1 SE) at Site 1, Eightmile River at Route 156 (Lyme) and Site 2, West Branch of Eightmile River at Hopyard Road (East Haddam) for all collection dates.



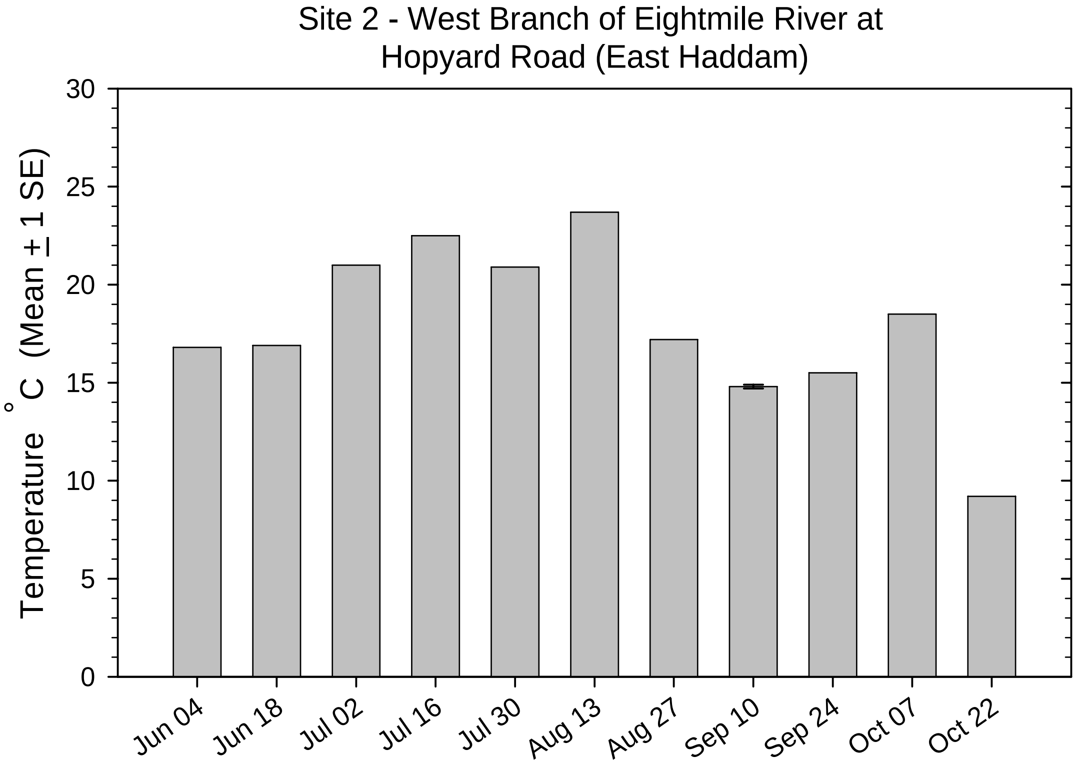
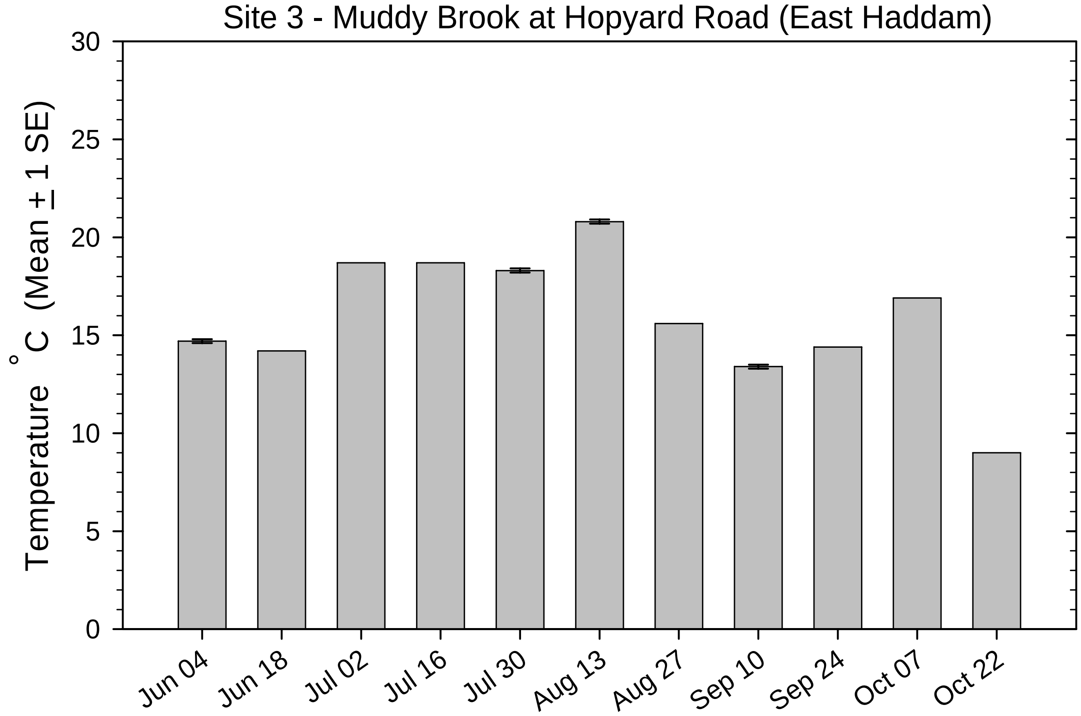


Figure D8. Temperature (° C, mean ± 1 SE) at Site 3, Muddy Brook at Hopyard Road (East Haddam) and Site 4, West Branch of Eightmile River at Haywardville Road (East Haddam) for all collection dates.



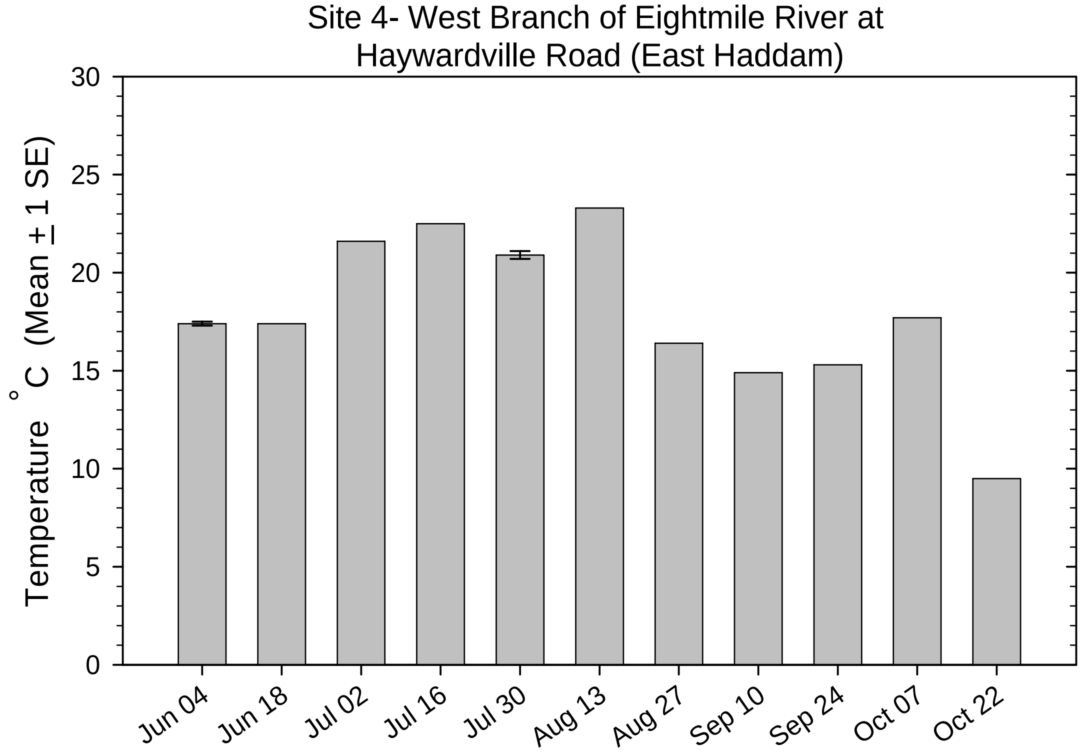
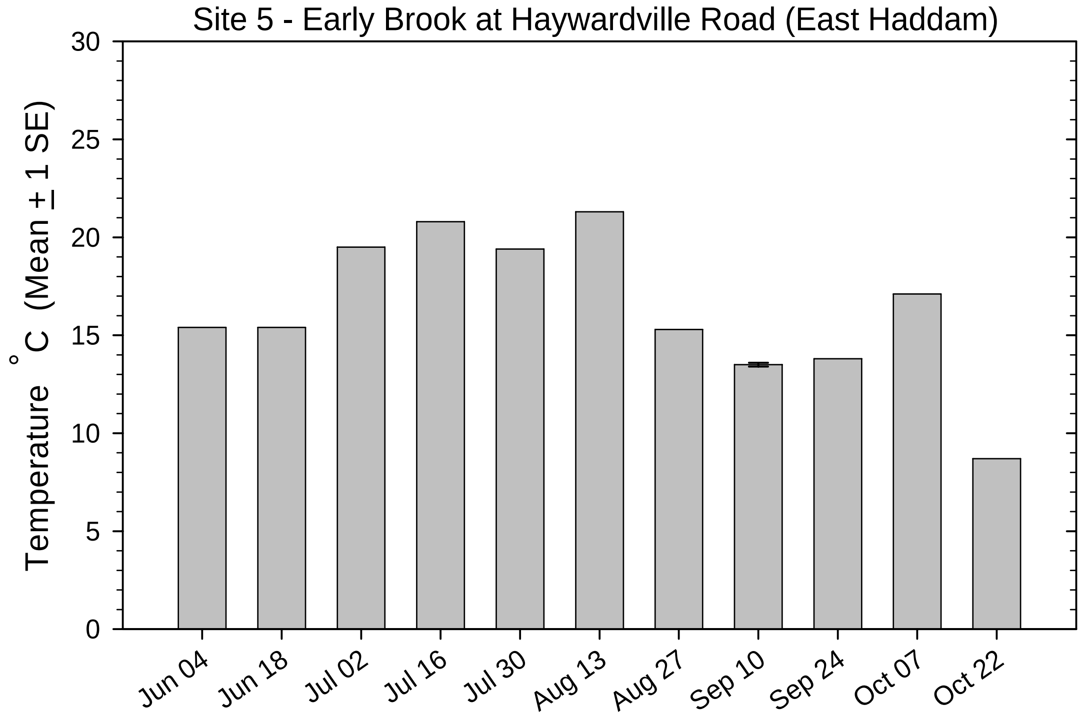


Figure D9. Temperature (° C, mean ± 1 SE) at Site 5, Early Brook at Haywardville Road (East Haddam) and Site 6, Lake Hayward Brook at Mill Lane for all collection dates.



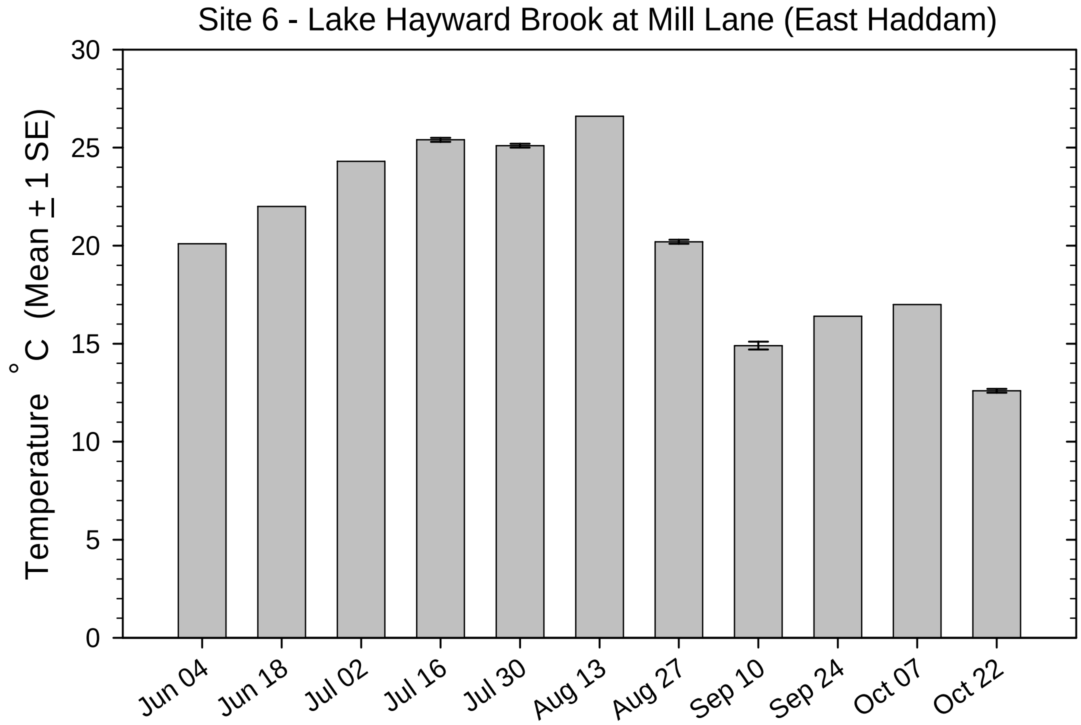
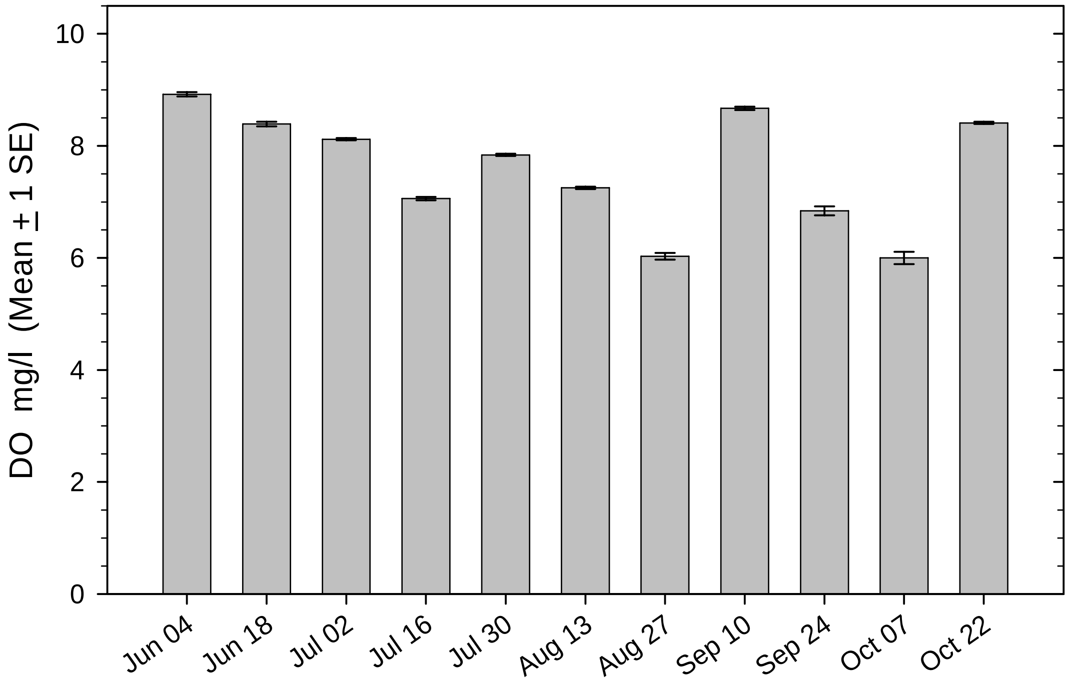


Figure D10. Dissolved oxygen (mg/l, mean ± 1 SE) at Site 1, Eightmile River at Route 156 (Lyme) and Site 2, West Branch of Eightmile River at Hopyard Road (East Haddam) for all collection dates.

Site 1 - Eightmile River at Route 156 (Lyme)



Site 2 - West Branch of Eightmile River at Hopyard Road (East Haddam)

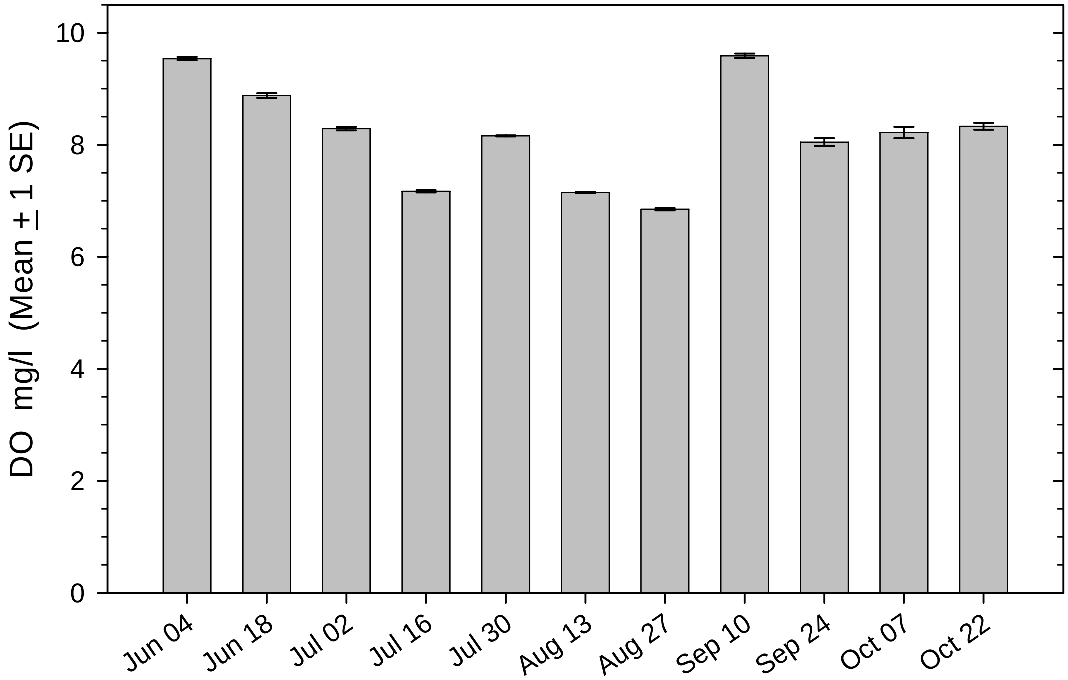
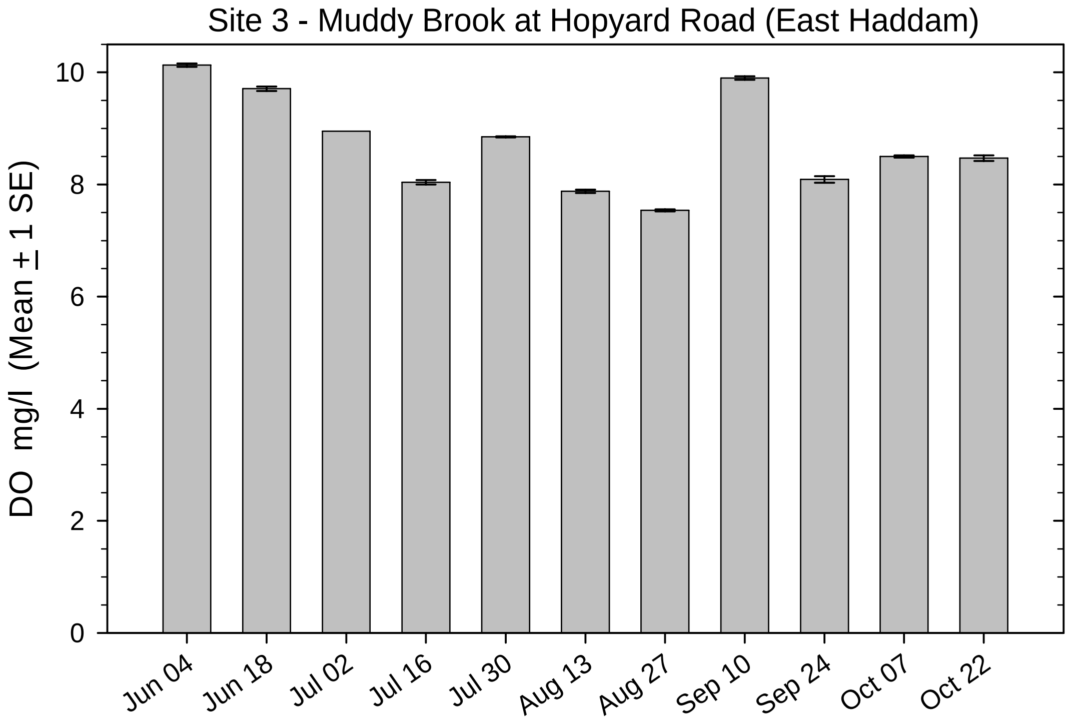


Figure D11. Dissolved oxygen (mg/l, mean ± 1 SE) at Site 3, Muddy Brook at Hopyard Road (East Haddam) and Site 4, West Branch of Eightmile River at Haywardville Road (East Haddam) for all collection dates.



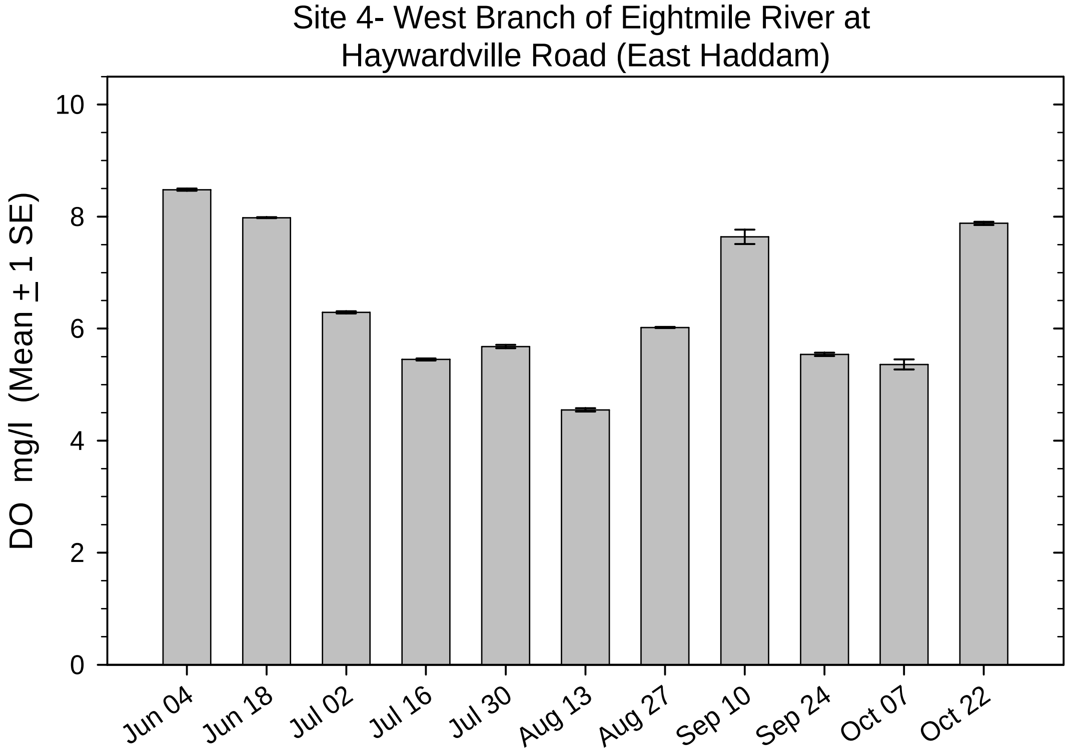
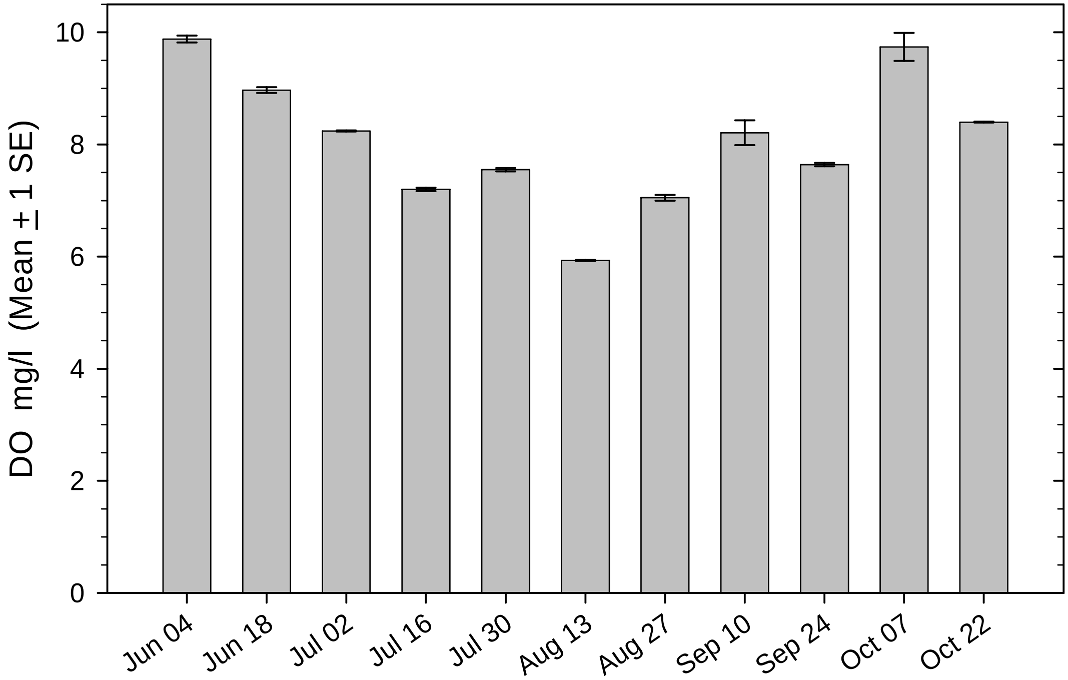


Figure D12. Dissolved oxygen (mg/l, mean ± 1 SE) at Site 5, Early Brook at Haywardville Road (East Haddam) and Site 6, Lake Hayward Brook at Mill Lane for all collection dates.


Site 5 - Early Brook at Haywardville Road (East Haddam)

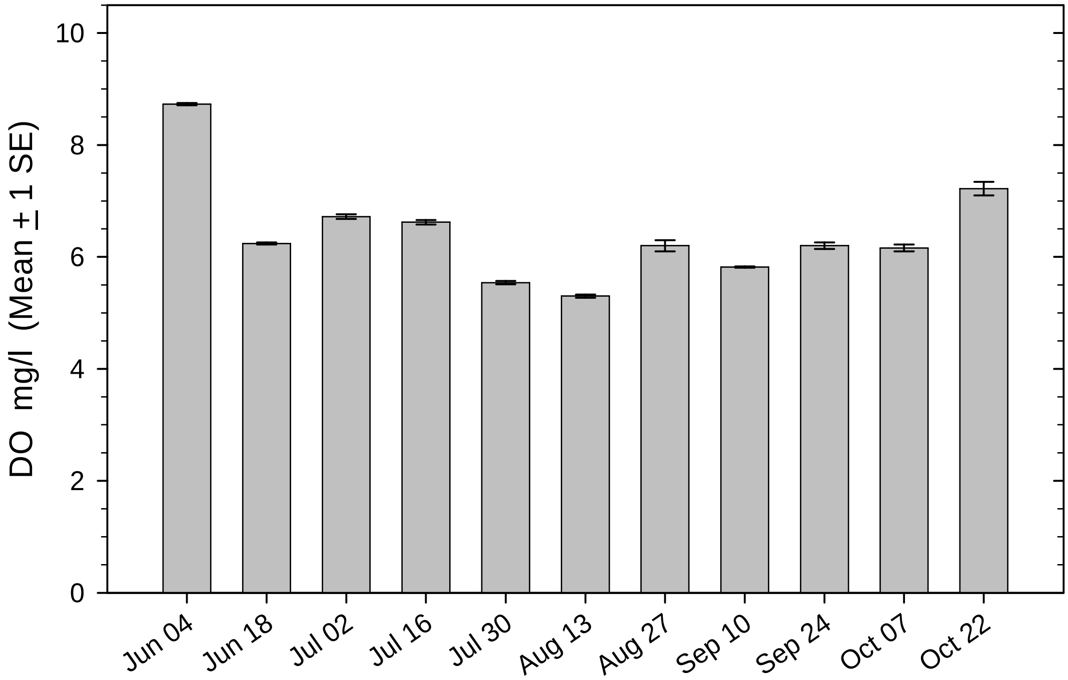
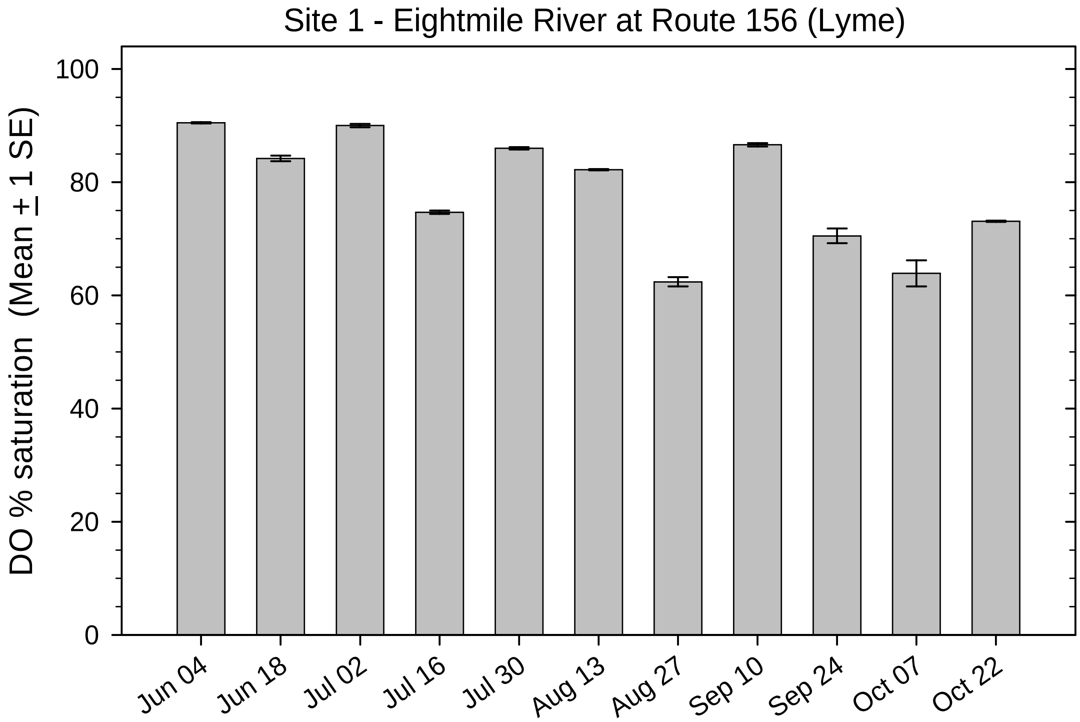

Site 6 - Lake Hayward Brook at Mill Lane (East Haddam)

Figure D13. Dissolved oxygen (% saturation, mean ± 1 SE) at Site 1, Eightmile River at Route 156 (Lyme) and Site 2, West Branch of Eightmile River at Hopyard Road (East Haddam) for all collection dates.



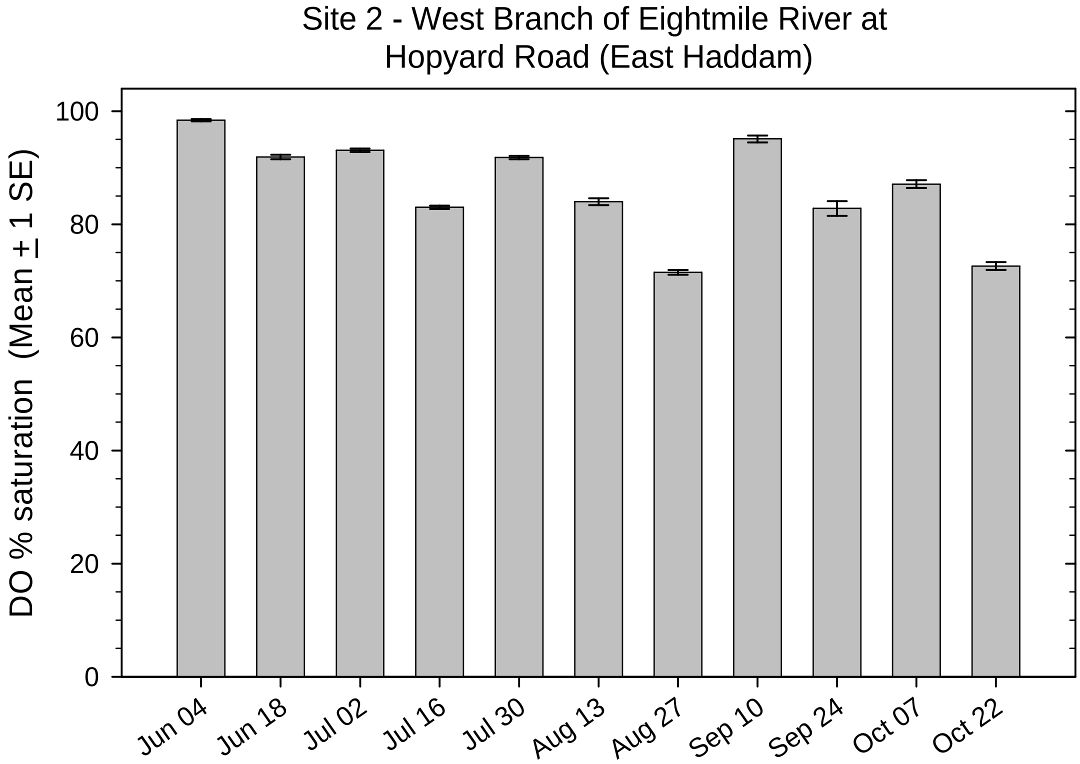
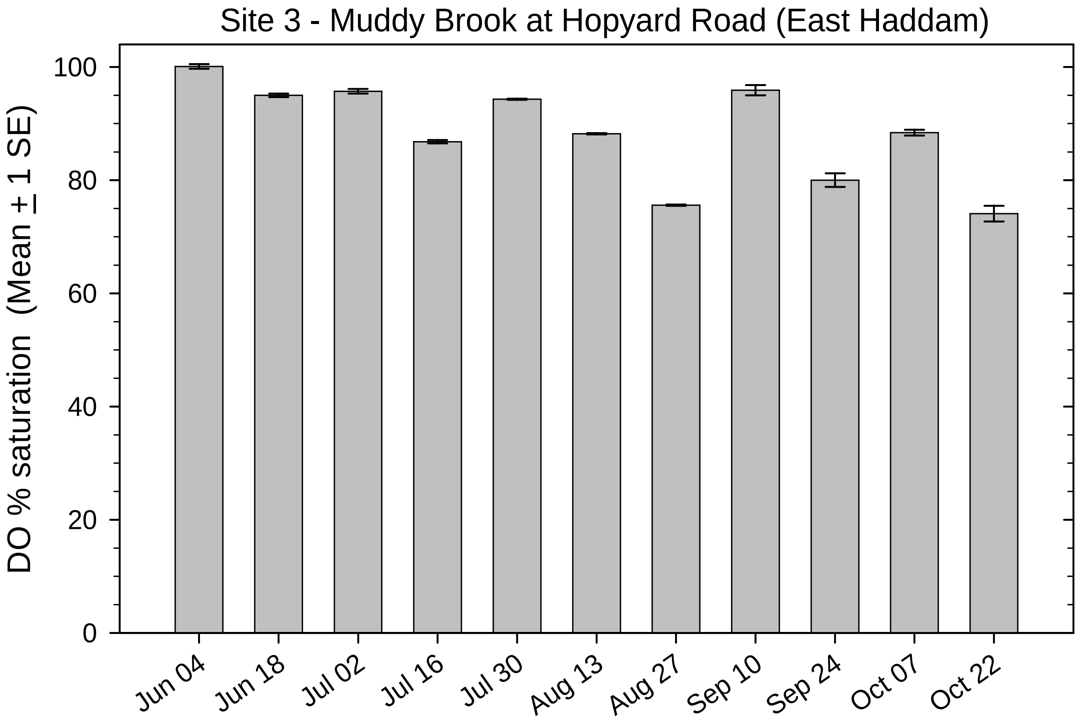


Figure D14. Dissolved oxygen (% saturation, mean + 1 SE) at Site 3, Muddy Brook at Hopyard Road (East Haddam) and Site 4, West Branch of Eightmile River at Haywardville Road (East Haddam) for all collection dates.



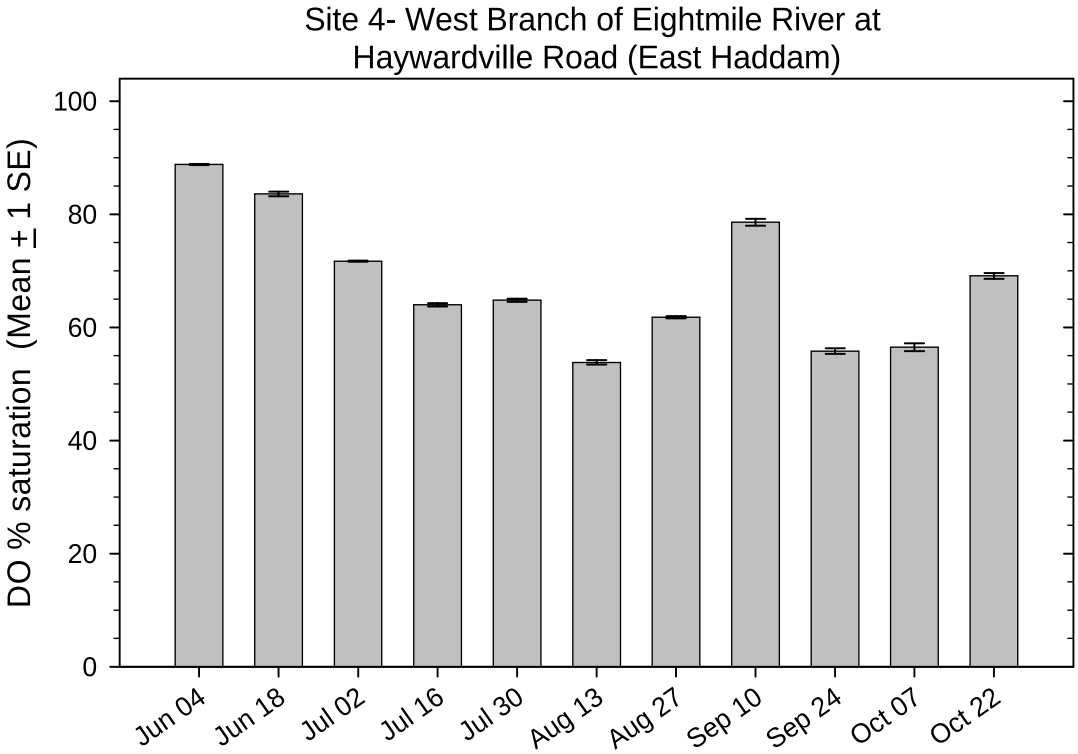
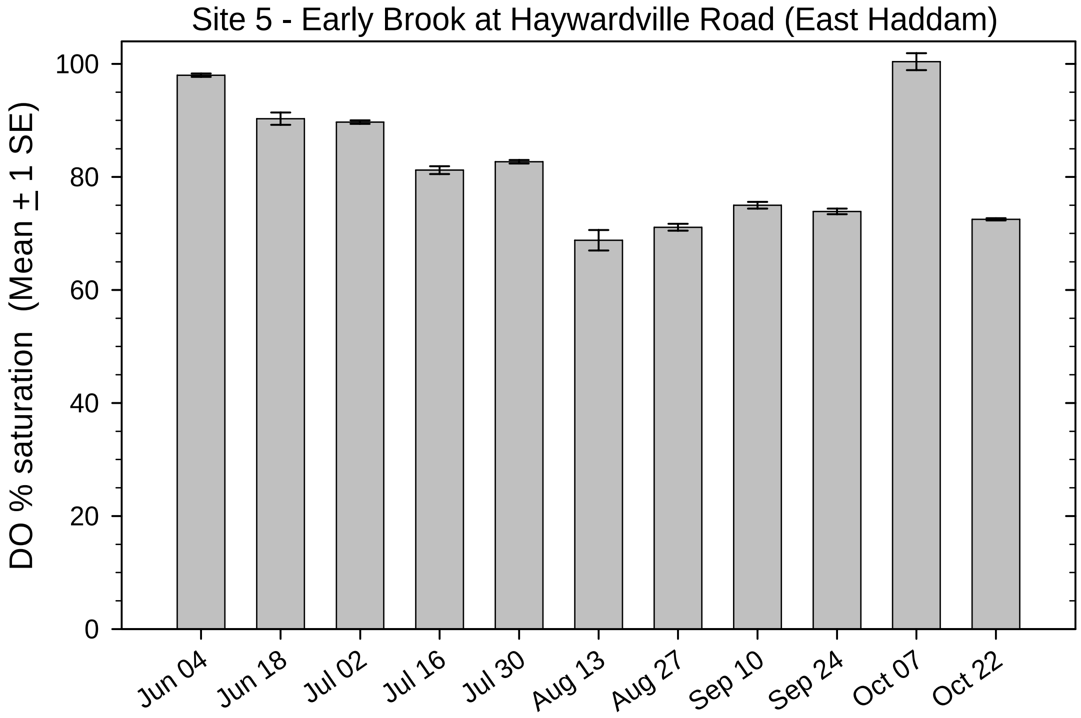


Figure D15. Dissolved oxygen (% saturation, mean + 1 SE) at Site 5, Early Brook at Haywardville Road (East Haddam) and Site 6, Lake Hayward Brook at Mill Lane for all collection dates.



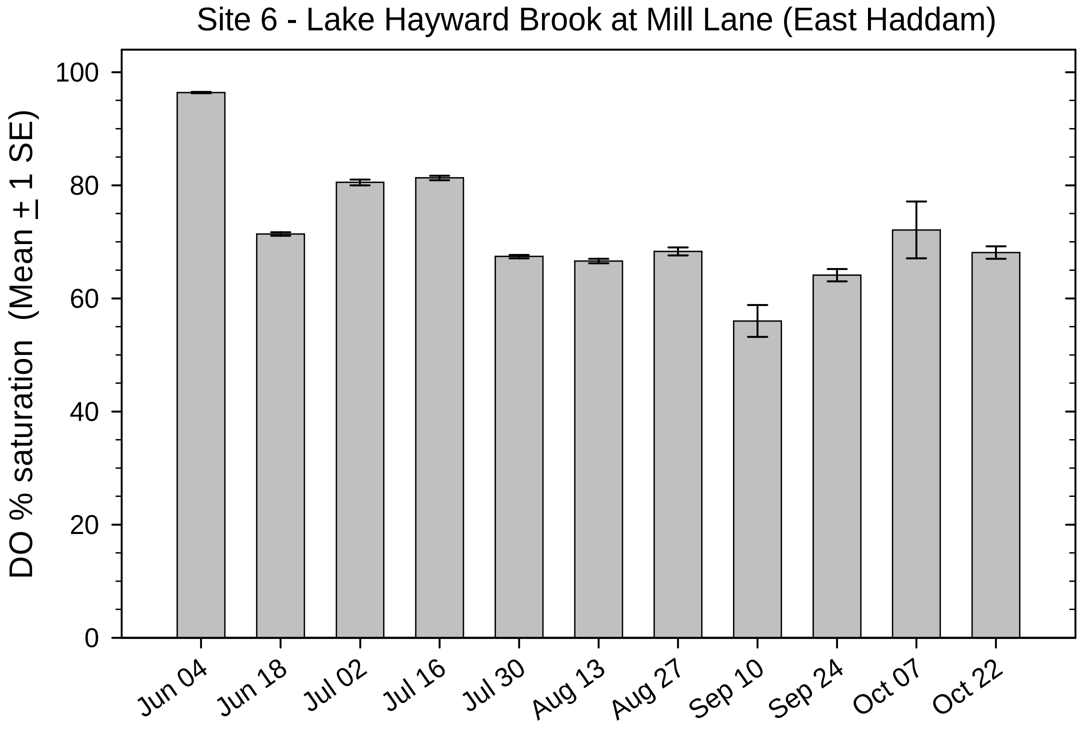
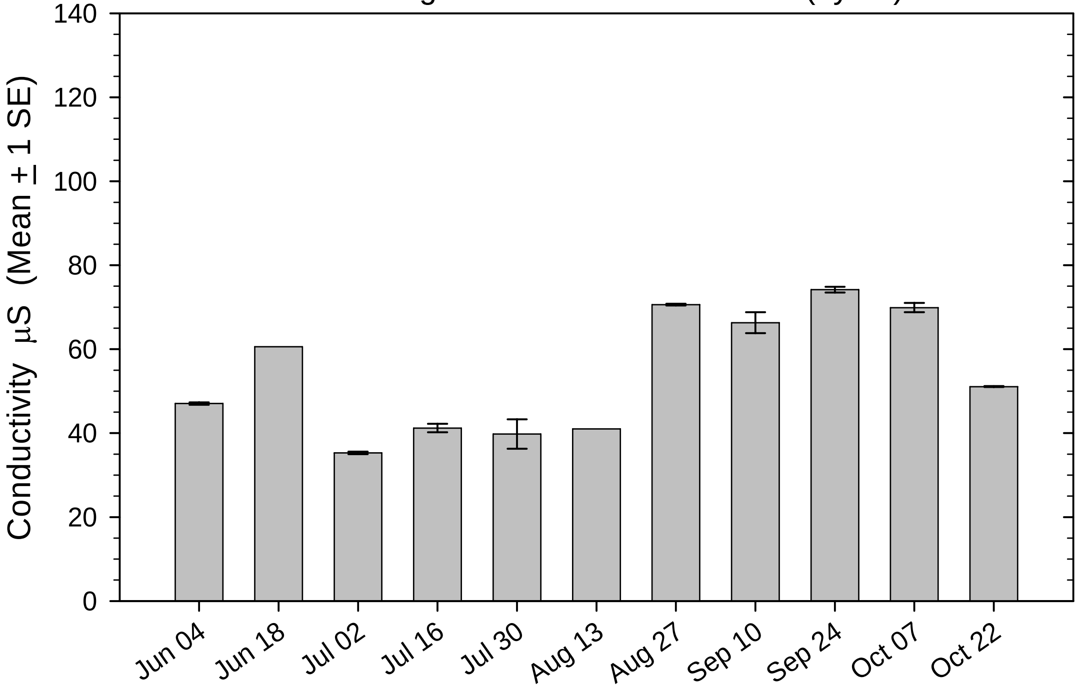


Figure D16. Conductivity (µS, mean ± 1 SE) at Site 1, Eightmile River at Route 156 (Lyme) and Site 2, West Branch of Eightmile River at Hopyard Road (East Haddam) for all collection dates.

Site 1 - Eightmile River at Route 156 (Lyme)



Site 2 - West Branch of Eightmile River at Hopyard Road (East Haddam)

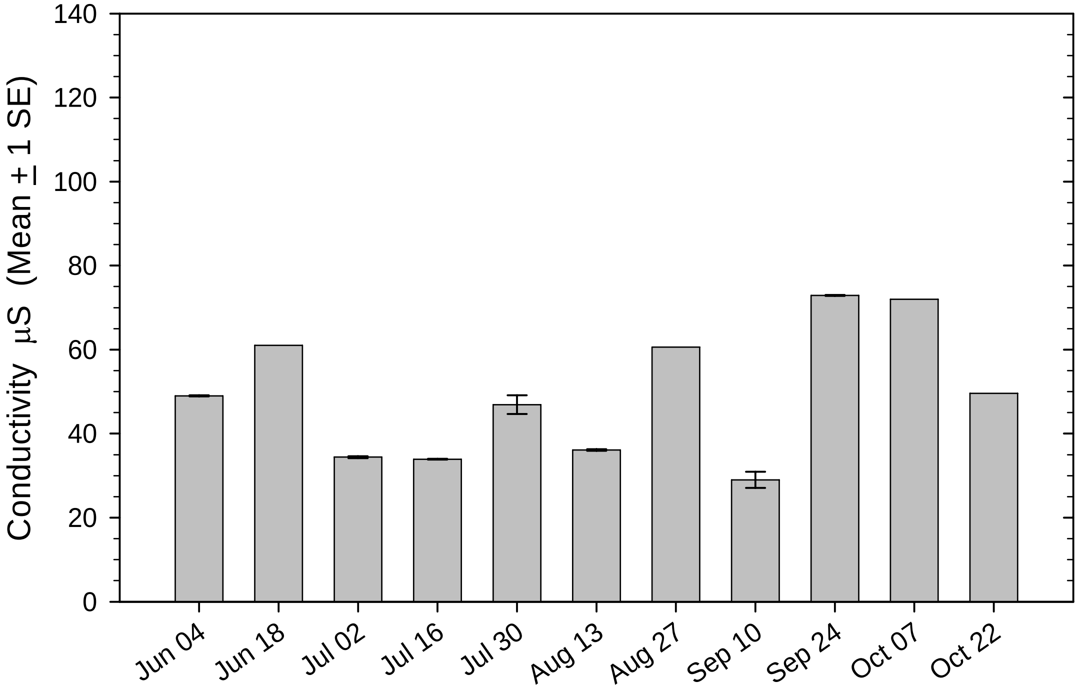
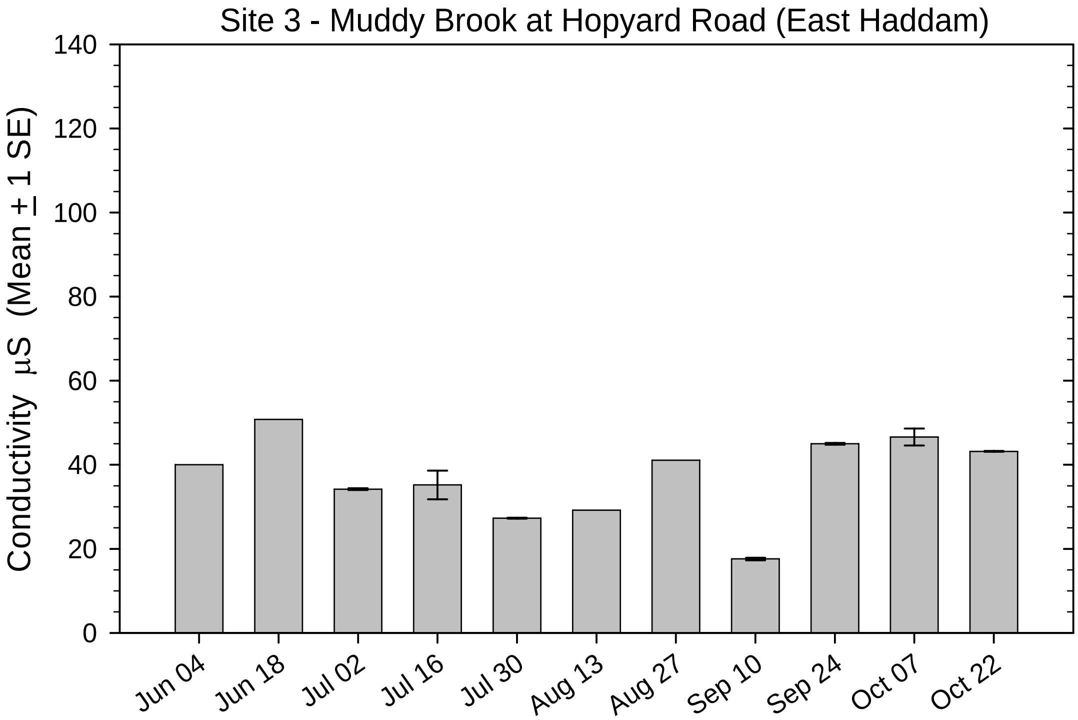


Figure D17. Conductivity (µS, mean ± 1 SE) at Site 3, Muddy Brook at Hopyard Road (East Haddam) and Site 4, West Branch of Eightmile River at Haywardville Road (East Haddam) for all collection dates.



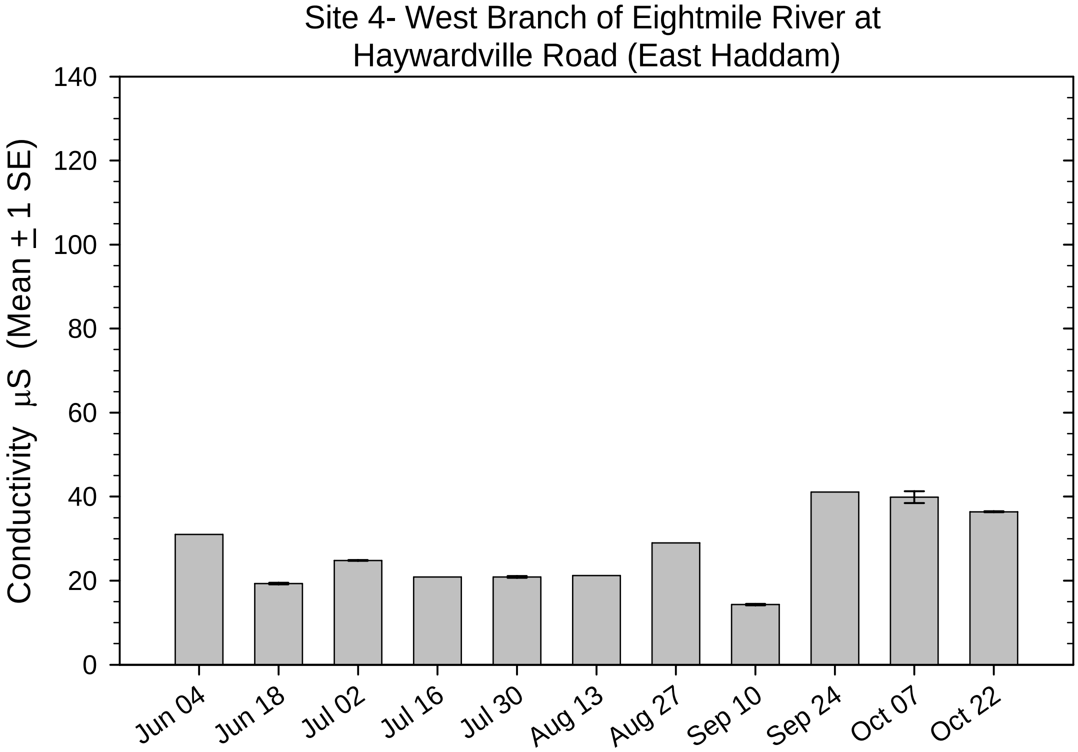
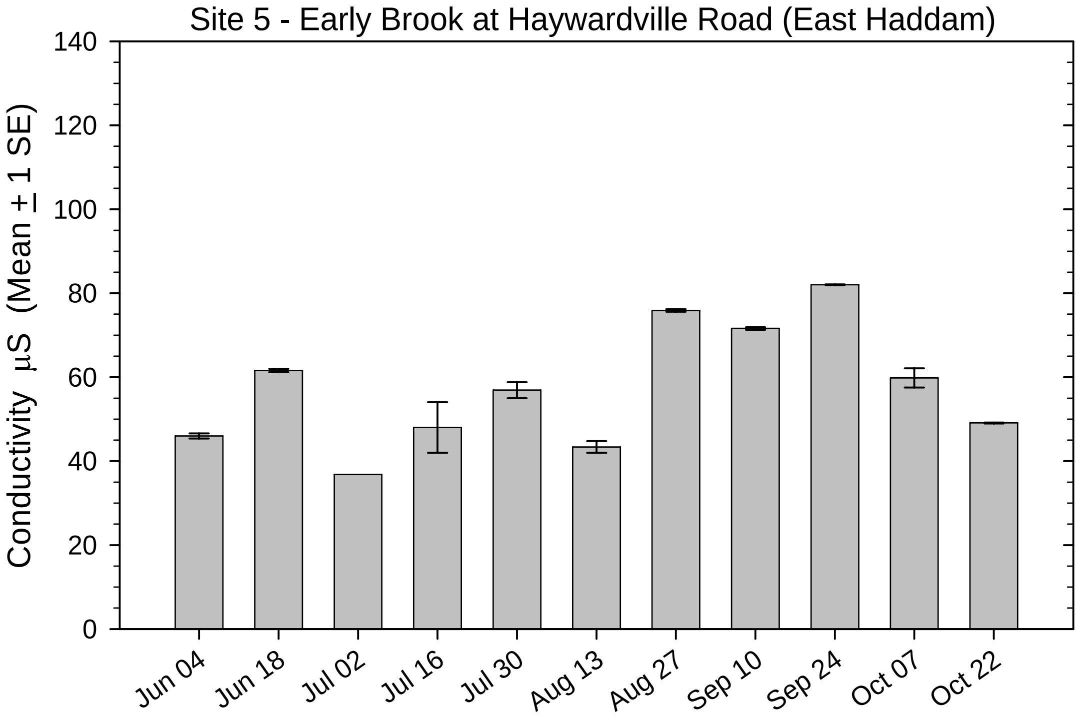


Figure D18. Conductivity (μS, mean ± 1 SE) at Site 5, Early Brook at Haywardville Road (East Haddam) and Site 6, Lake Hayward Brook at Mill Lane for all collection dates.



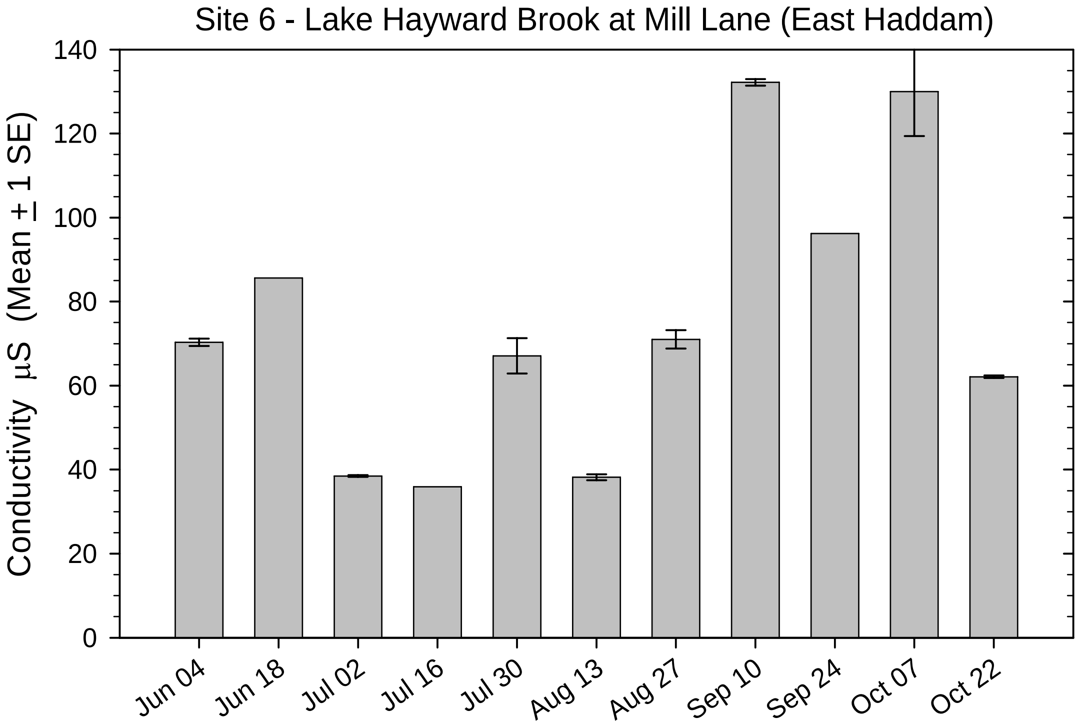
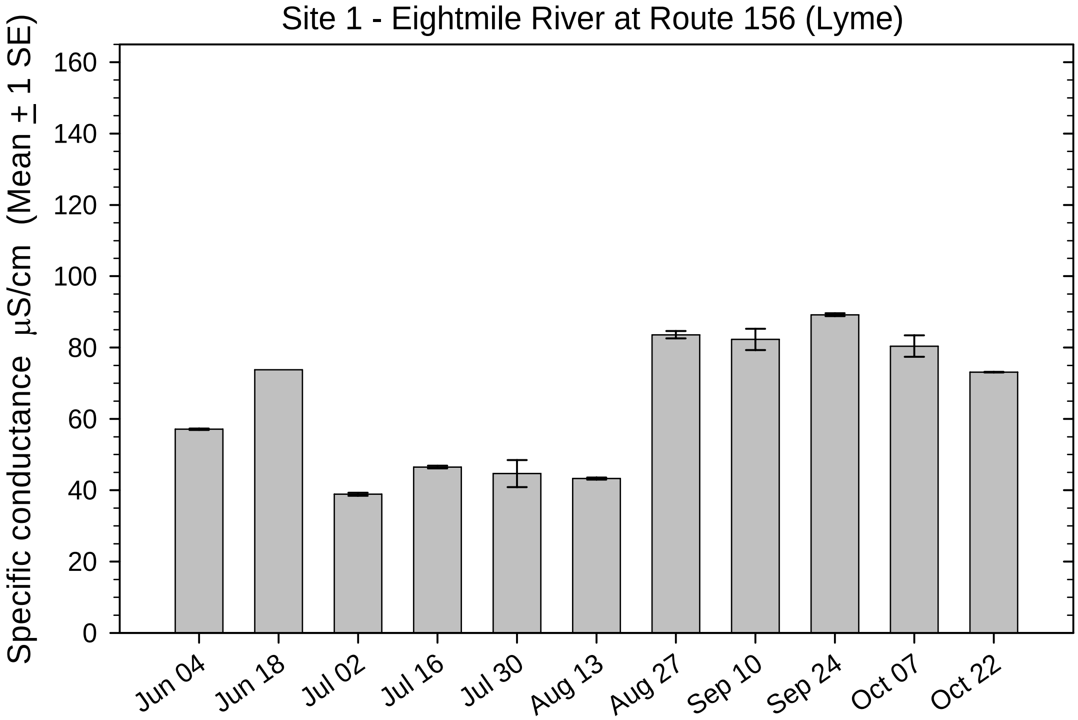


Figure D19. Specific conductance (µS/cm, mean ± 1 SE) at Site 1, Eightmile River at Route 156 (Lyme) and Site 2, West Branch of Eightmile River at Hopyard Road (East Haddam) for all collection dates.



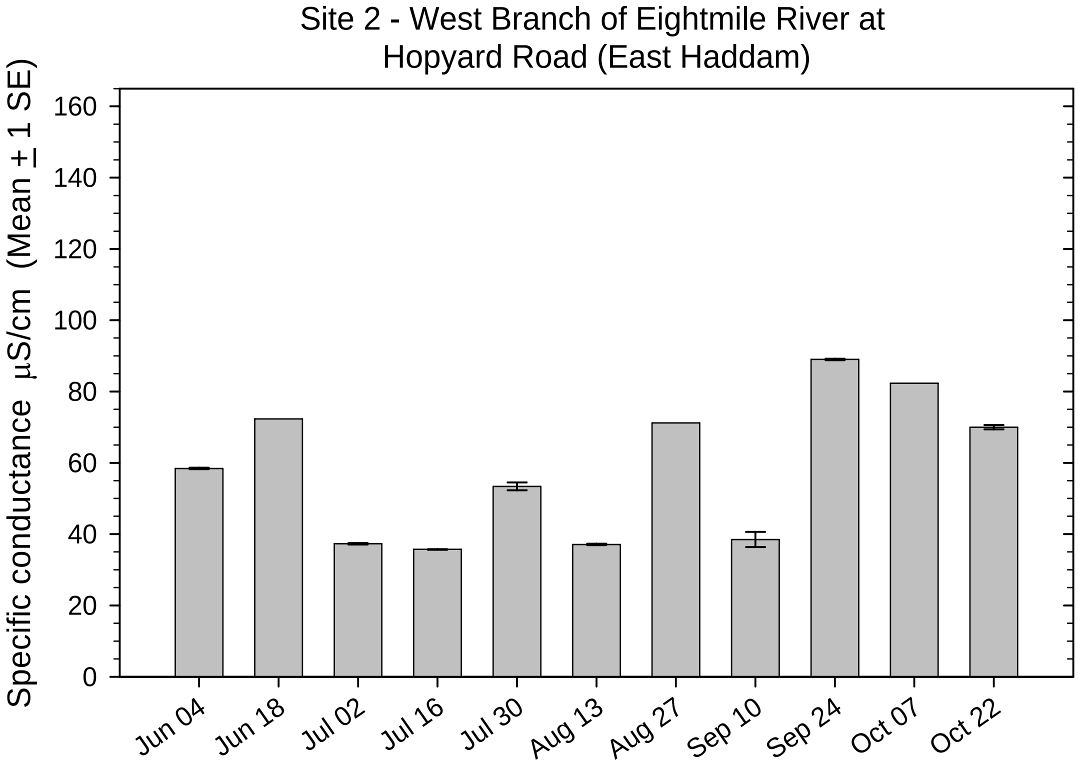
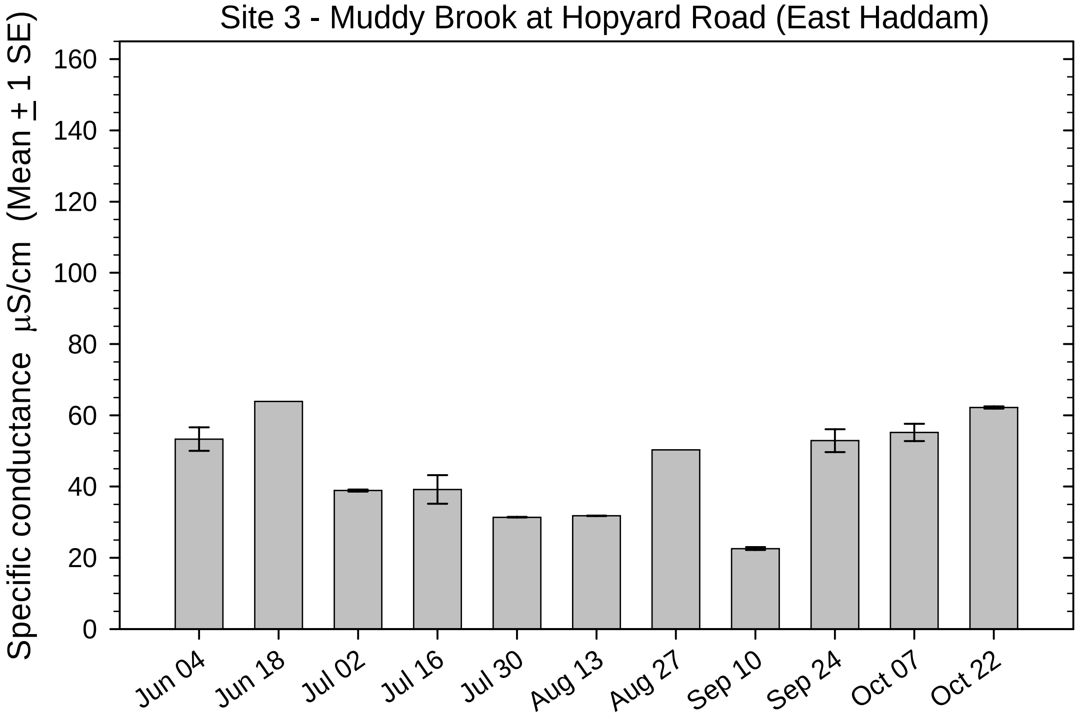


Figure D20. Specific conductance (µS/cm, mean ± 1 SE) at Site 3, Muddy Brook at Hopyard Road (East Haddam) and Site 4, West Branch of Eightmile River at Haywardville Road (East Haddam) for all collection dates.



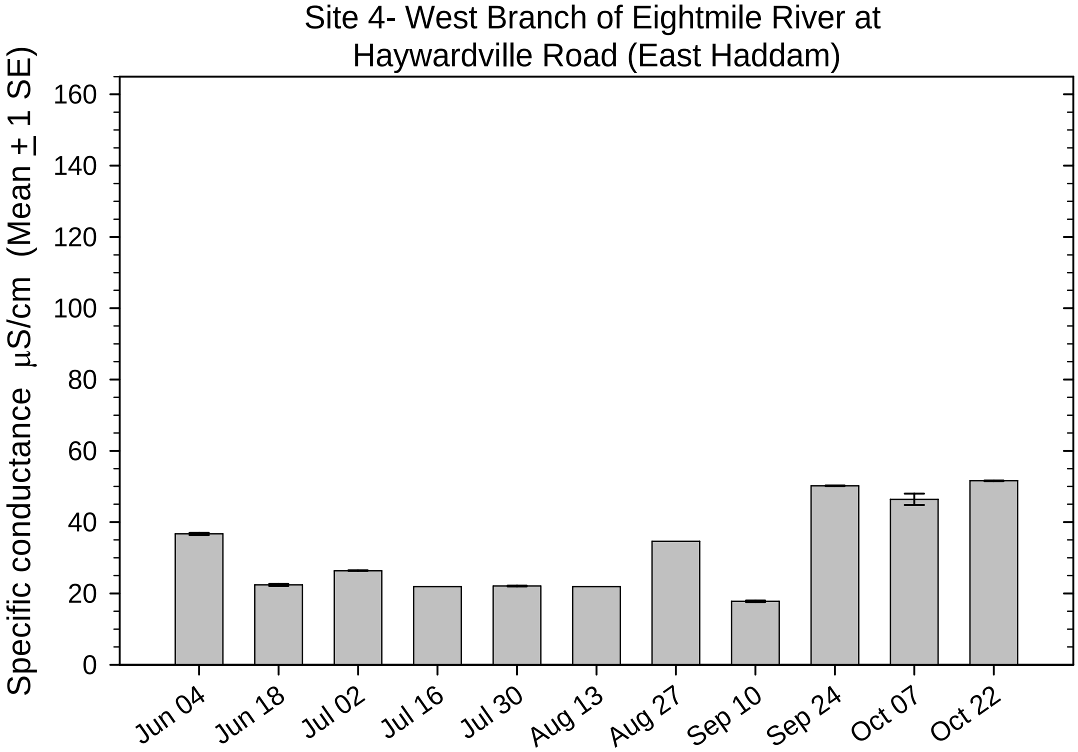
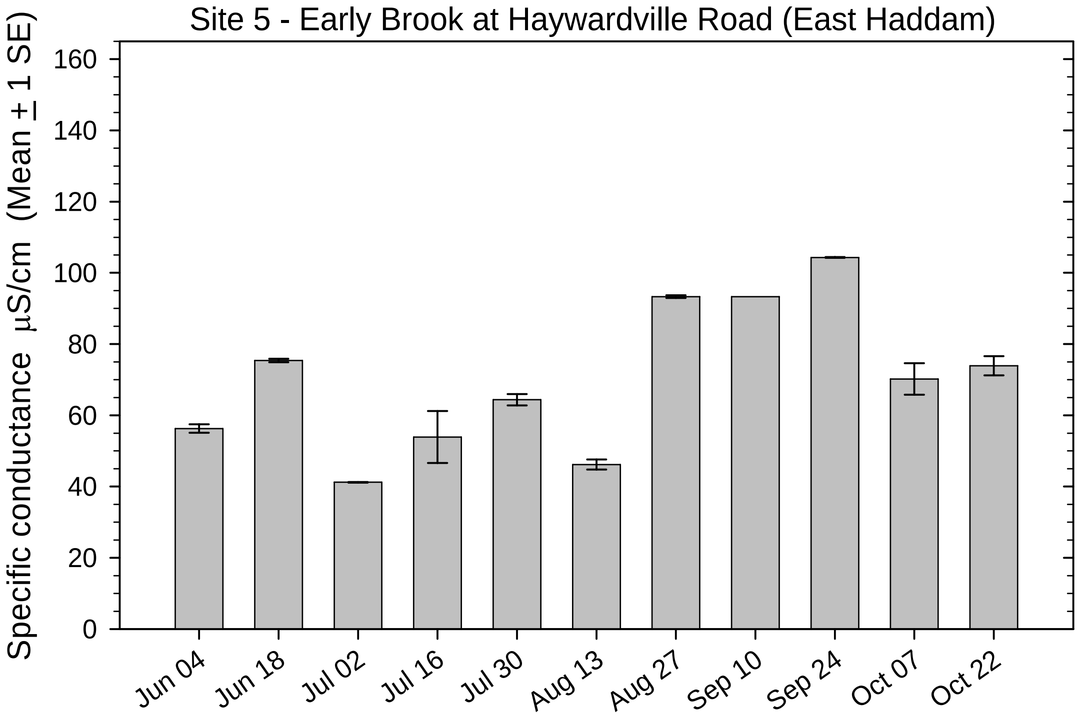


Figure D21. Specific conductance (µS/cm, mean + 1 SE) at Site 5, Early Brook at Haywardville Road (East Haddam) and Site 6, Lake Hayward Brook at Mill Lane for all collection dates.



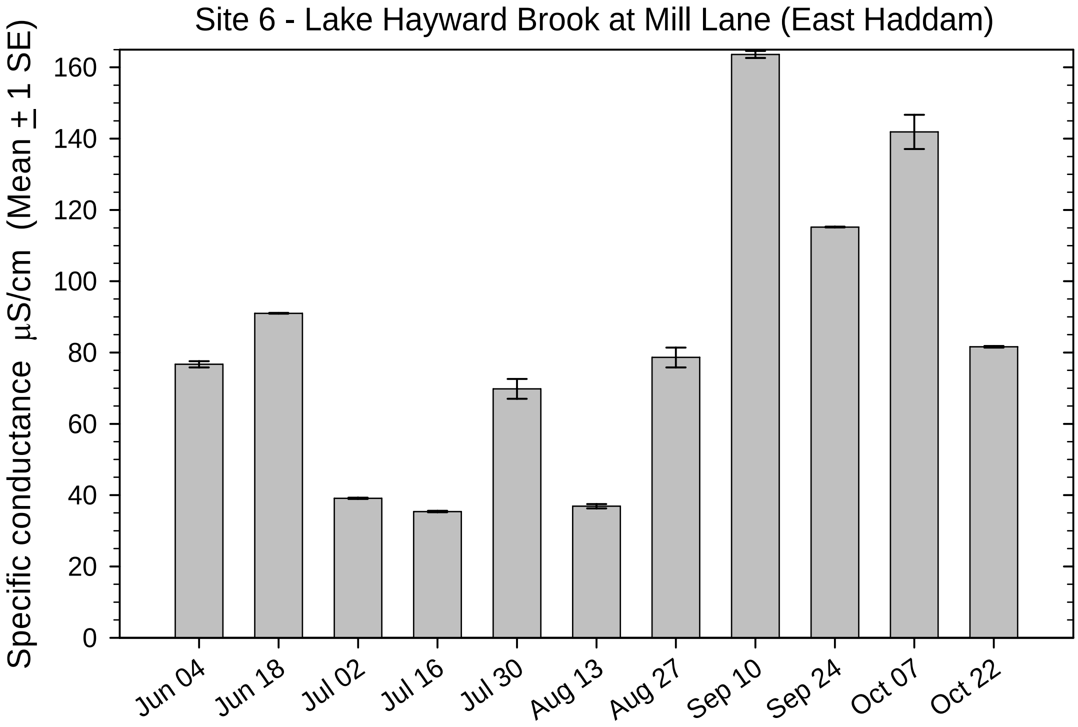
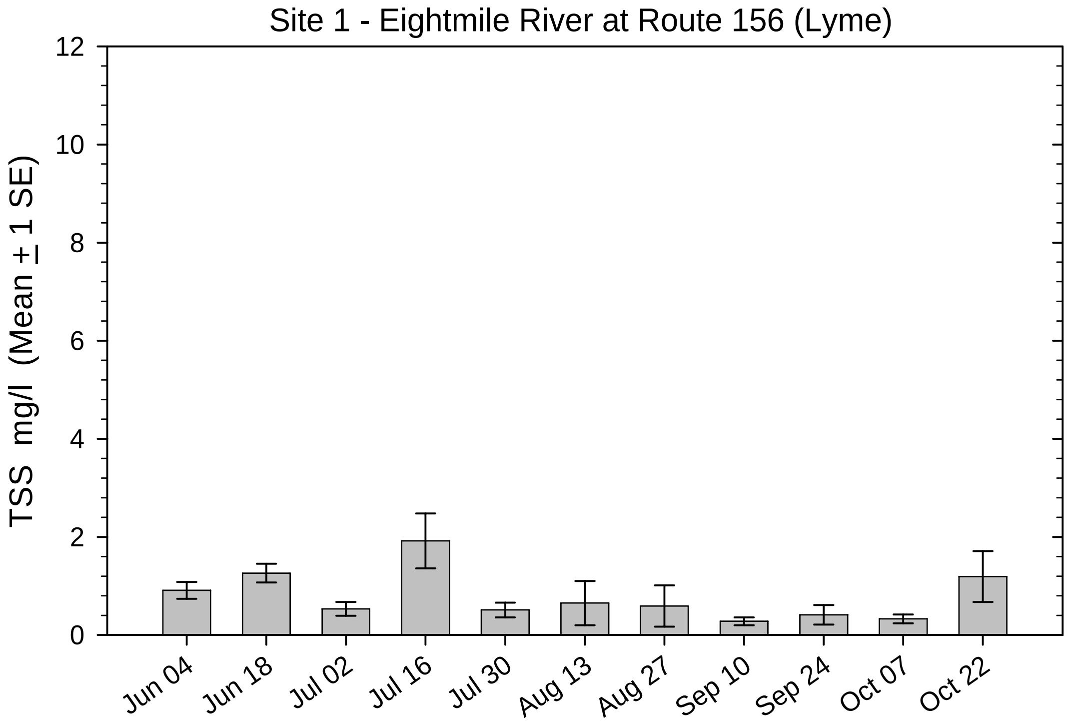
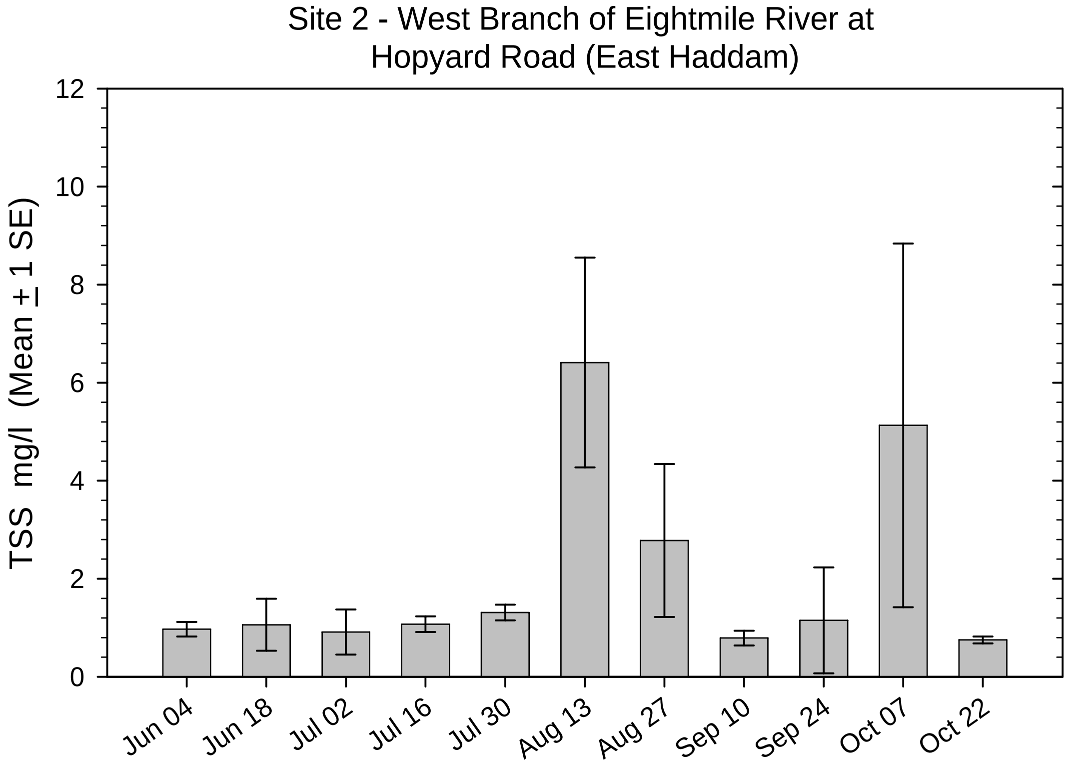


Figure D22. Total suspended solids (mg/l, mean ± 1 SE) at Site 1, Eightmile River at Route 156 (Lyme) and Site 2, West Branch of Eightmile River at Hopyard Road (East Haddam) for all collection dates.

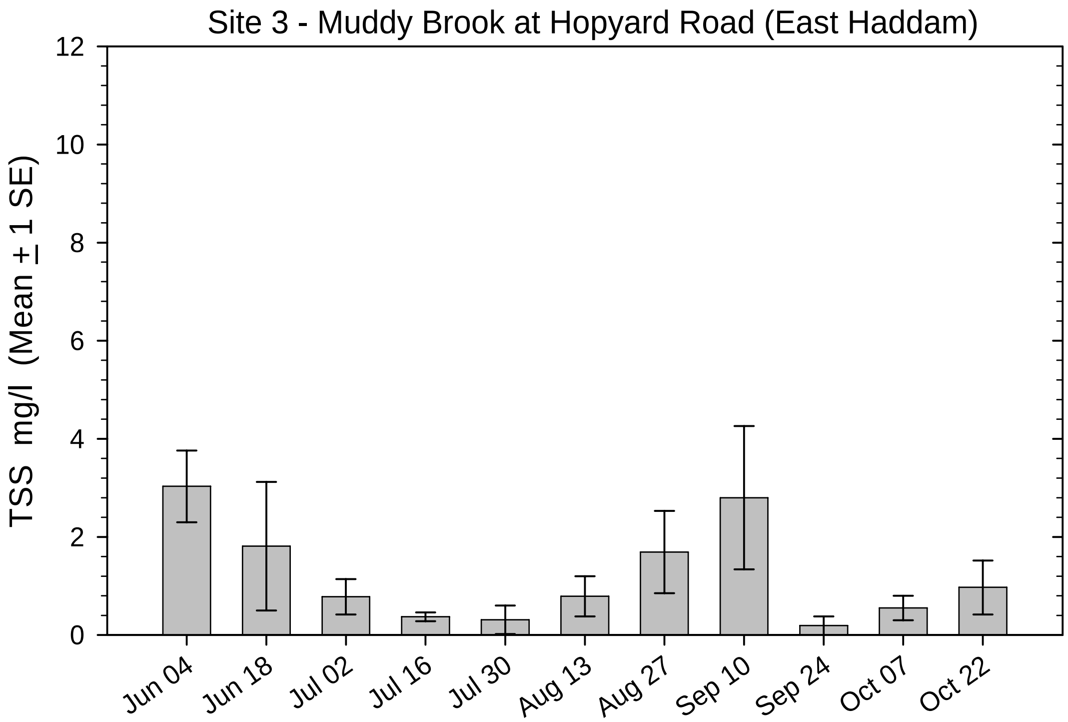


Site 1 - Eightmile River at Route 156 (Lyme)



Site 2 - West Branch of Eightmile River at Hopyard Road (East Haddam)

Figure D23. Total suspended solids (mg/l, mean ± 1 SE) at Site 3, Muddy Brook at Hopyard Road (East Haddam) and Site 4, West Branch of Eightmile River at Haywardville Road (East Haddam) for all collection dates.


Site 3 - Muddy Brook at Hopyard Road (East Haddam)

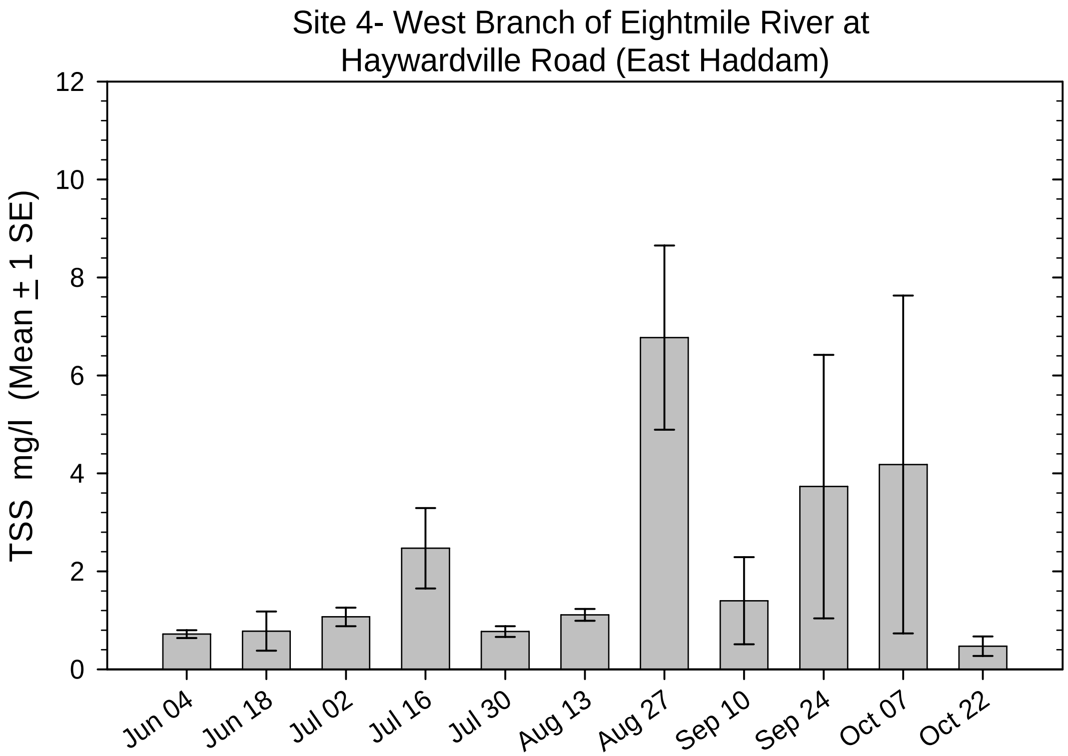
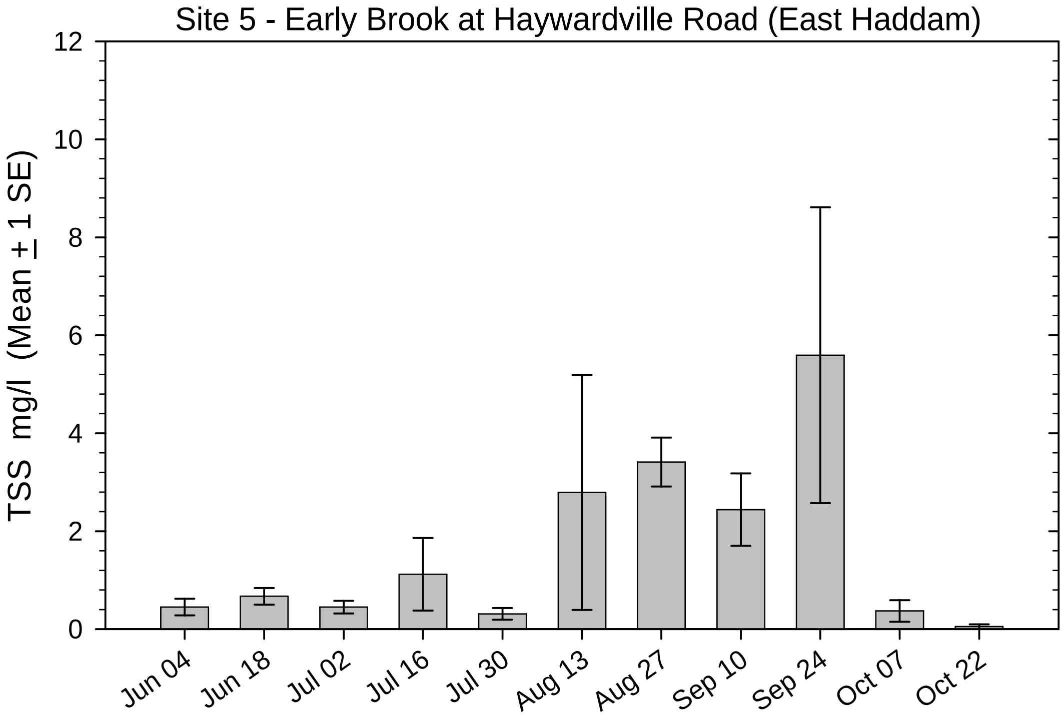

Site 4- West Branch of Eightmile River at Haywardville Road (East Haddam)

Figure D24. Total suspended solids (mg/l, mean + 1 SE) at Site 5, Early Brook at Haywardville Road (East Haddam) and Site 6, Lake Hayward Brook at Mill Lane for all collection dates.



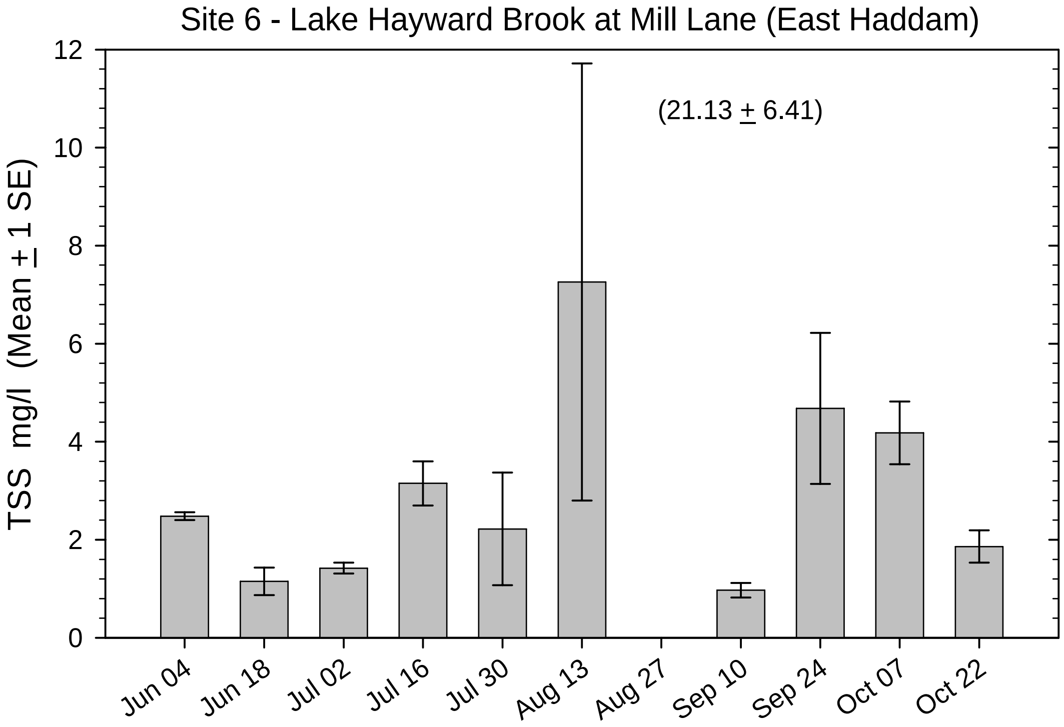
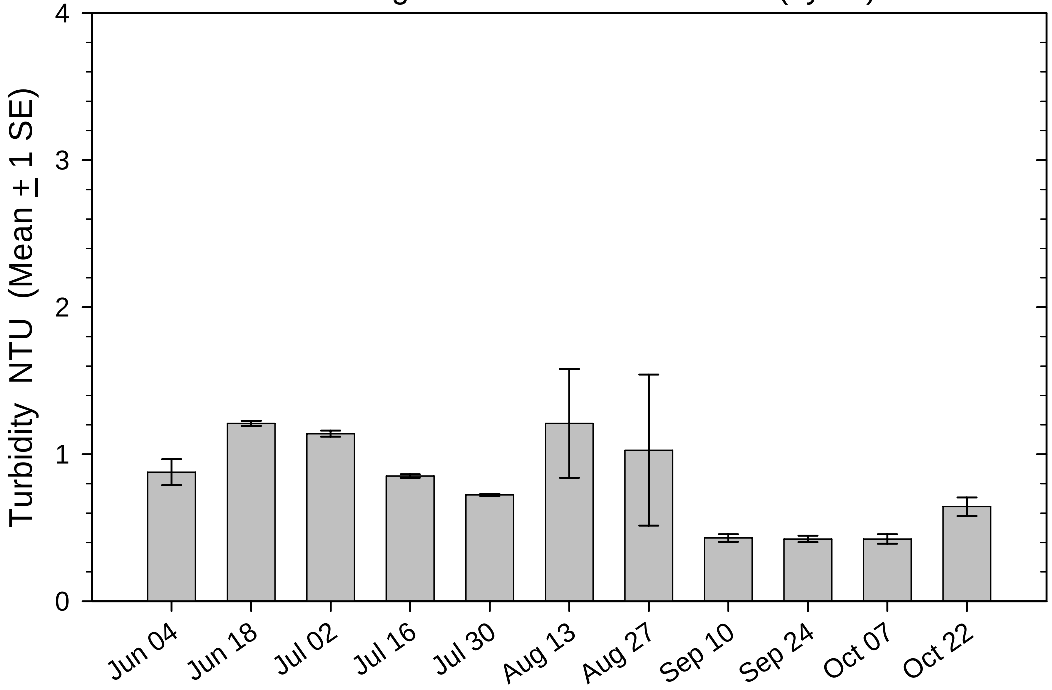


Figure D25. Turbidity (NTU, mean ± 1 SE) at Site 1, Eightmile River at Route 156 (Lyme) and Site 2, West Branch of Eightmile River at Hopyard Road (East Haddam) for all collection dates.

Site 1 - Eightmile River at Route 156 (Lyme)



Site 2 - West Branch of Eightmile River at Hopyard Road (East Haddam)

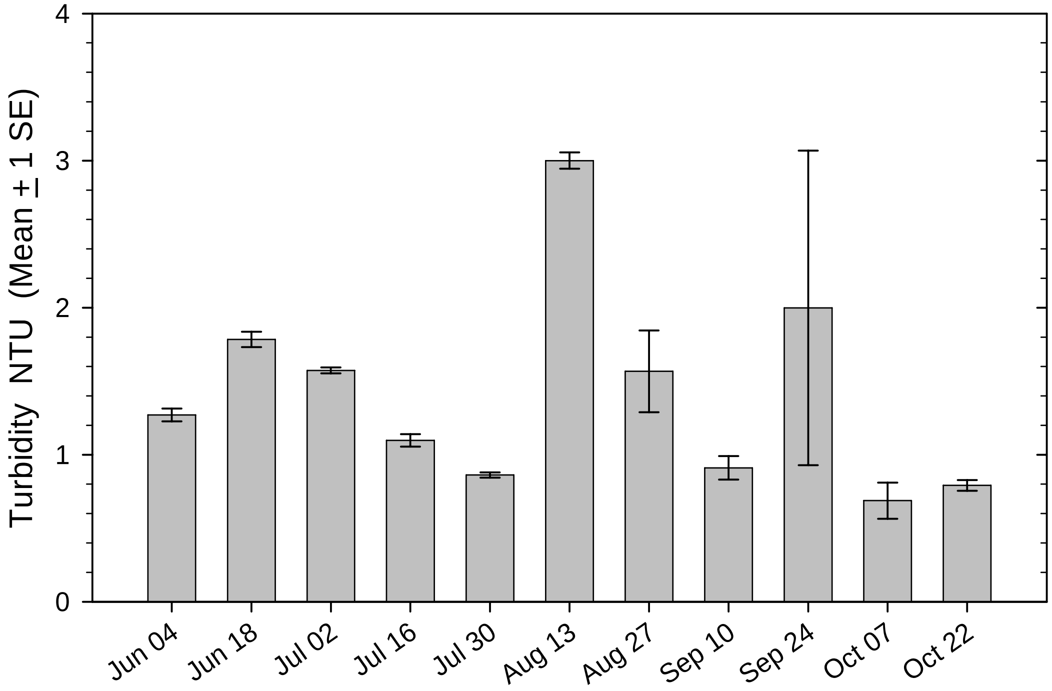
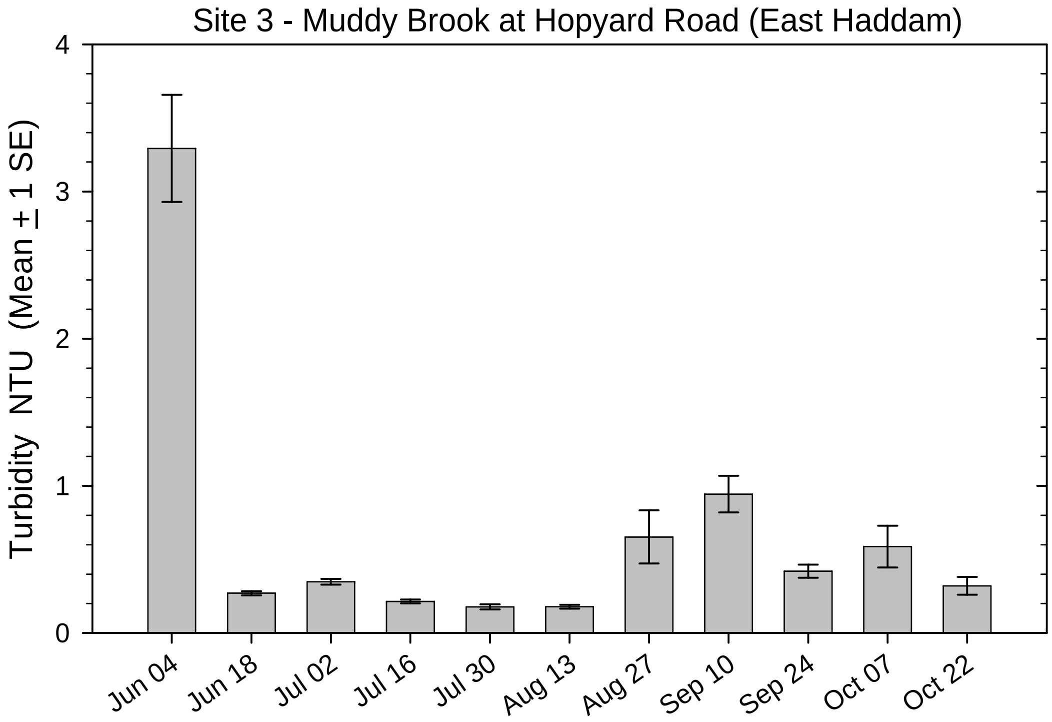


Figure D26. Turbidity (NTU, mean ± 1 SE) at Site 3, Muddy Brook at Hopyard Road (East Haddam) and Site 4, West Branch of Eightmile River at Haywardville Road (East Haddam) for all collection dates.



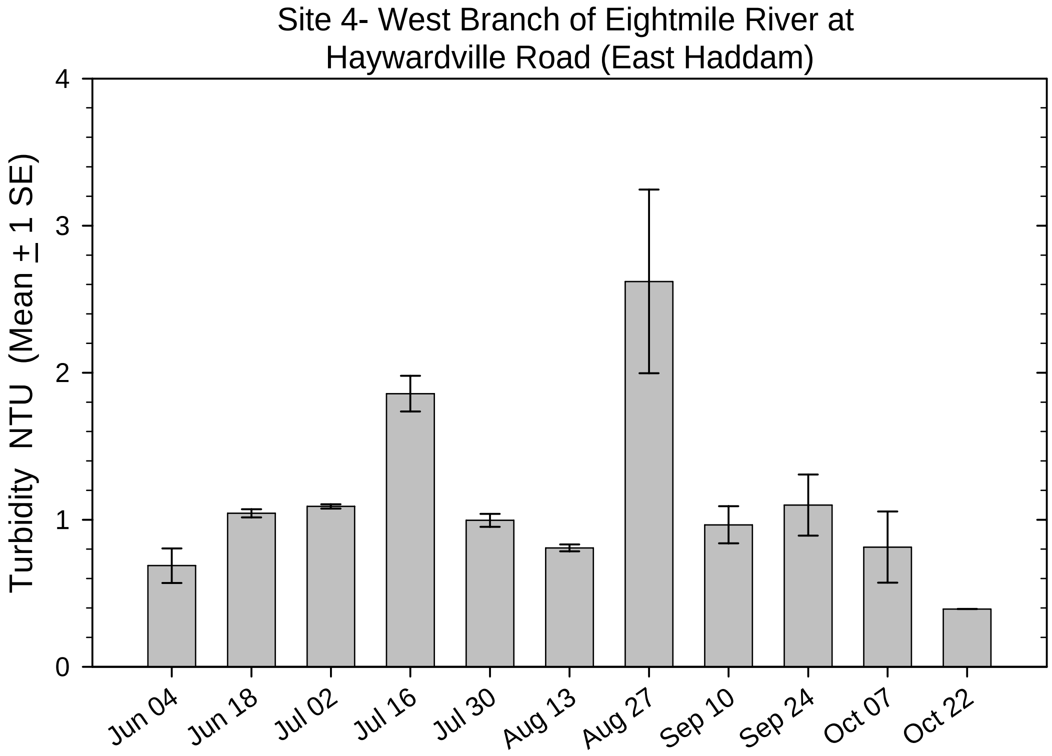
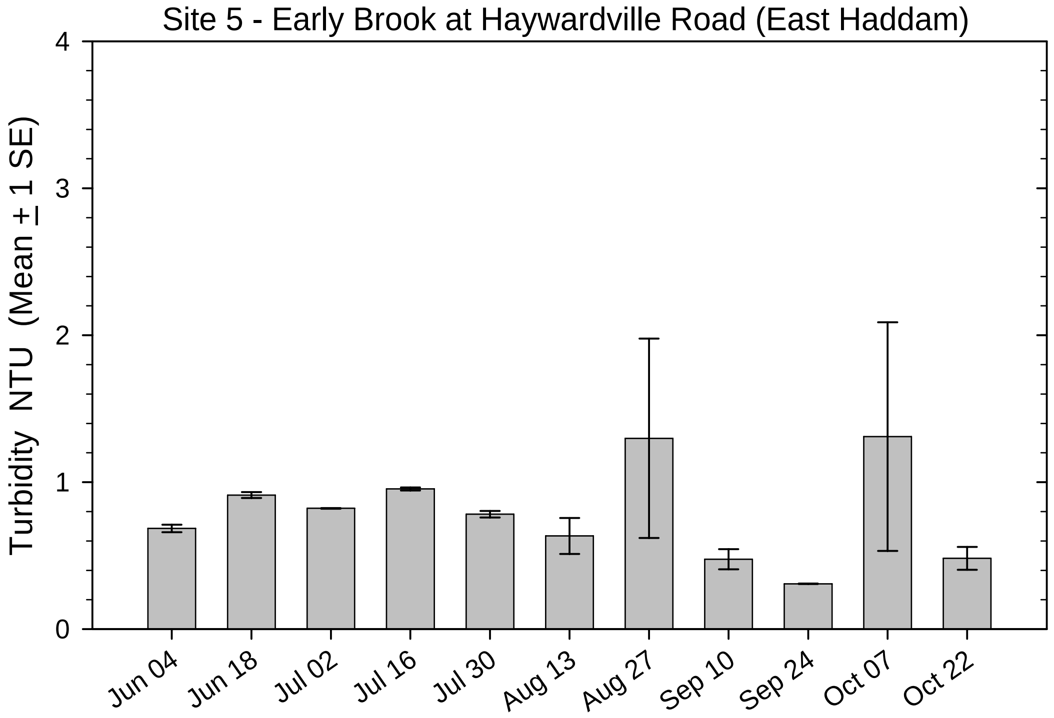
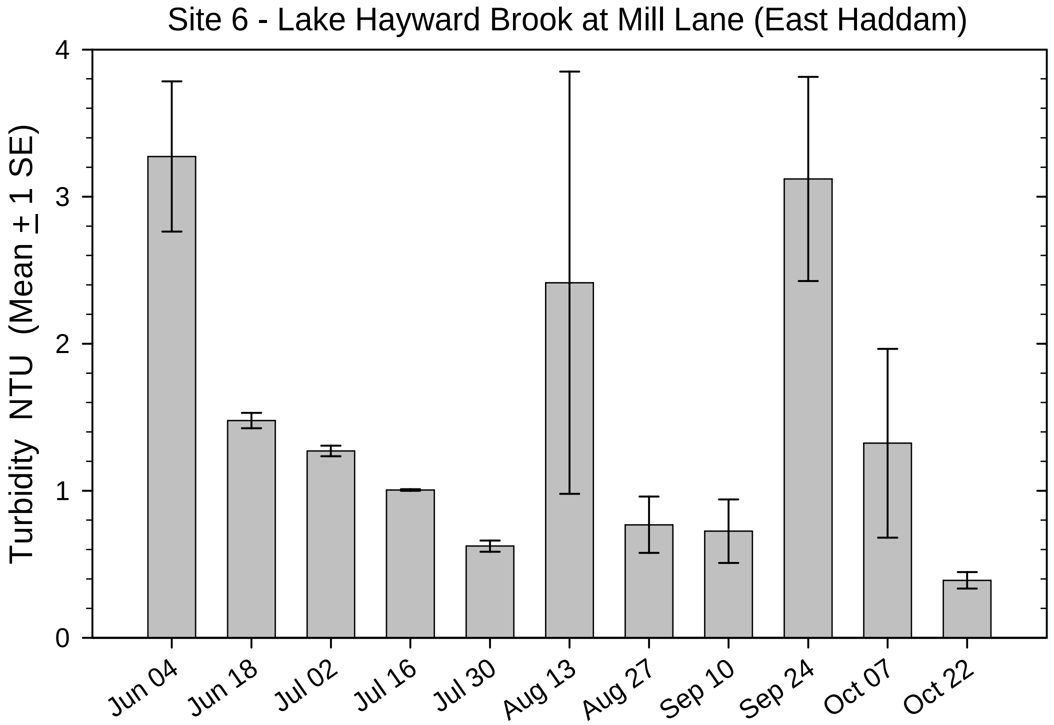


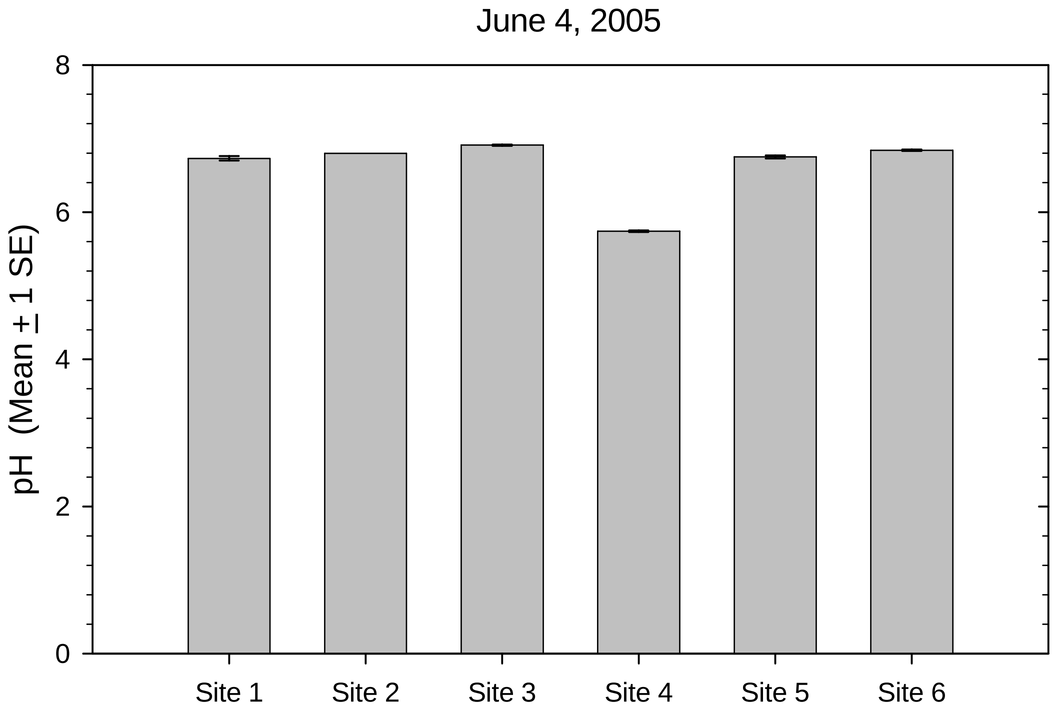
Figure D27. Turbidity (NTU, mean ± 1 SE) at Site 5, Early Brook at Haywardville Road (East Haddam) and Site 6, Lake Hayward Brook at Mill Lane for all collection dates.





Appendix E

Figure E1. pH (mean ± 1 SE) for collection dates June 4 and June 18, 2005, for all collection sites on the Eightmile River West Branch.



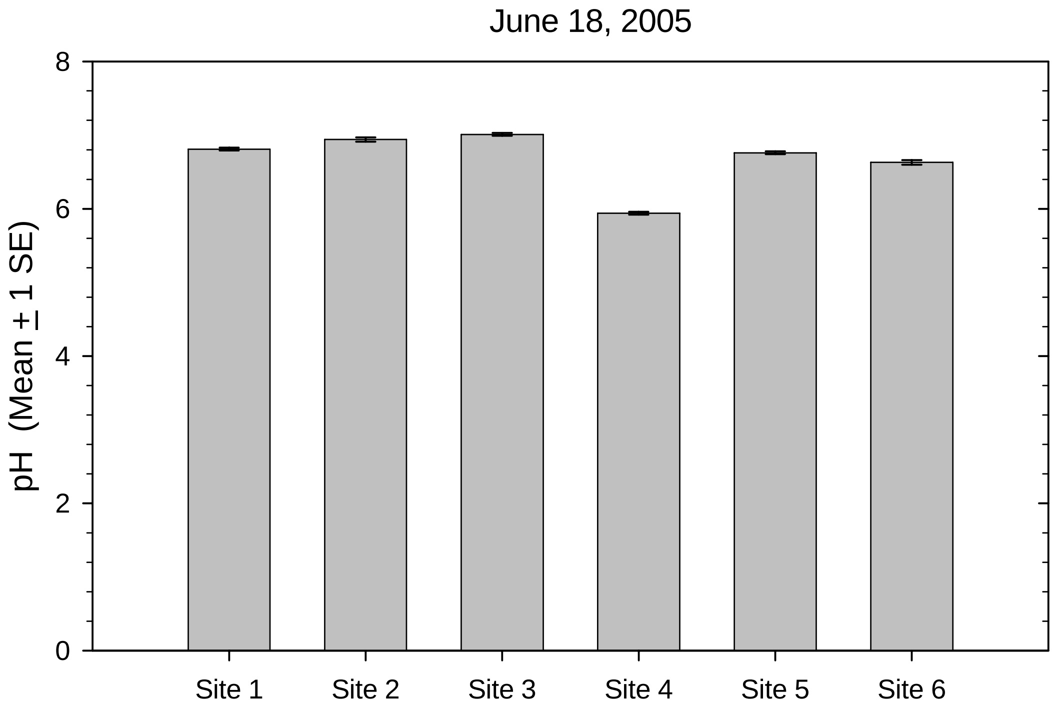
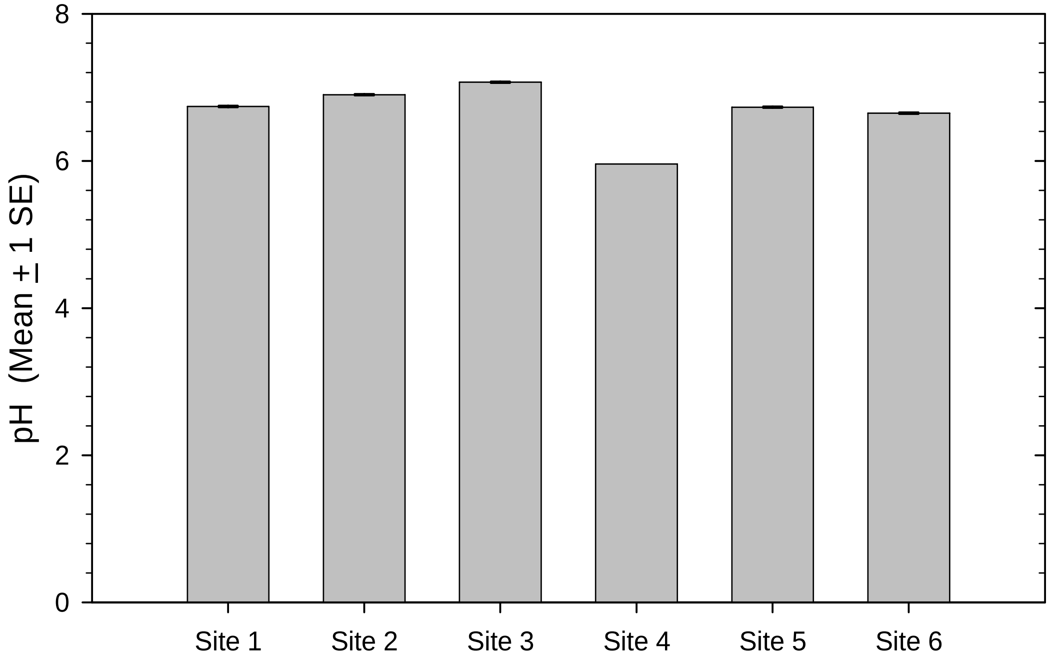


Figure E2. pH (mean ± 1 SE) for collection dates July 2 and July 16, 2005, for all collection sites on the Eightmile River West Branch.

July 2, 2005



July 16, 2005

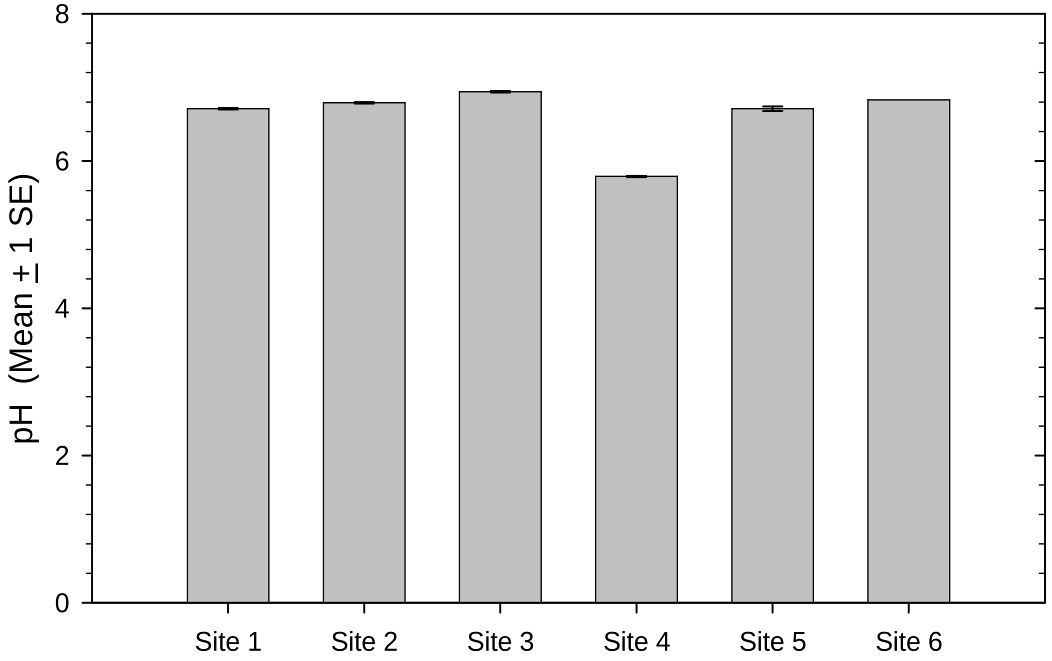
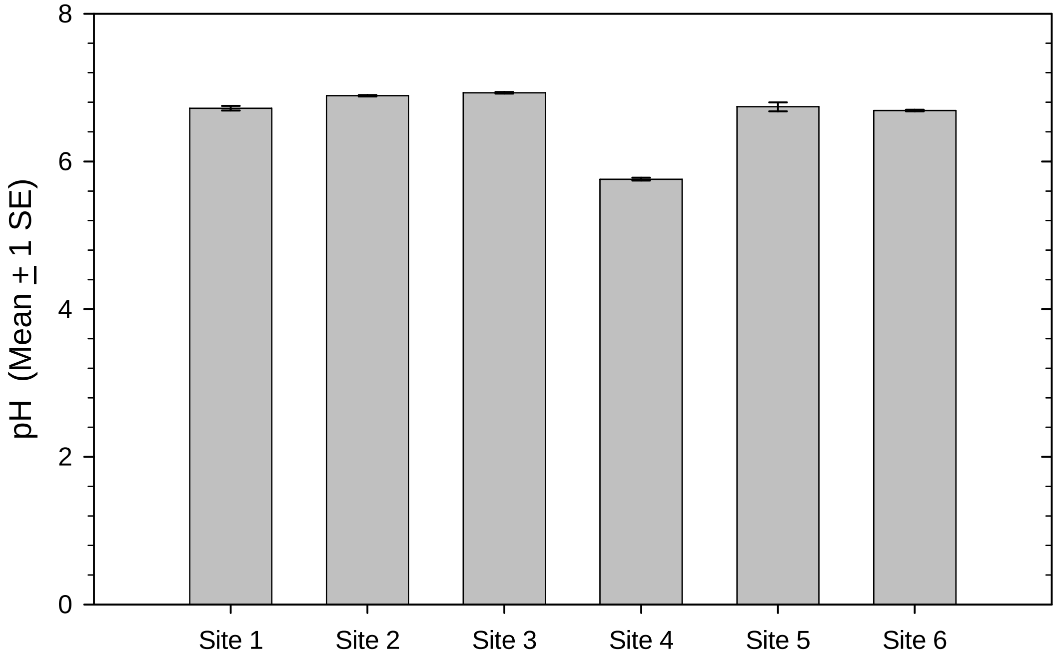


Figure E3. pH (mean ± 1 SE) for collection dates July 30 and August 13, 2005, for all collection sites on the Eightmile River West Branch.

July 30, 2005



August 13, 2005

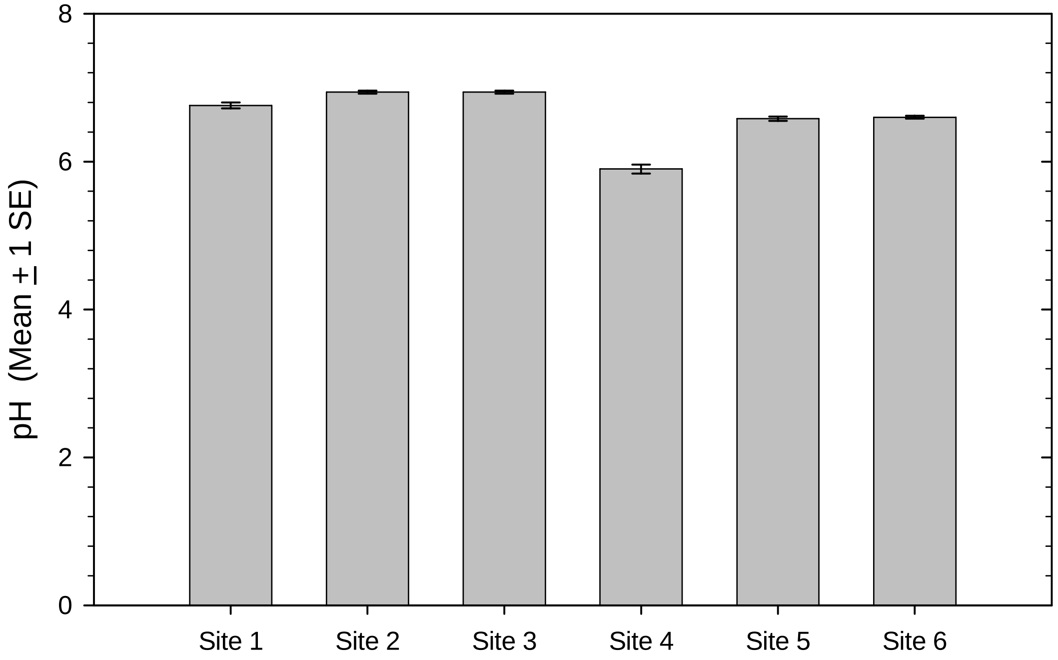
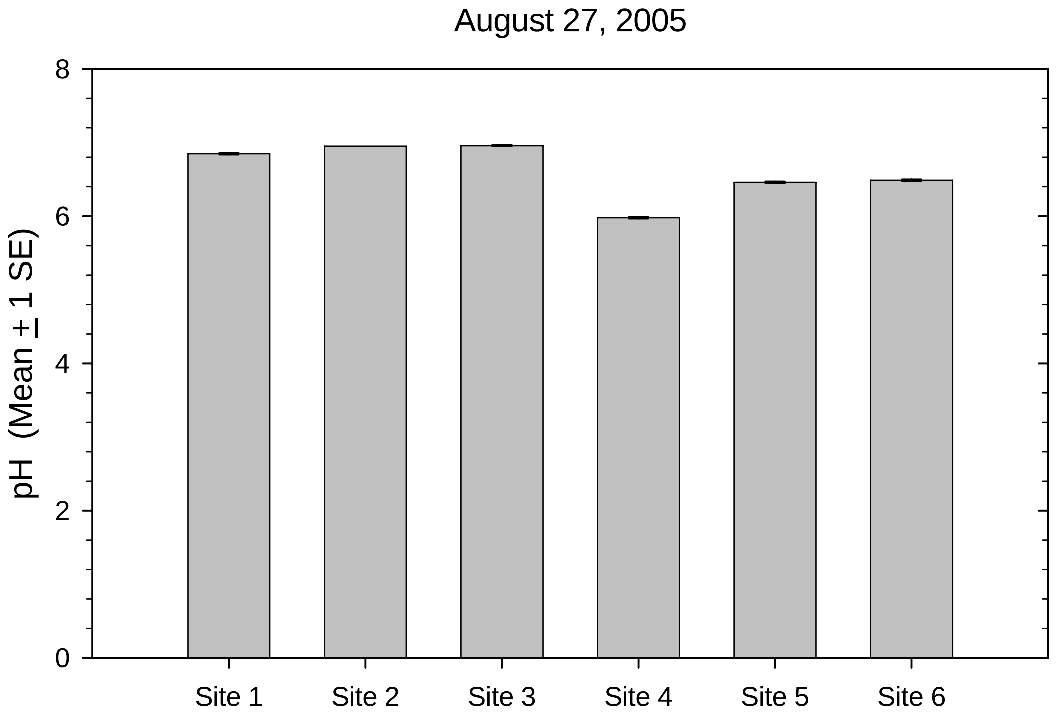


Figure E4. pH (mean + 1 SE) for collection dates August 27 and September 10, 2005, for all collection sites on the Eightmile River West Branch.



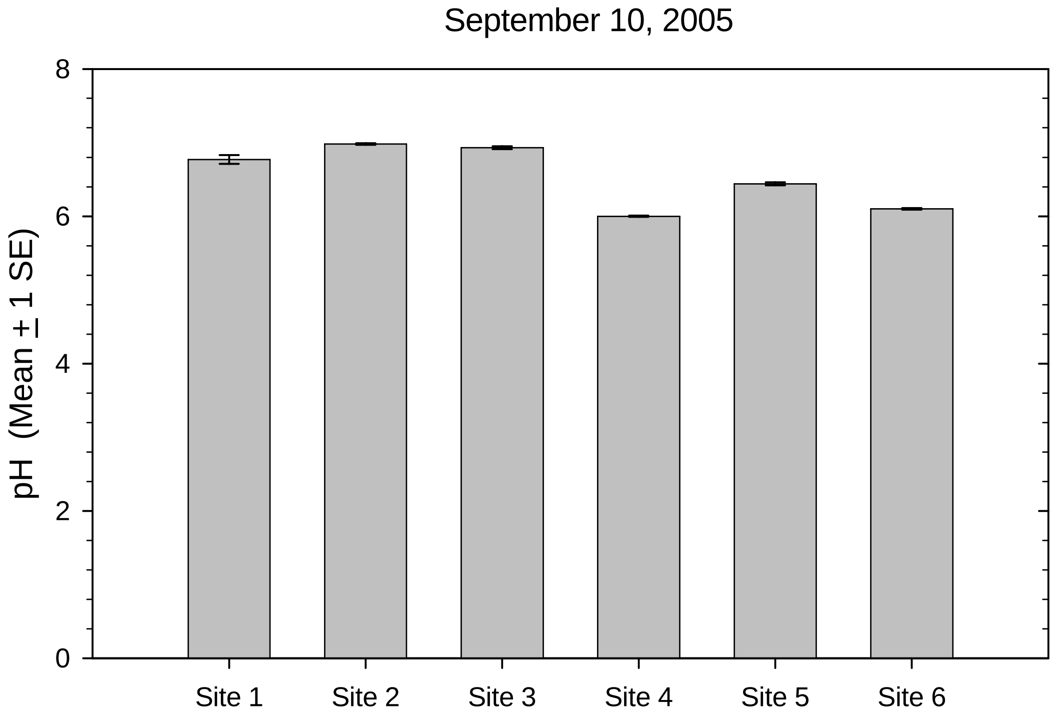
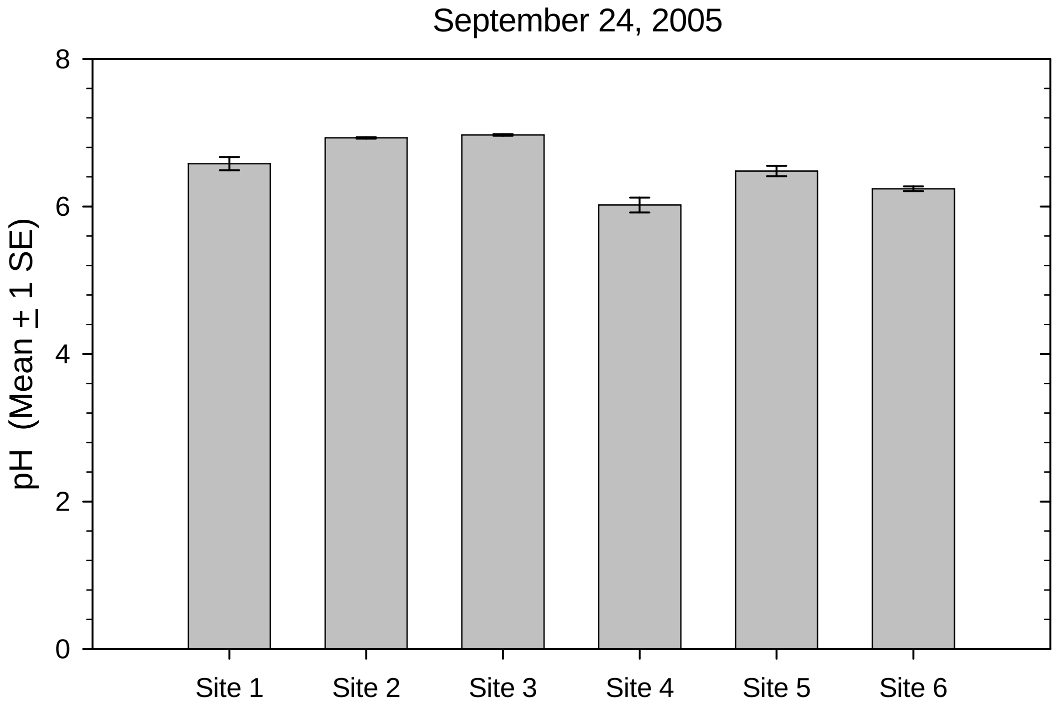


Figure E5. pH (mean + 1 SE) for collection dates September 24 and October 7, 2005, for all collection sites on the Eightmile River West Branch.



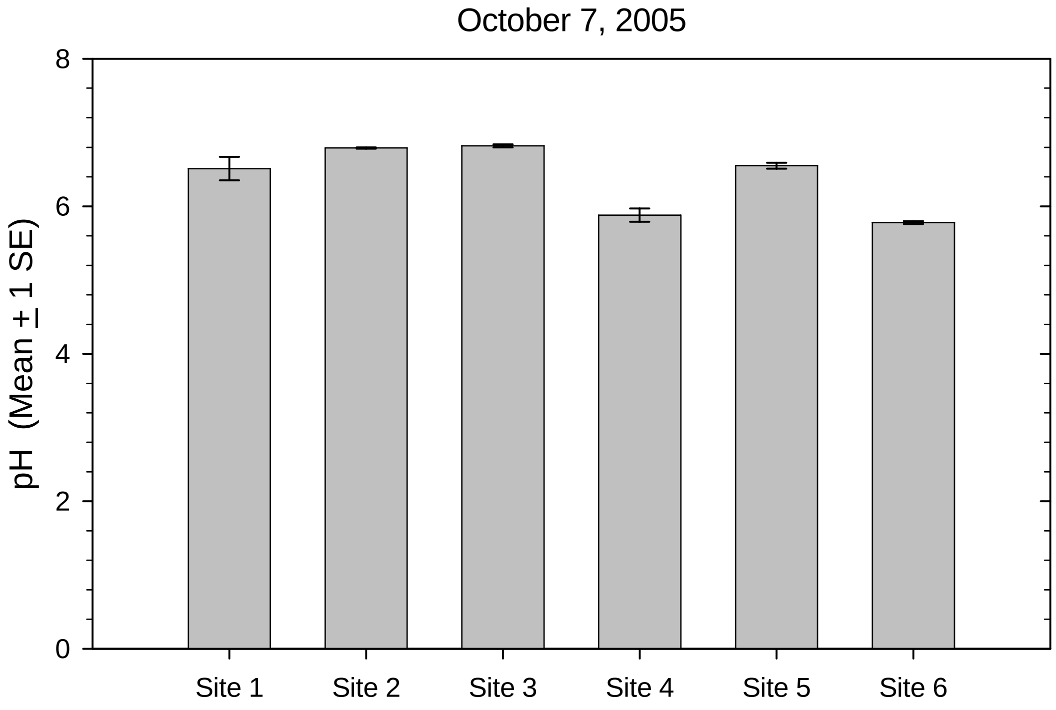


Figure E6. pH (mean ± 1 SE) for collection date October 22, 2005, for all collection sites on the Eightmile River West Branch.

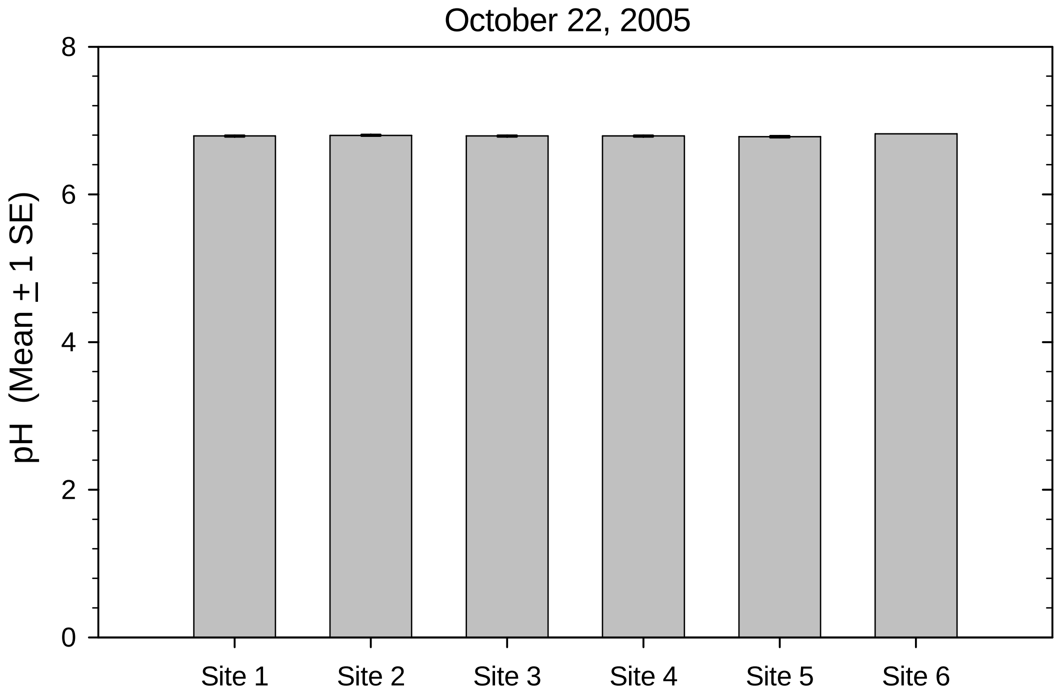
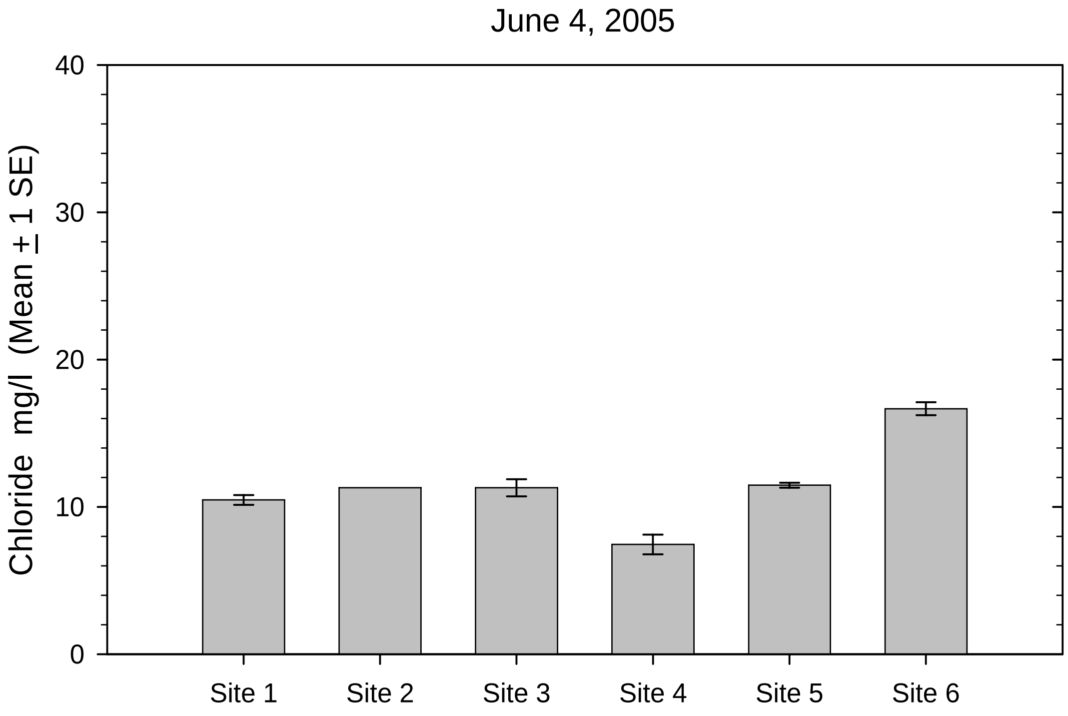


Figure E7. Chloride (mg/l, mean ± 1 SE) for collection dates June 4 and June 18, 2005, for all collection sites on the Eightmile River West Branch.



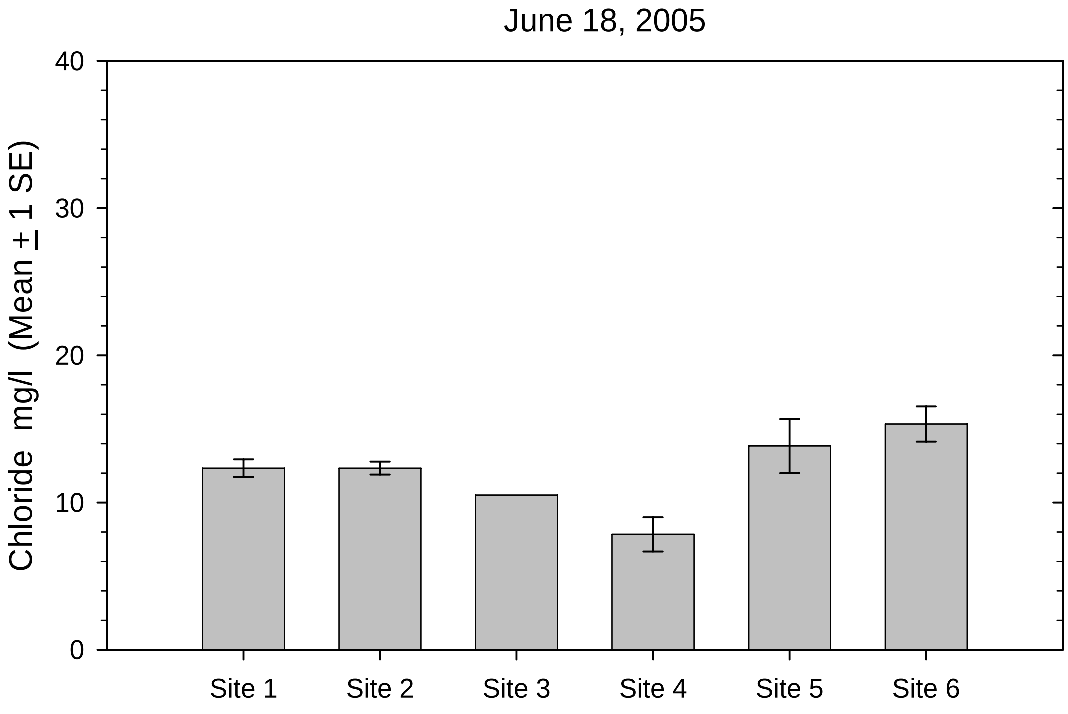


Figure E8. Chloride (mg/l, mean + 1 SE) for collection dates July 2 and July 16, 2005, for all collection sites on the Eightmile River West Branch.

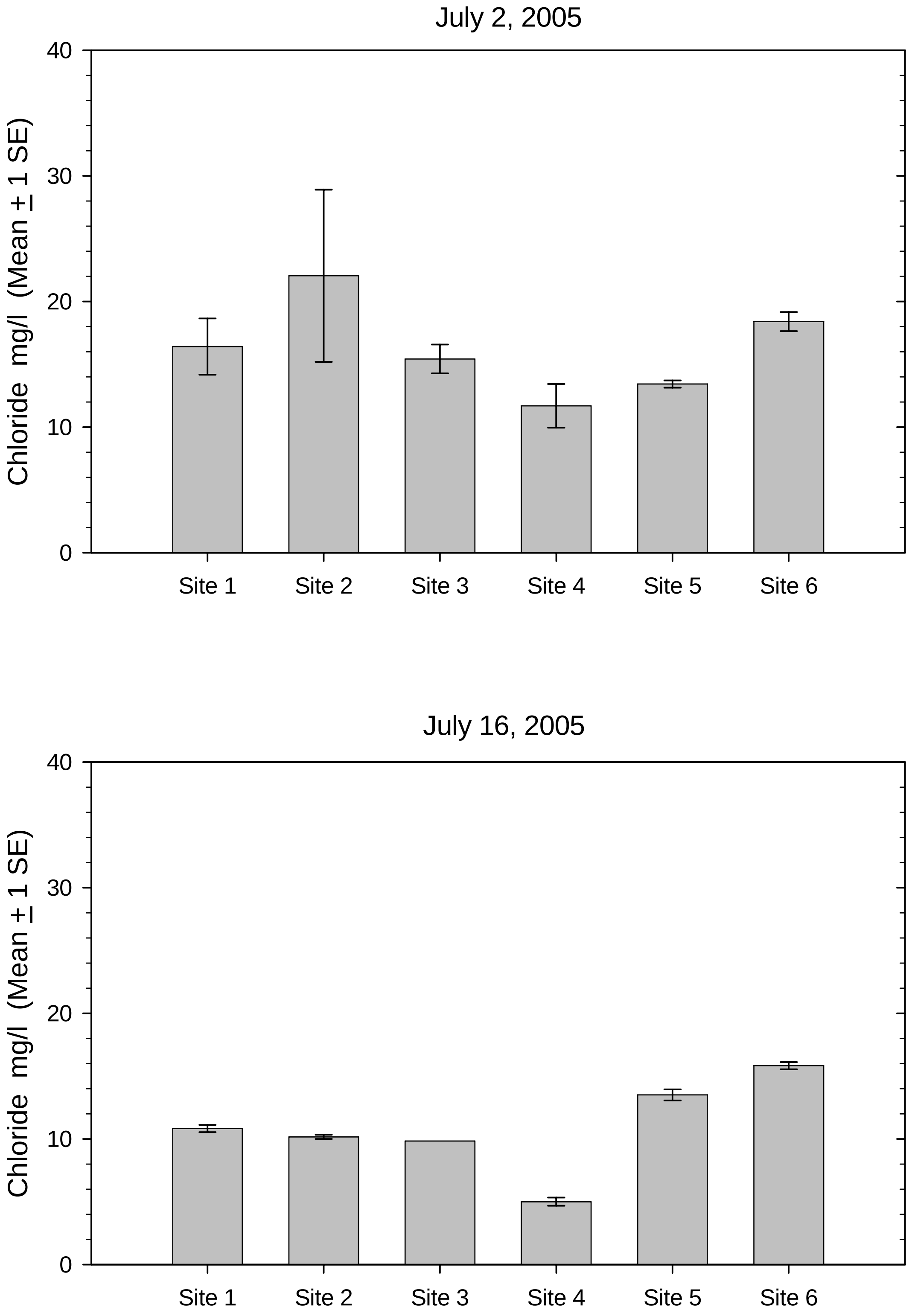
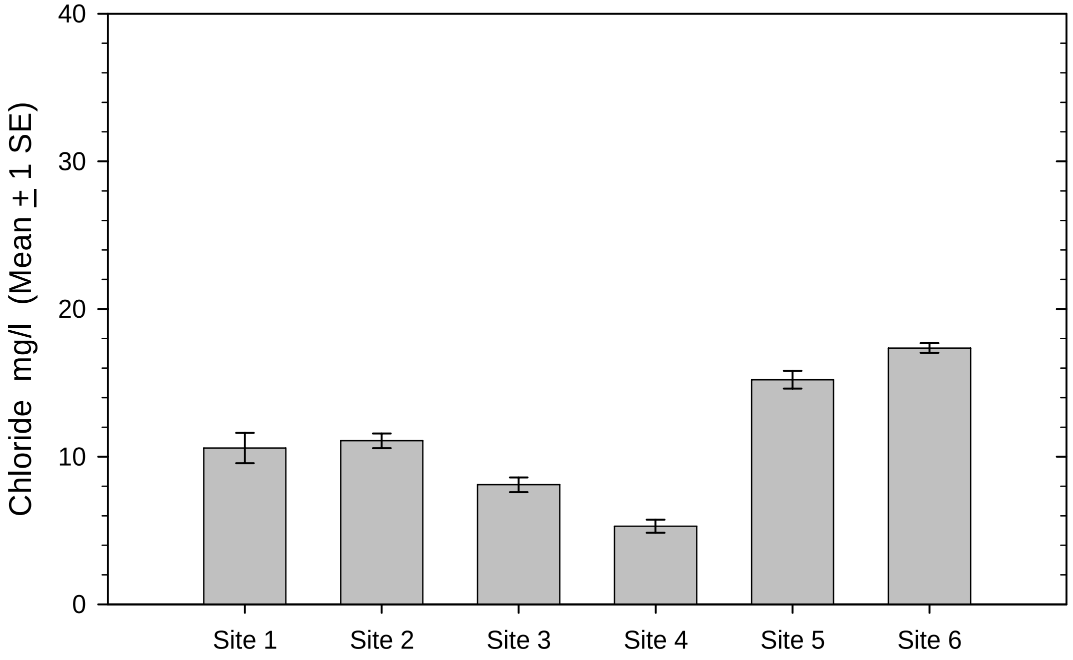
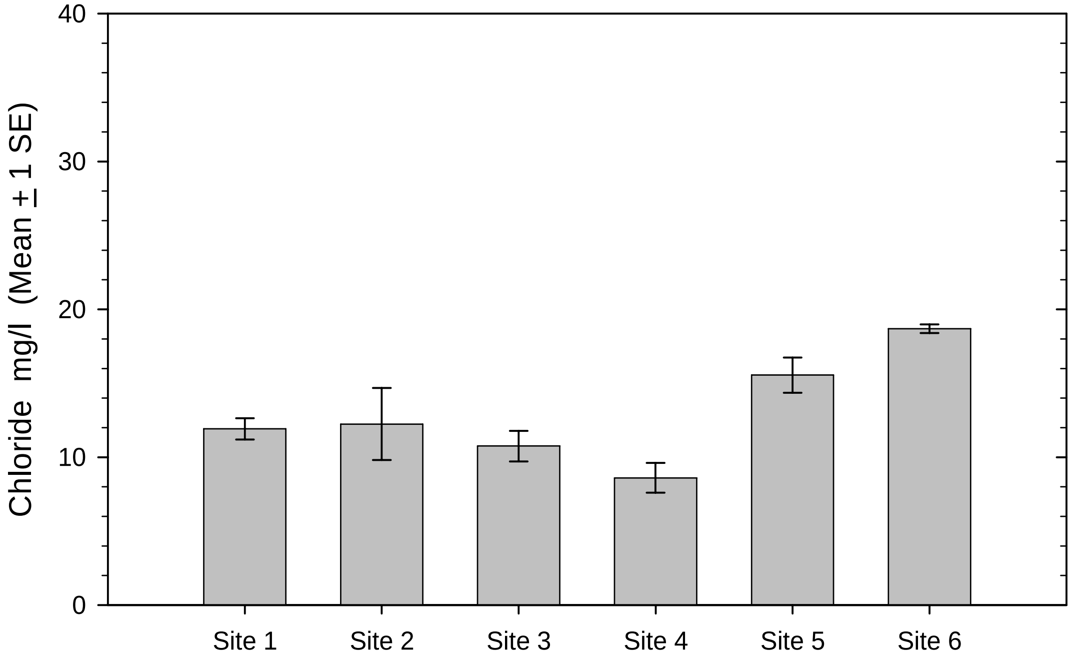


Figure E9. Chloride (mg/l, mean + 1 SE) for collection dates July 30 and August 13, 2005, for all collection sites on the Eightmile River West Branch.

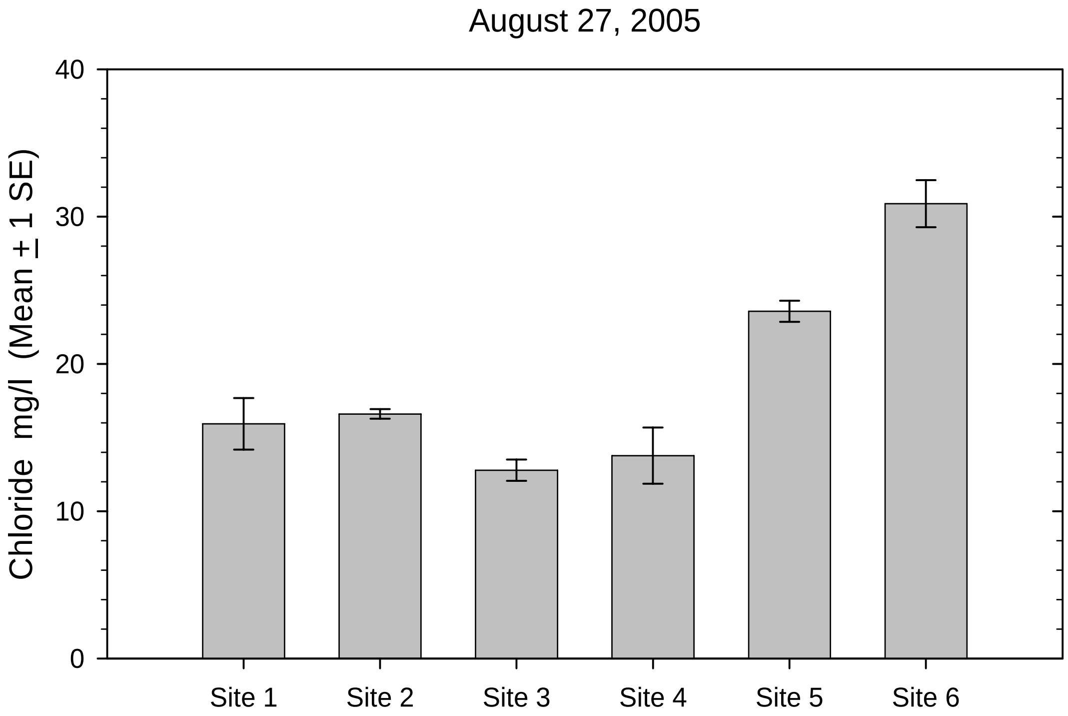


July 30, 2005



August 13, 2005

Figure E10. Chloride (mg/l, mean ± 1 SE) for collection dates August 27 and September 10, 2005, for all collection sites on the Eightmile River West Branch.



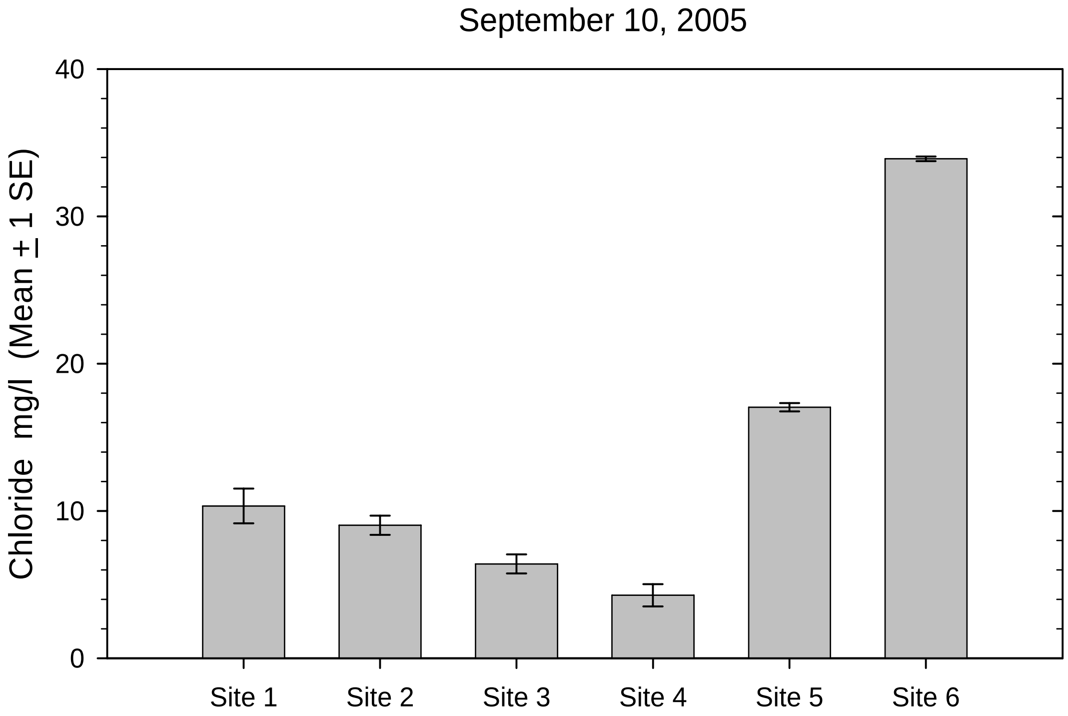
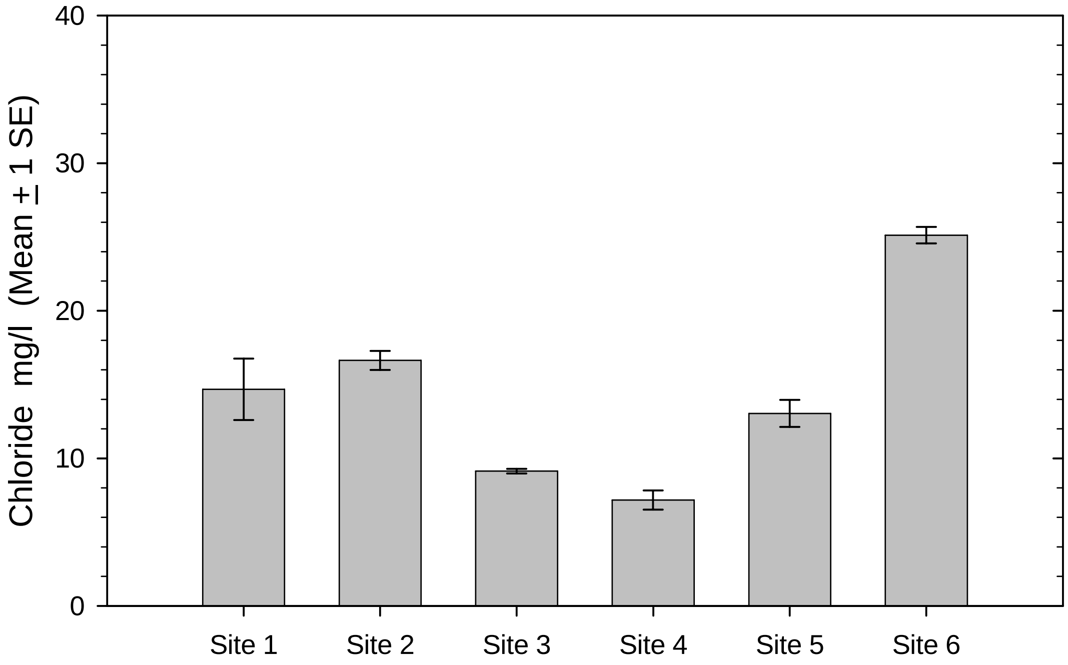


Figure E11. Chloride (mg/l, mean ± 1 SE) for collection dates September 24 and October 7, 2005, for all collection sites on the Eightmile River West Branch.

September 24, 2005



October 7, 2005

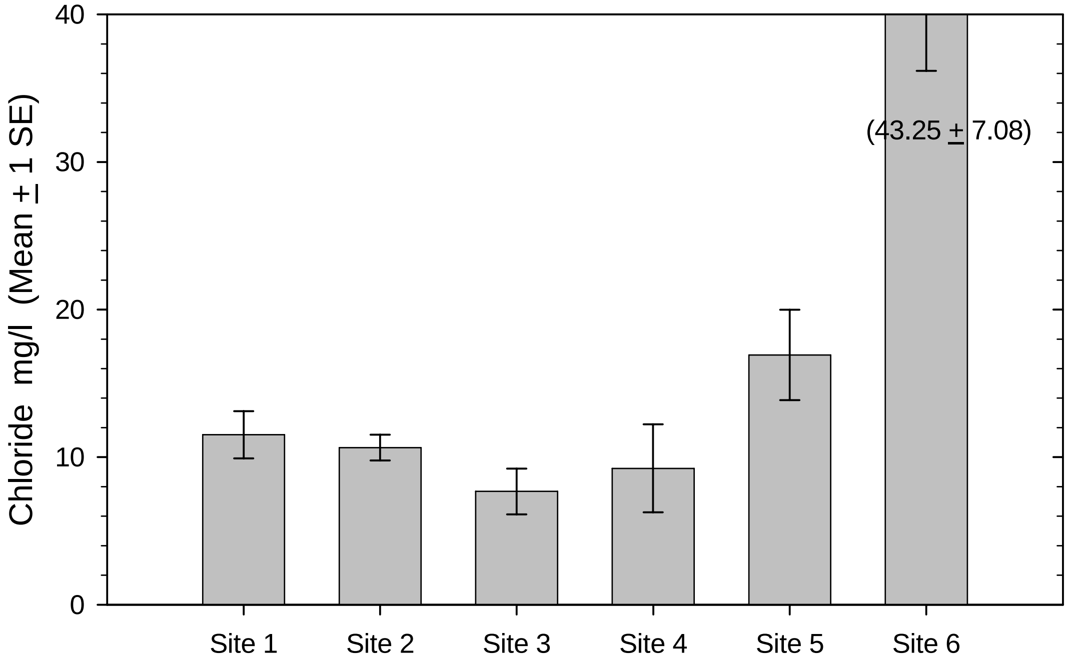


Figure E12. Chloride (mg/l, mean + 1 SE) for collection date October 22, 2005, for all collection sites on the Eightmile River West Branch.

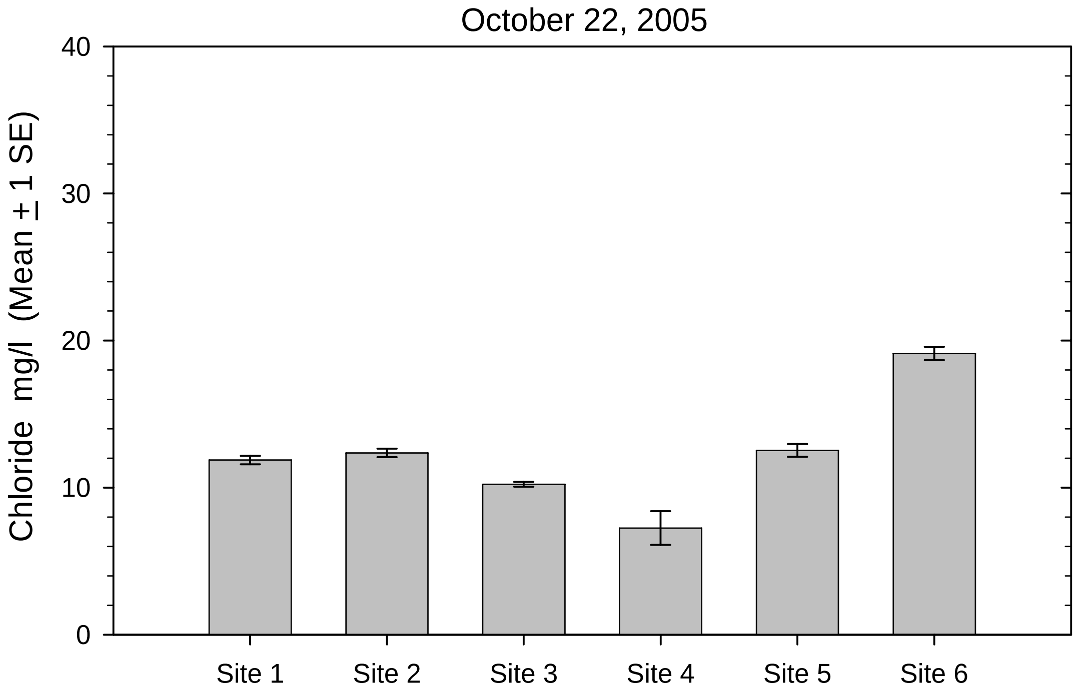


Figure E13. Reactive phosphate ($P\text{-}PO_4^{3-}$ µg/l, mean ± 1 SE) for collection dates June 4 and June 18, 2005, for all collection sites on the Eightmile River West Branch.

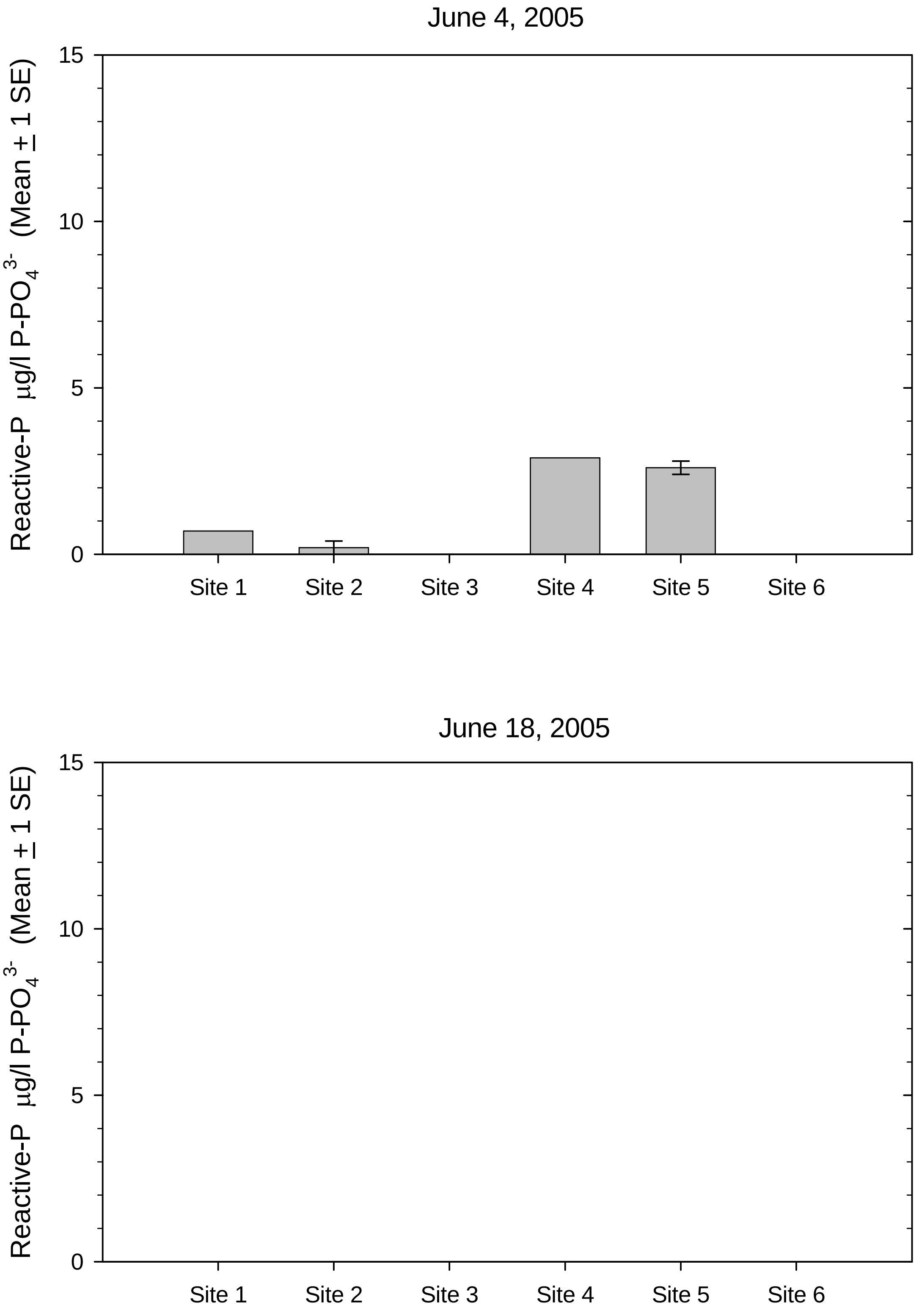
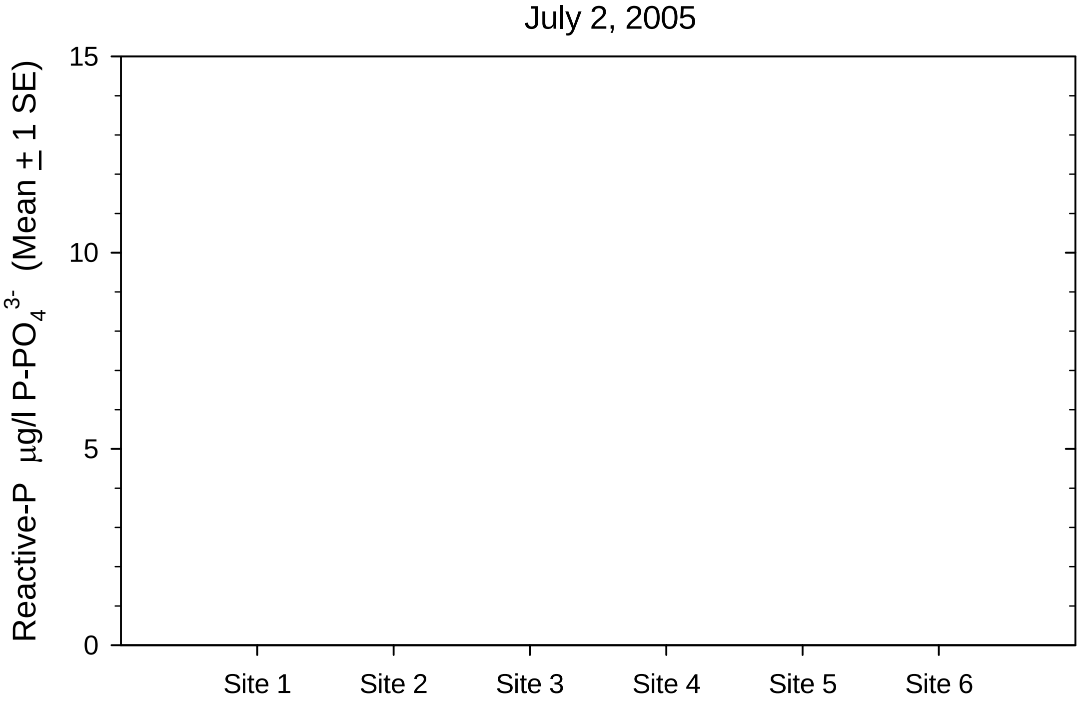


Figure E14. Reactive phosphate (P-PO_4^{3-} μg/l, mean ± 1 SE) for collection dates July 2 and July 16, 2005, for all collection sites on the Eightmile River West Branch.



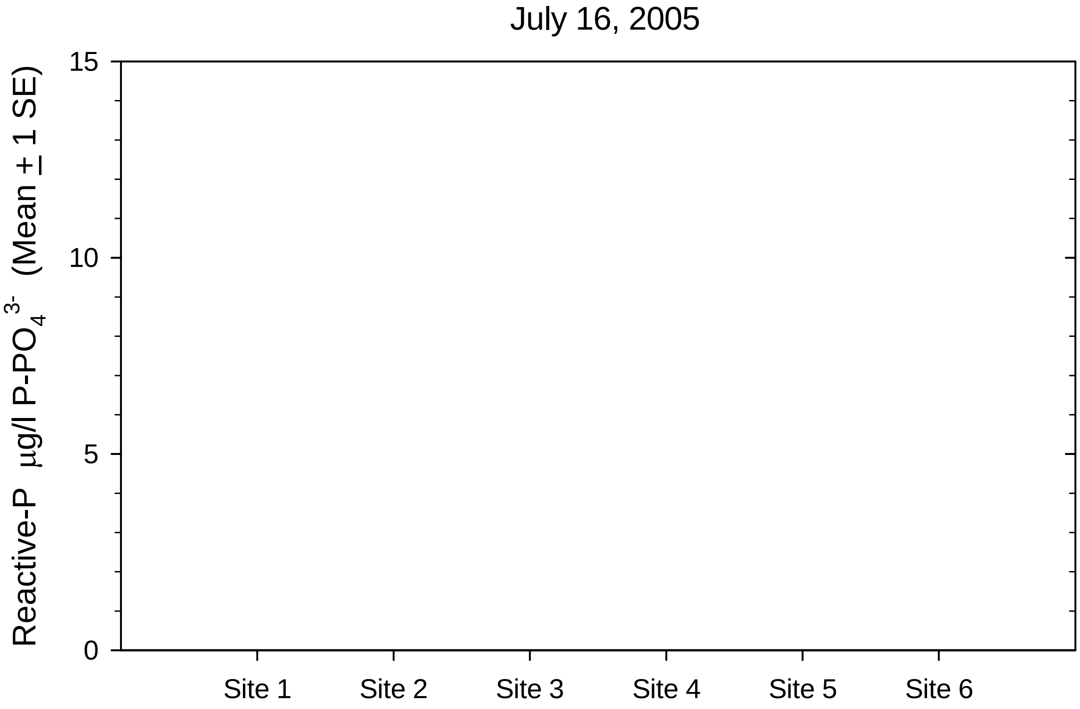
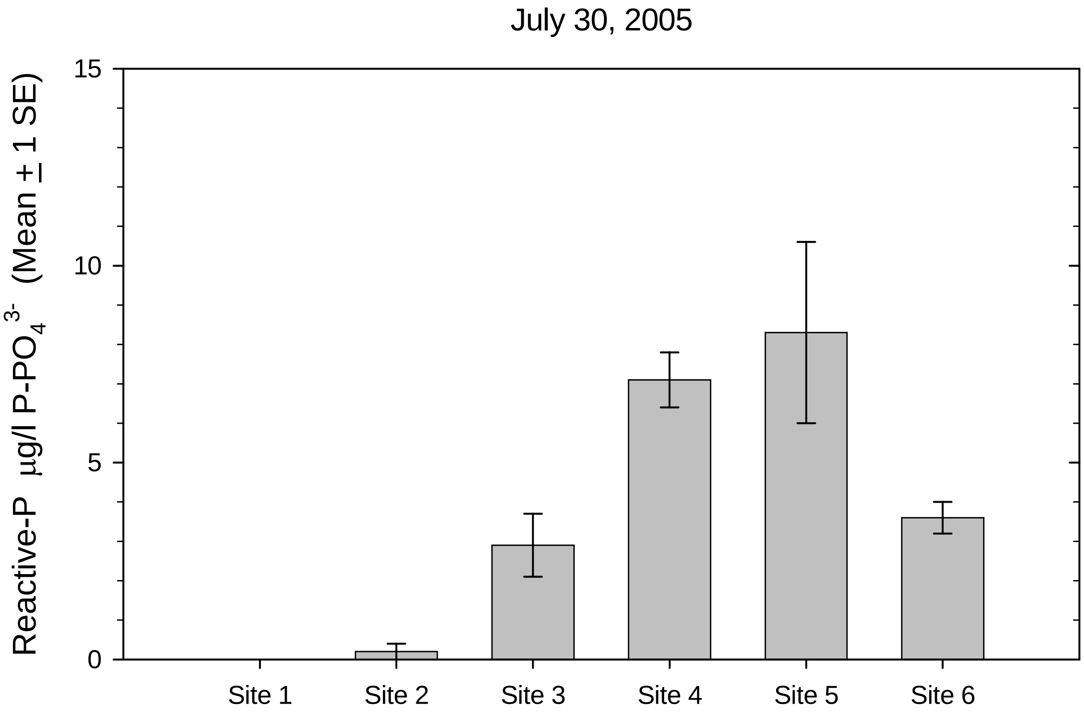


Figure E15. Reactive phosphate (P-PO_4^{3-} µg/l, mean ± 1 SE) for collection dates July 30 and August 13, 2005, for all collection sites on the Eightmile River West Branch.



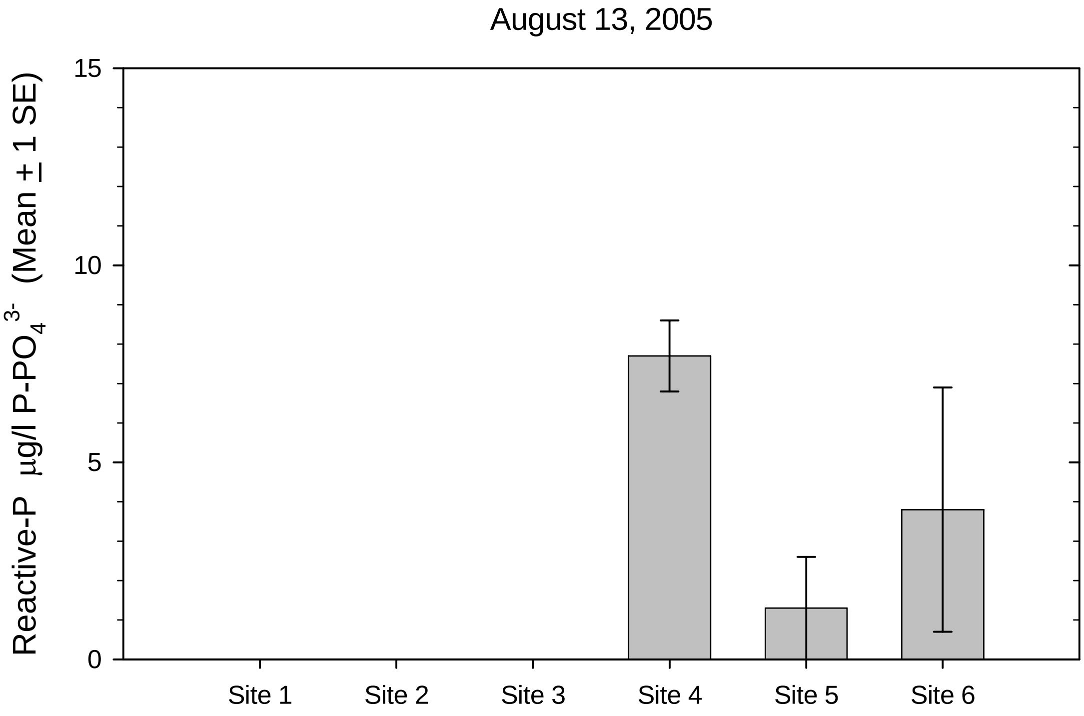
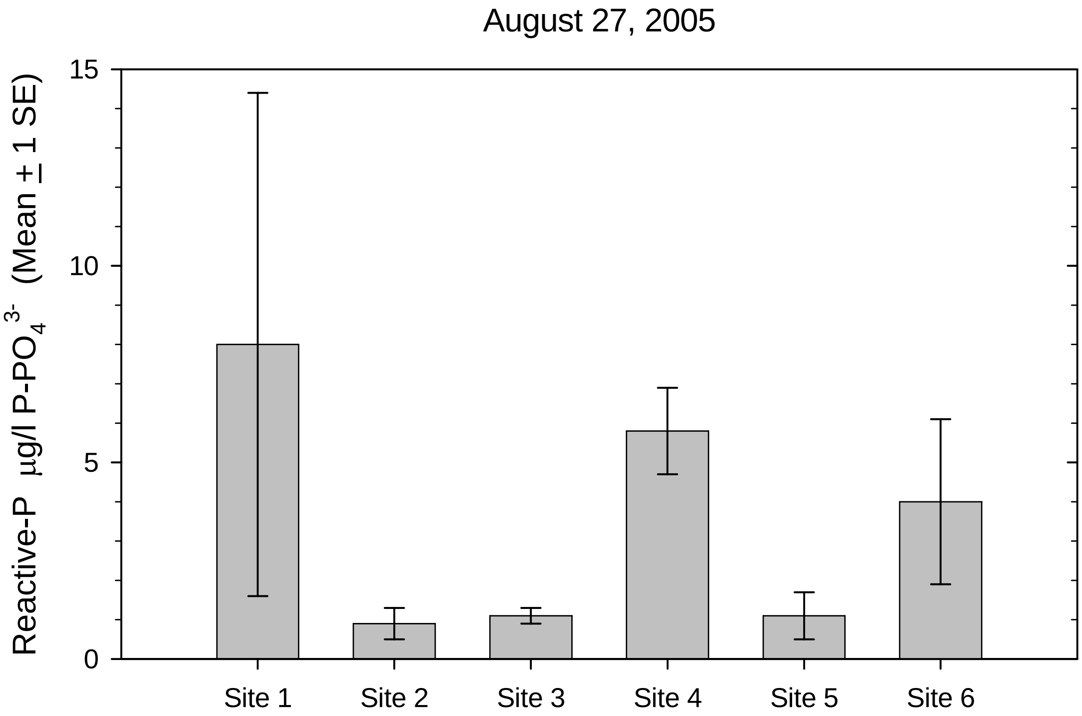


Figure E16. Reactive phosphate ($P\text{-}PO_4^{3-}$ μg/l, mean ± 1 SE) for collection dates August 27 and September 10, 2005, for all collection sites on the Eightmile River West Branch.


August 27, 2005

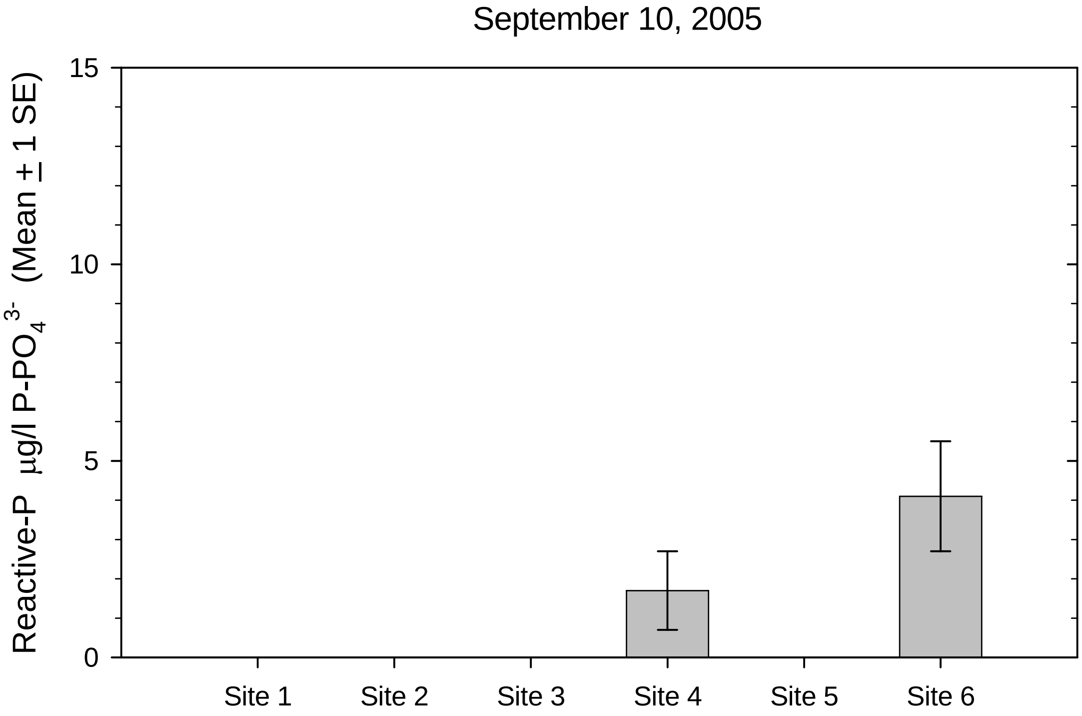
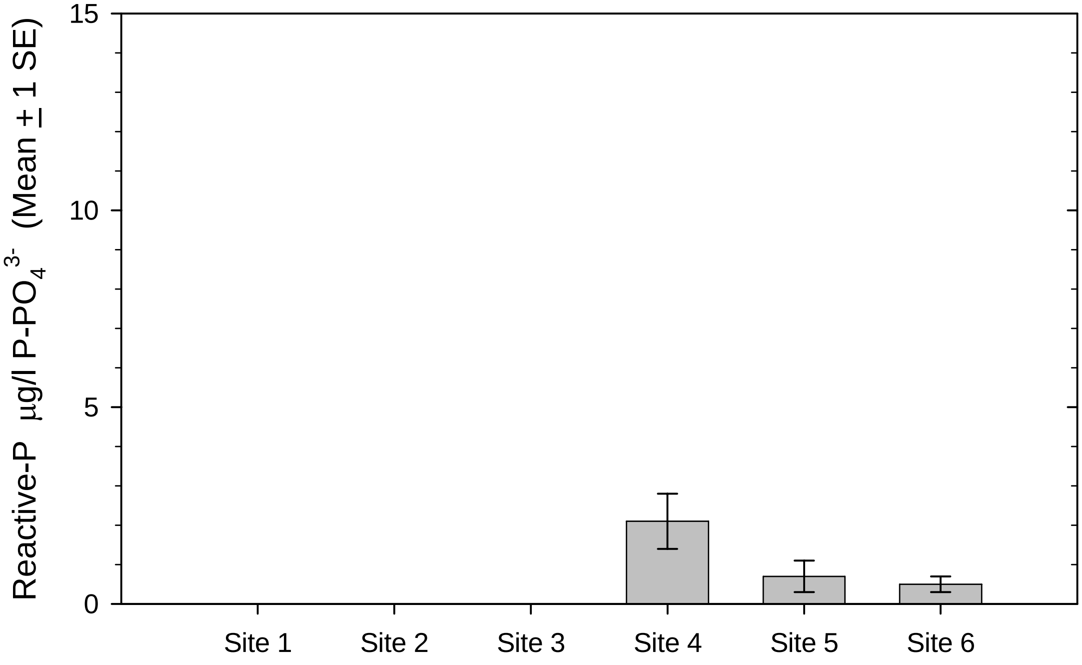

September 10, 2005

Figure E17. Reactive phosphate (P-PO_4^{3-} µg/l, mean ± 1 SE) for collection dates September 24 and October 7, 2005, for all collection sites on the Eightmile River West Branch.


September 24, 2005

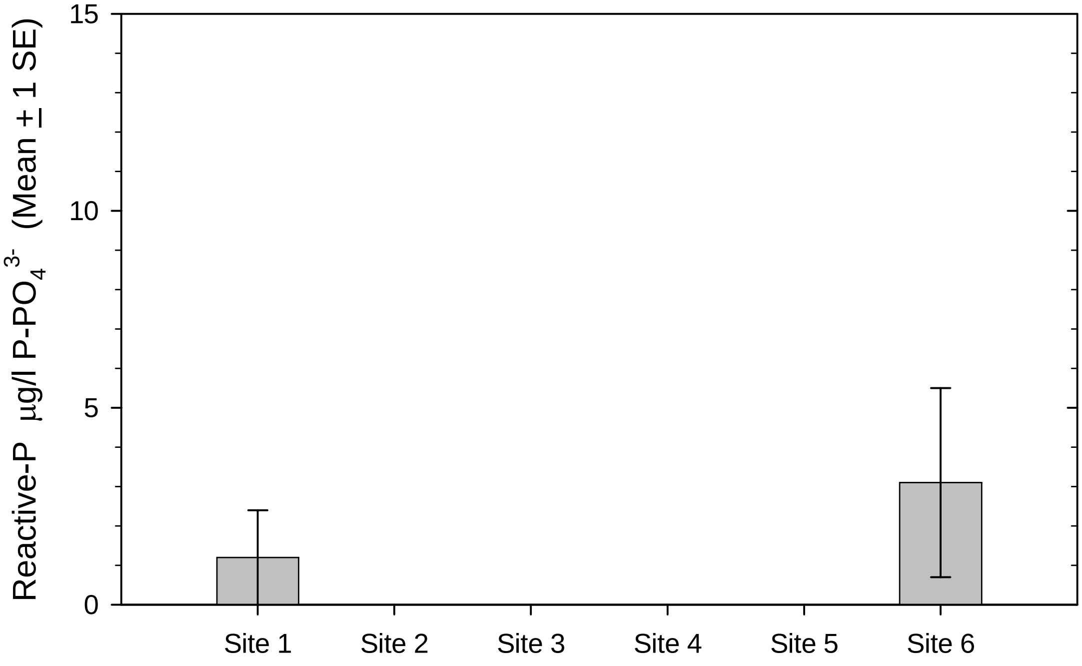

October 7, 2005

Figure E18. Reactive phosphate (P-PO_4^{3-} µg/l, mean ± 1 SE) for collection date October 22, 2005, for all collection sites on the Eightmile River West Branch.

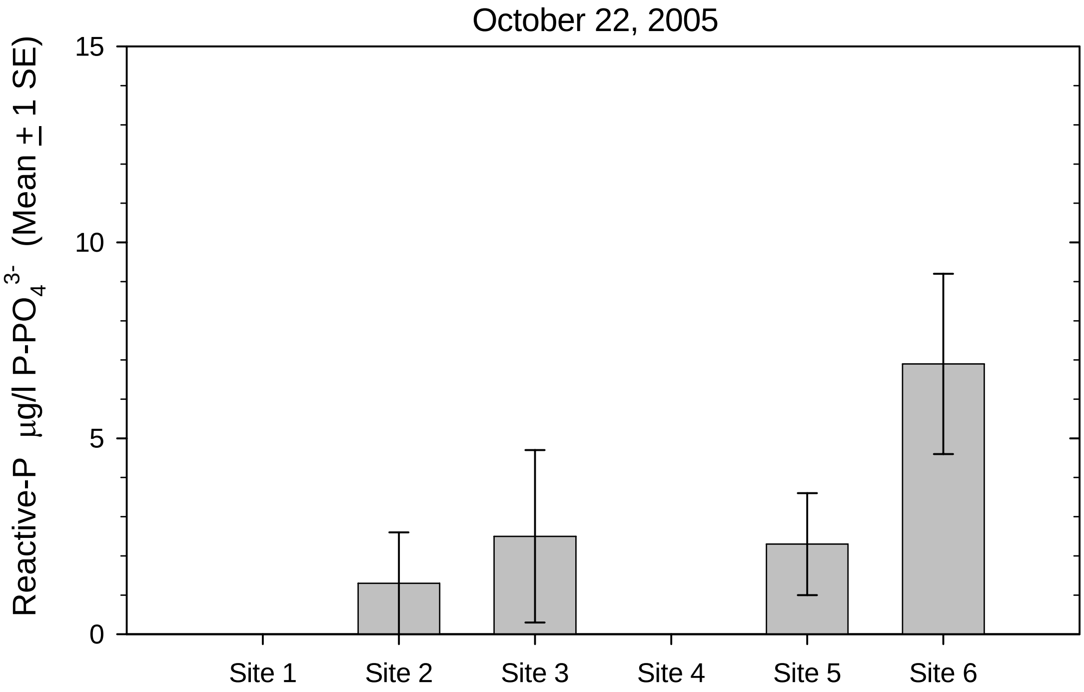
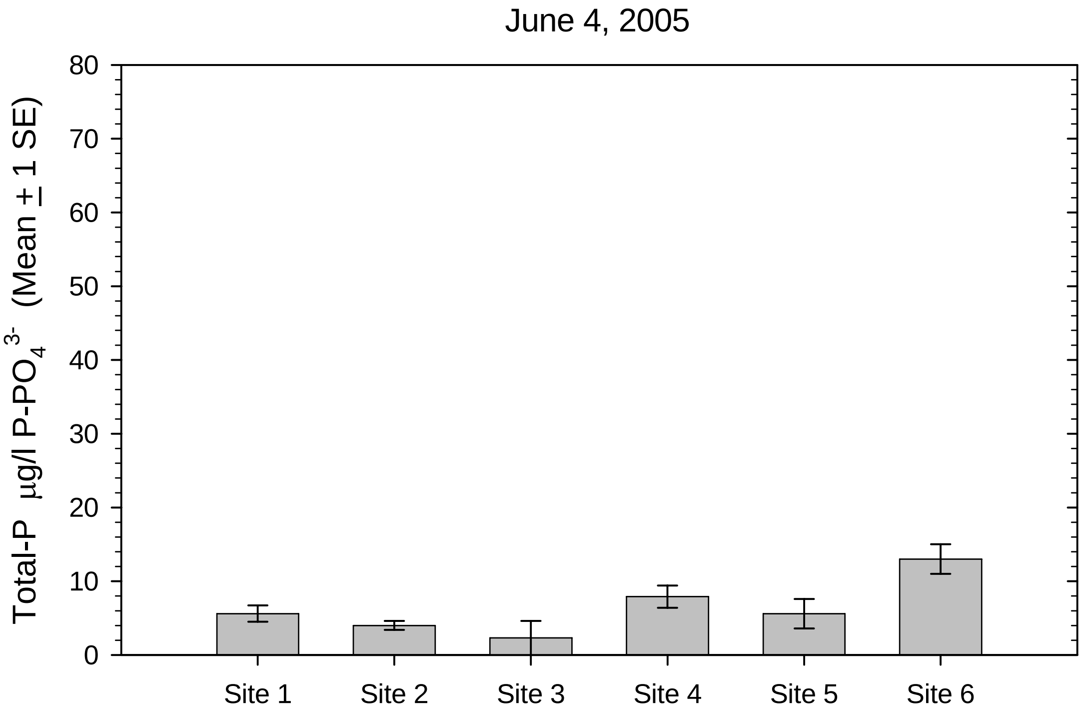


Figure E19. Total phosphate ($P\text{-}PO_4^{3-}$ µg/l, mean ± 1 SE) for collection dates June 4 and June 18, 2005, for all collection sites on the Eightmile River West Branch.



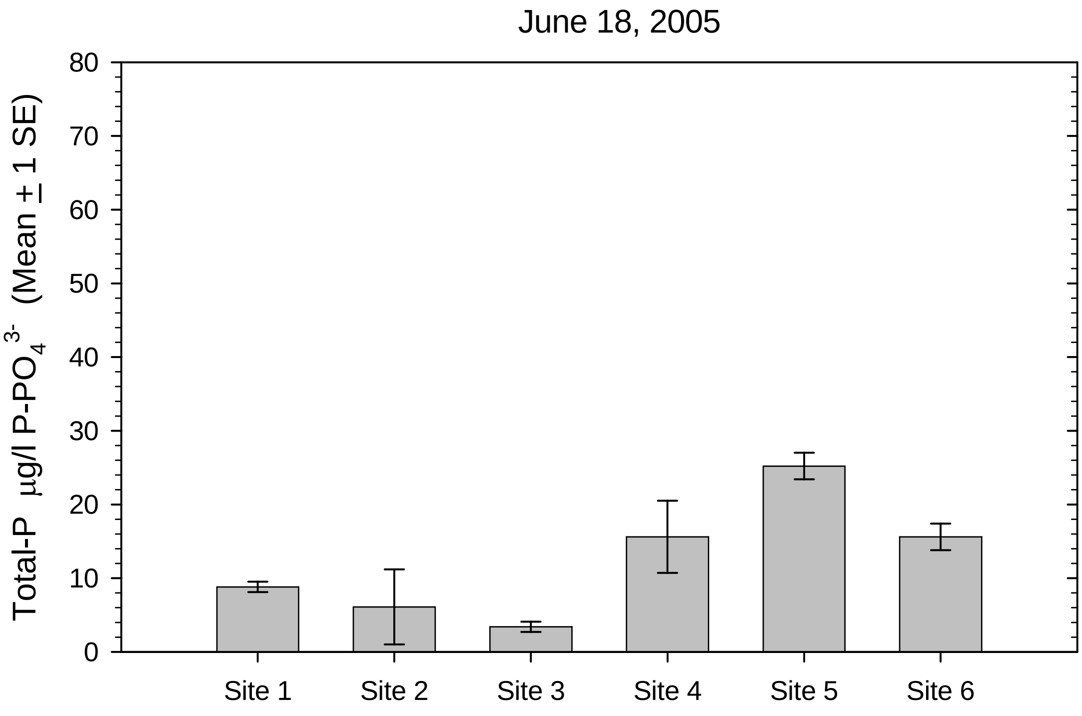
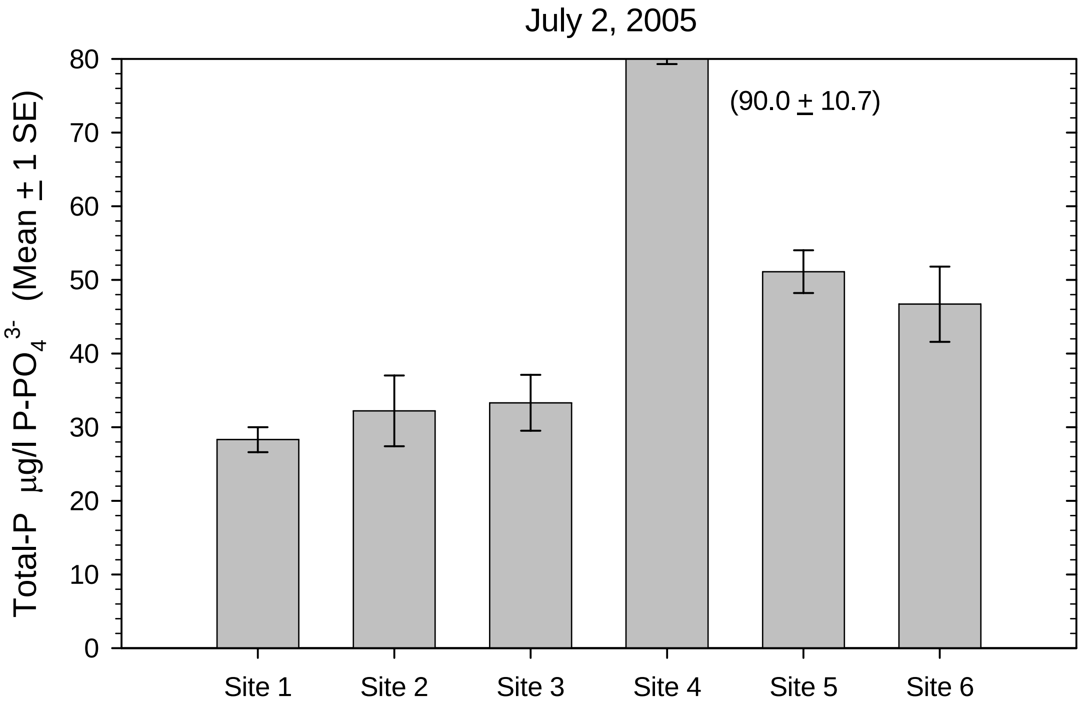


Figure E20. Total phosphate ($P\text{-}PO_4^{3-}$ µg/l, mean ± 1 SE) for collection dates July 2 and July 16, 2005, for all collection sites on the Eightmile River West Branch.



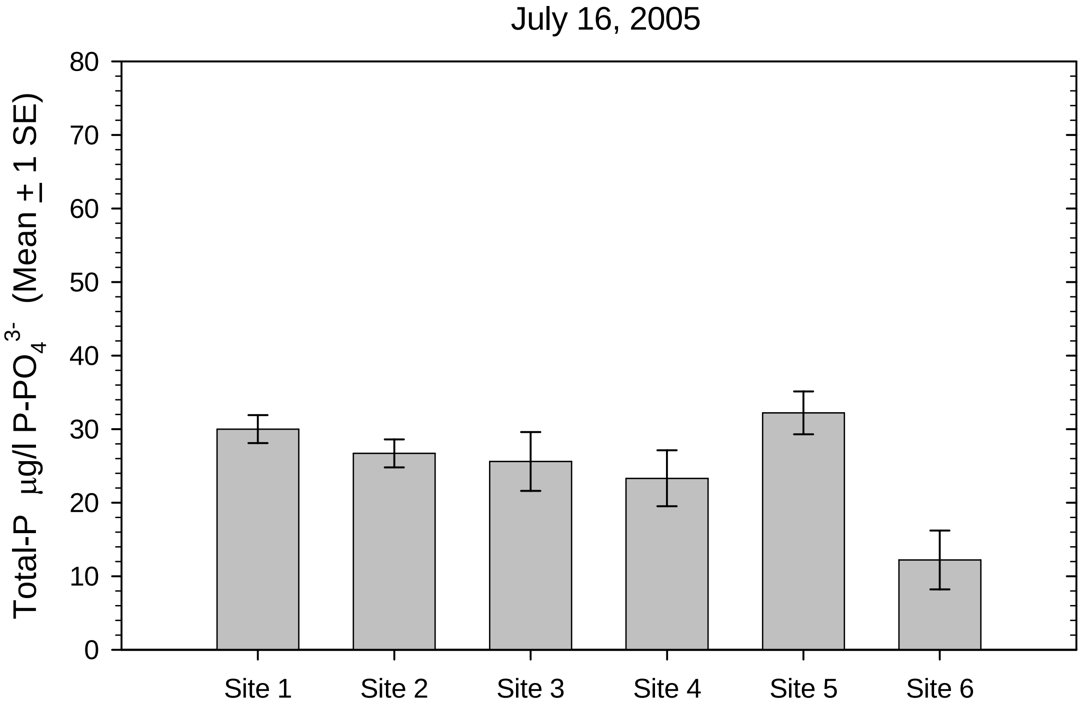
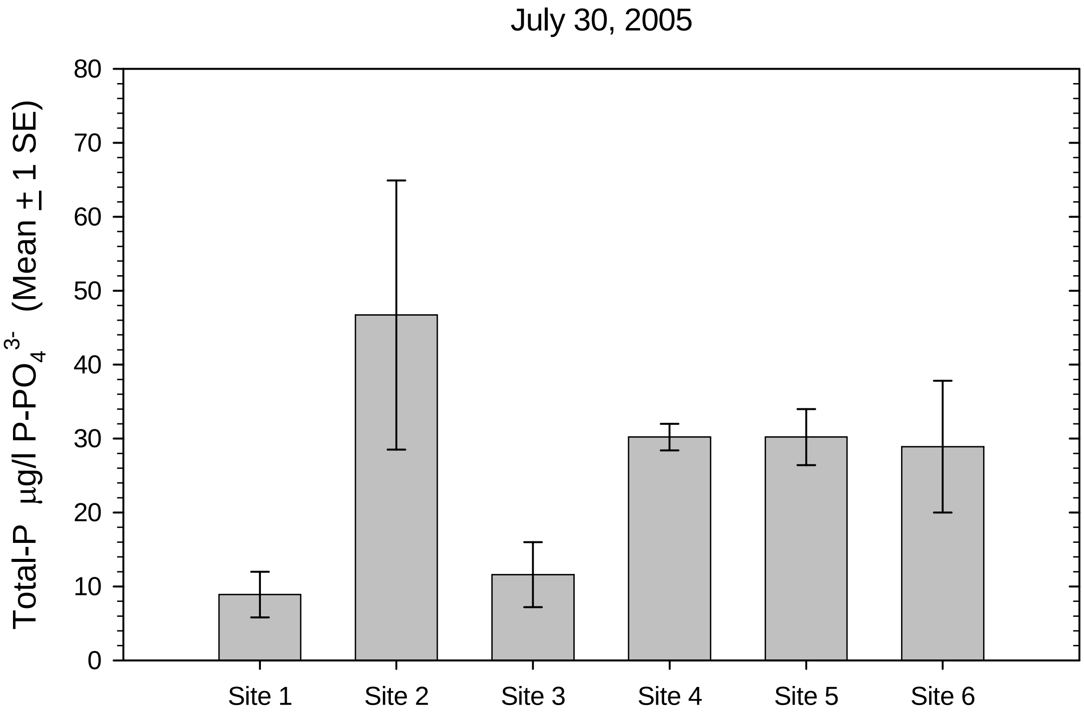


Figure E21. Total phosphate (P-PO_4^{3-} µg/l, mean ± 1 SE) for collection dates July 30 and August 13, 2005, for all collection sites on the Eightmile River West Branch.


July 30, 2005

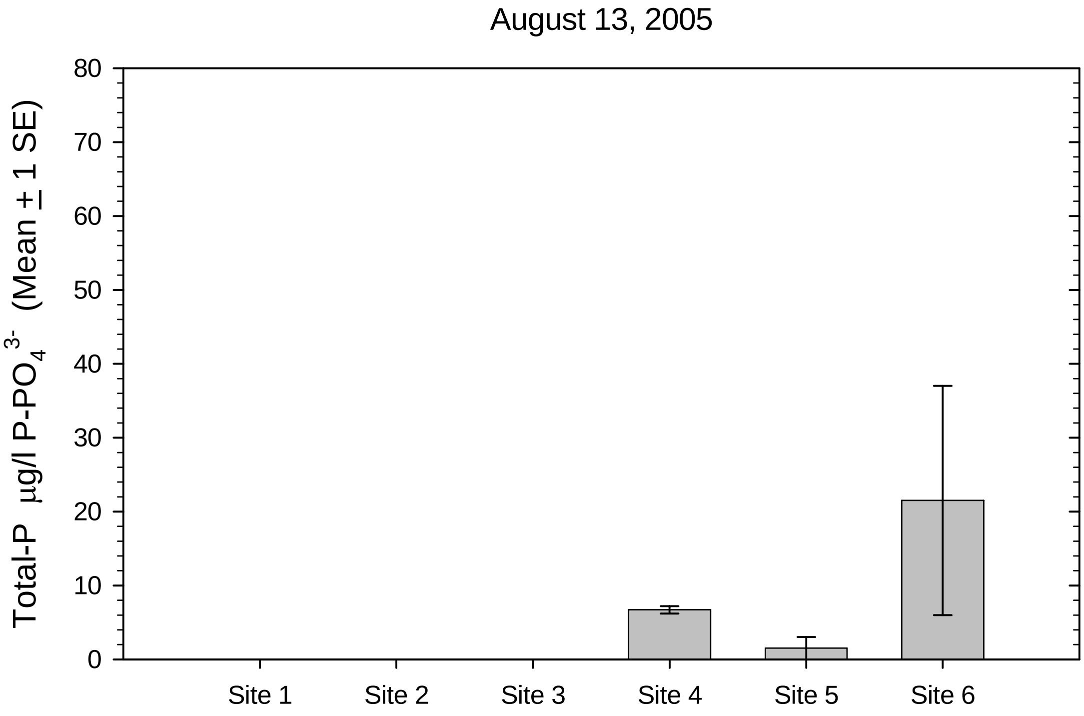
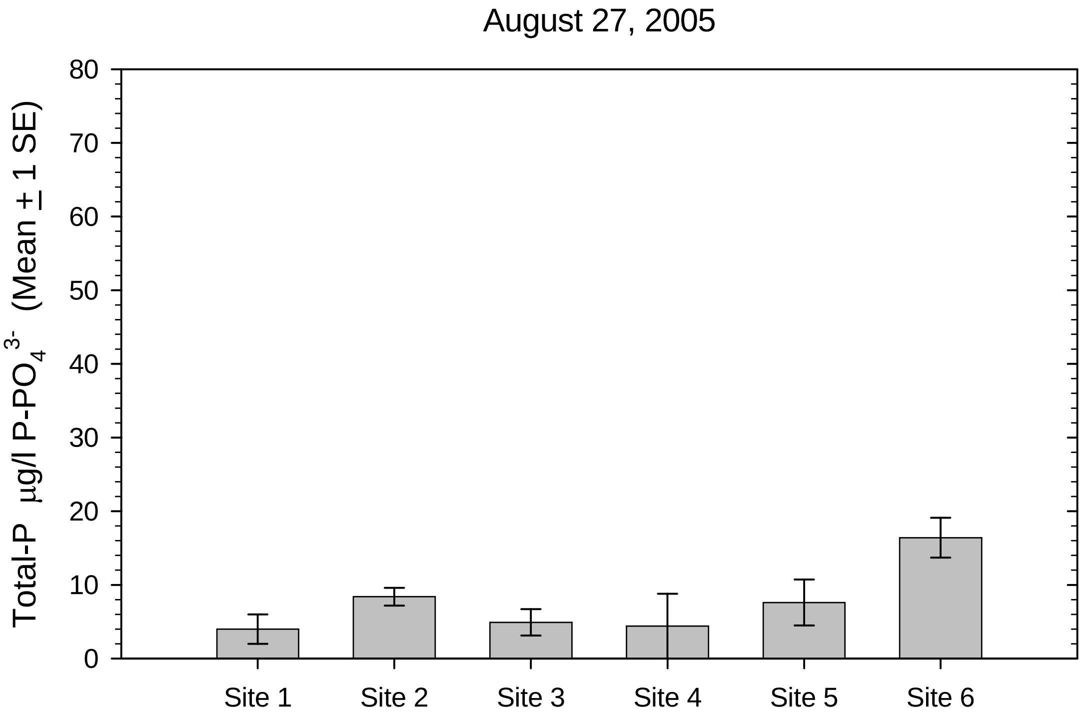

August 13, 2005

Figure E22. Total phosphate ($P\text{-}PO_4^{3-}$ µg/l, mean ± 1 SE) for collection dates August 27 and September 10, 2005, for all collection sites on the Eightmile River West Branch.



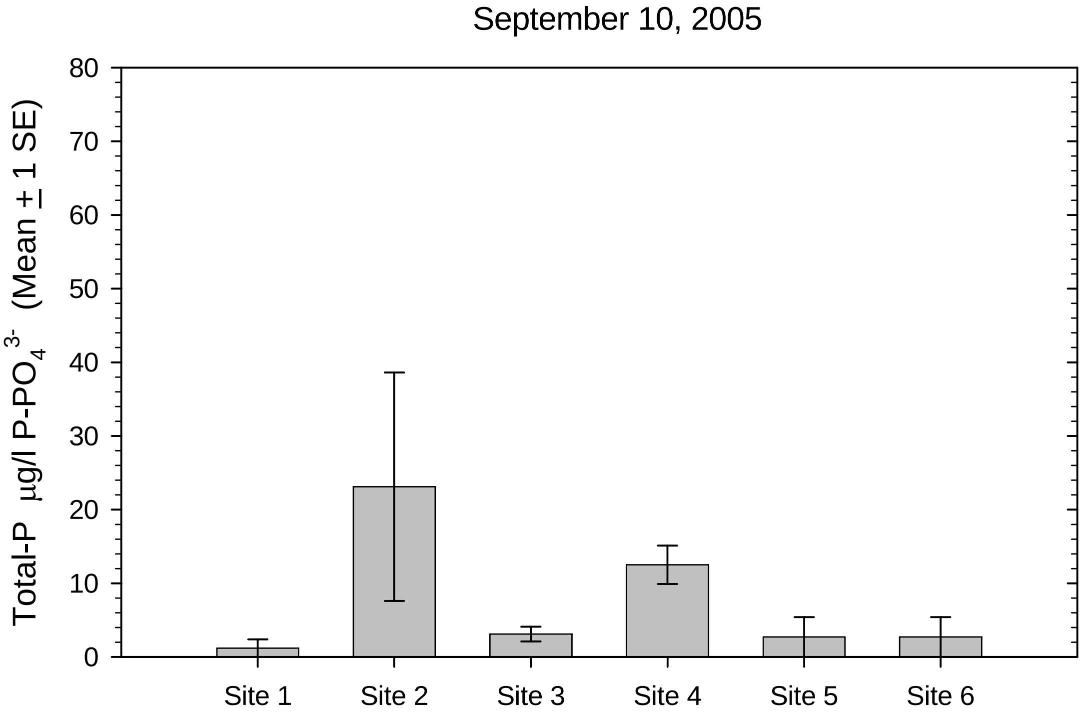
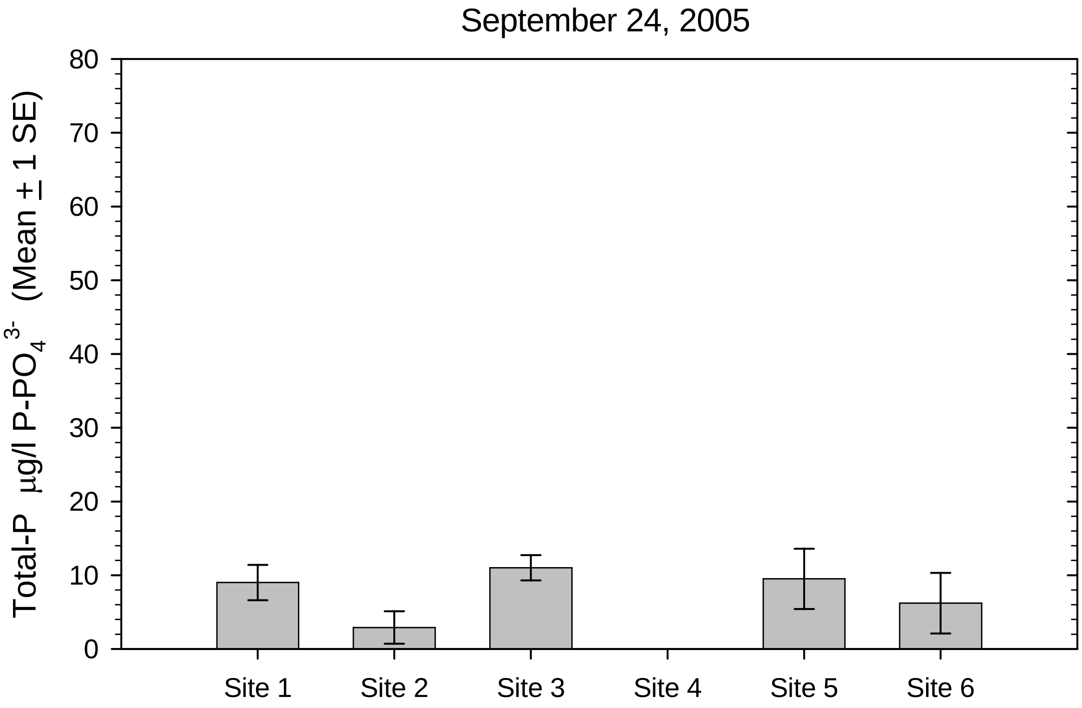


Figure E23. Total phosphate (P-PO_4^{3-} μg/l, mean ± 1 SE) for collection dates September 24 and October 7, 2005, for all collection sites on the Eightmile River West Branch.



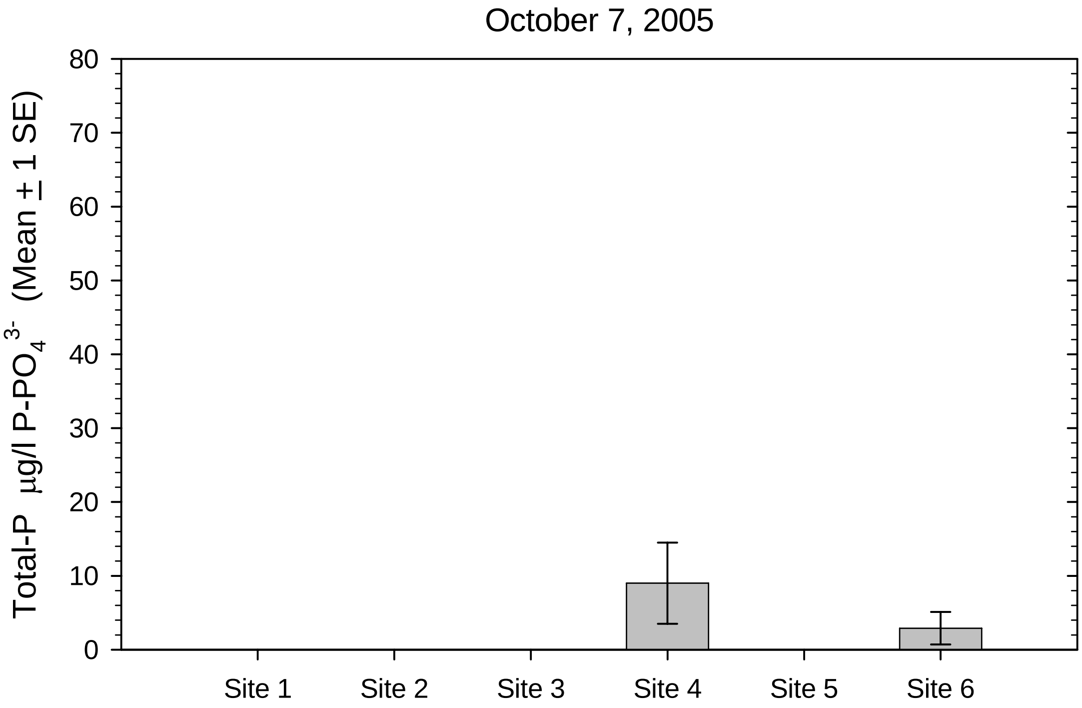


Figure E24. Total phosphate (P-PO_4^{3-} µg/l, mean ± 1 SE) for collection date October 22, 2005, for all collection sites on the Eightmile River West Branch.

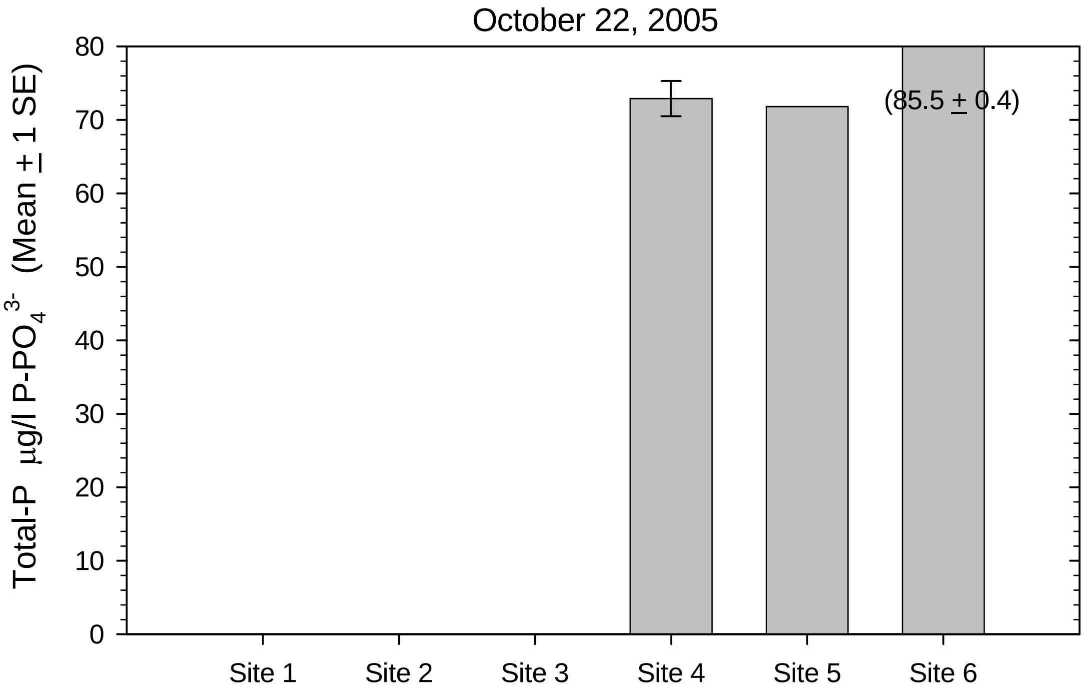


Figure E25. Nitrate-N (N-NO_3^- µg/l, mean ± 1 SE) for collection dates June 4 and June 18, 2005, for all collection sites on the Eightmile River West Branch.

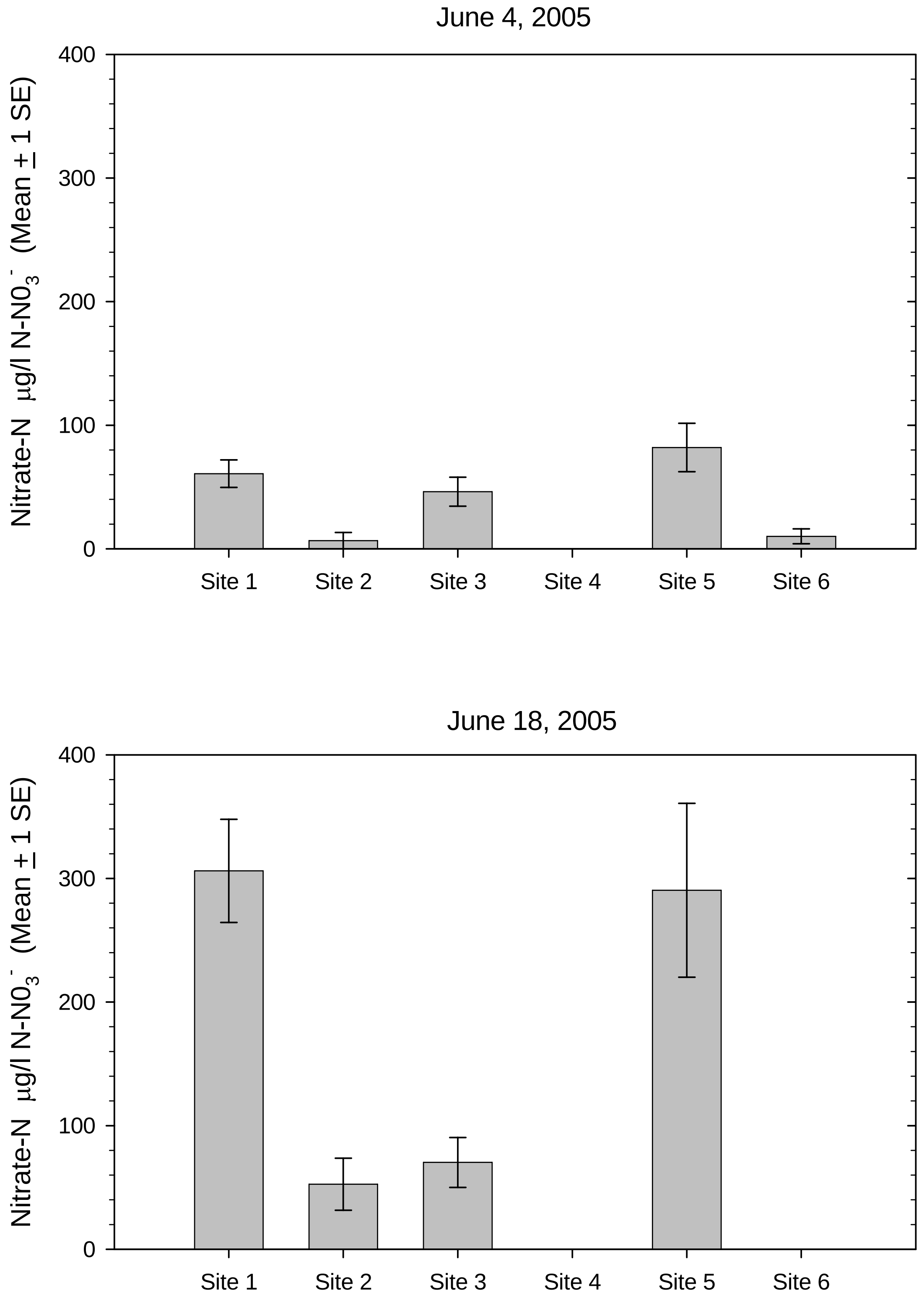
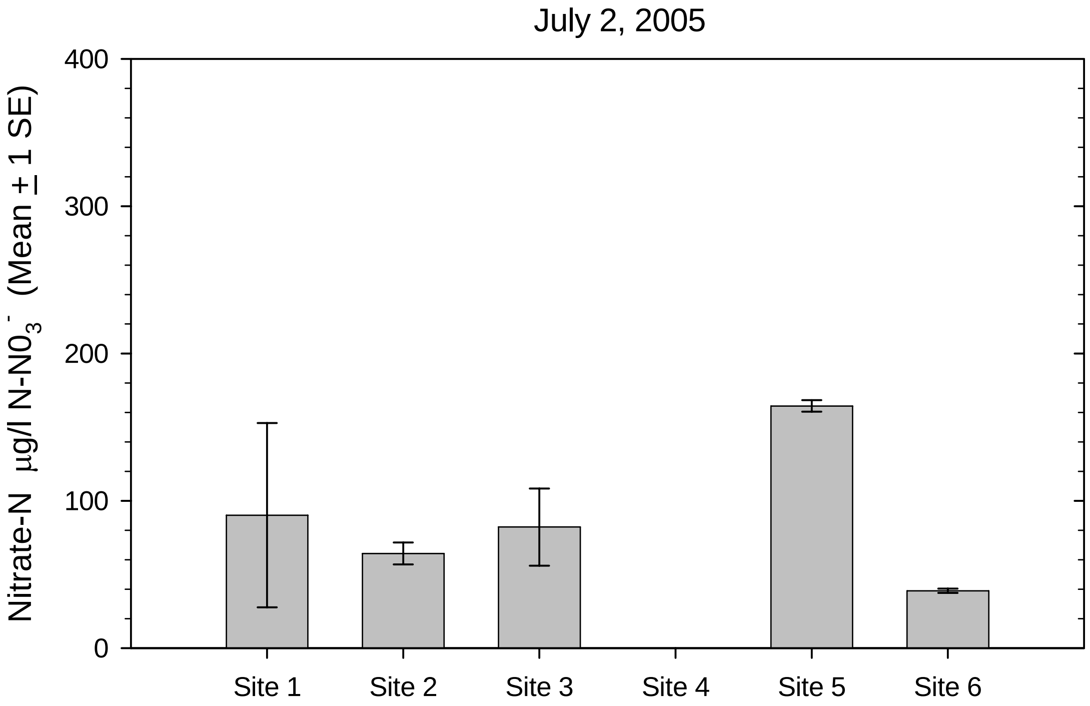


Figure E26. Nitrate-N (N-NO_3^- µg/l, mean + 1 SE) for collection dates July 2 and July 16, 2005, for all collection sites on the Eightmile River West Branch.



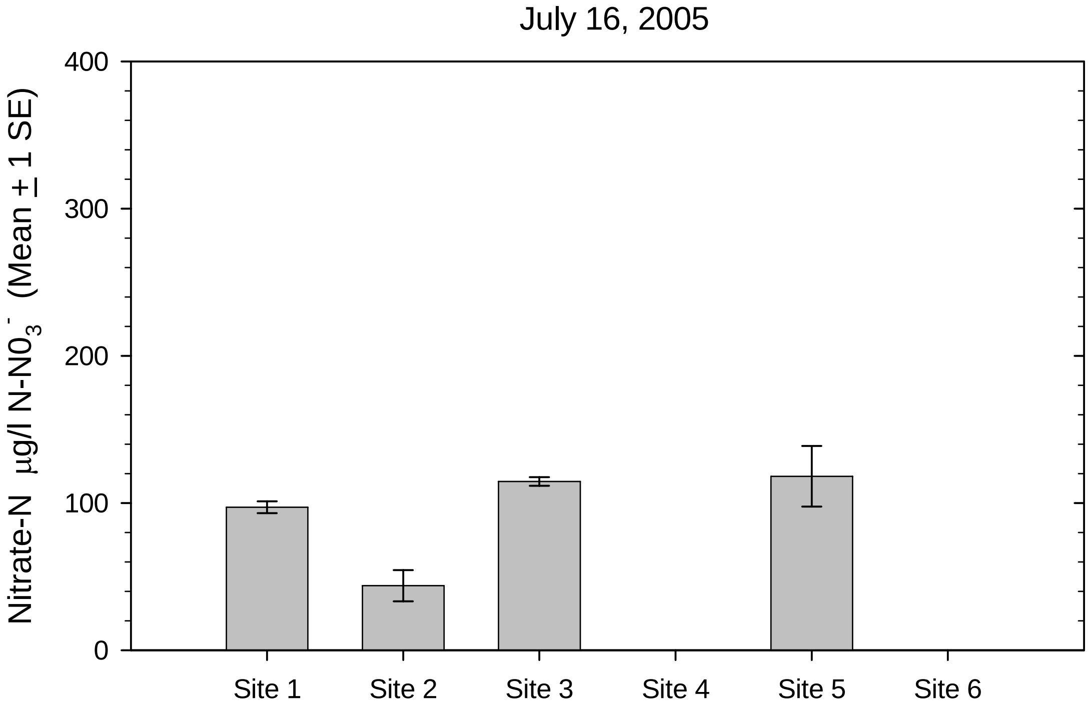
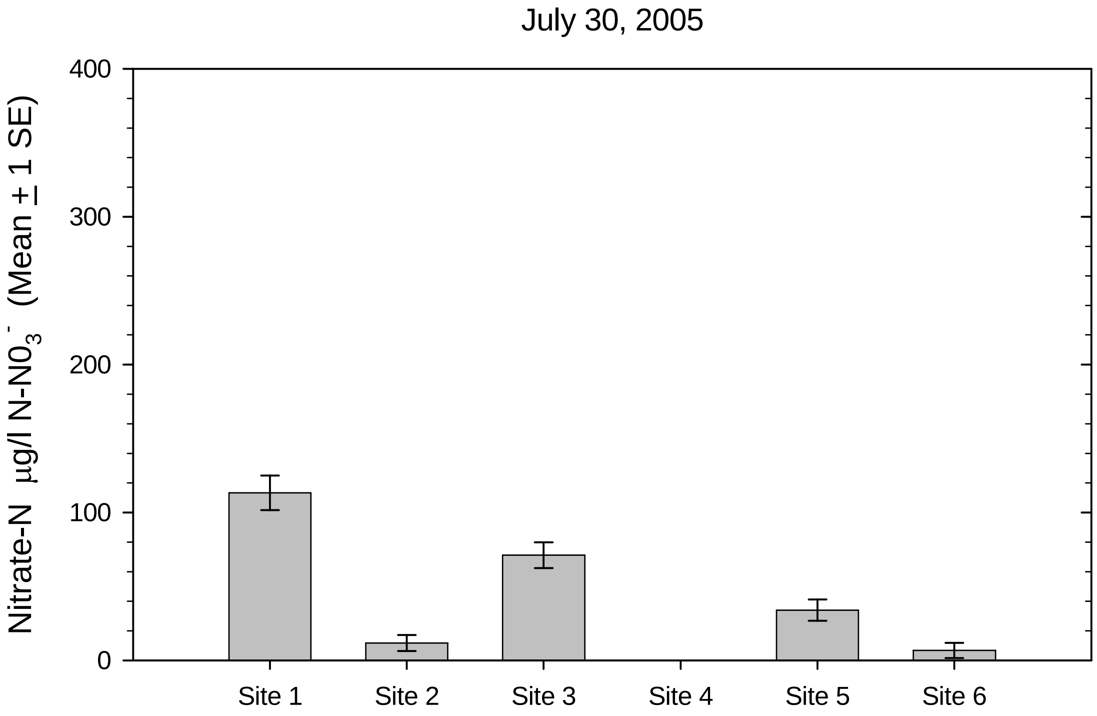


Figure E27. Nitrate-N (N-NO_3^- µg/l, mean ± 1 SE) for collection dates July 30 and August 13, 2005, for all collection sites on the Eightmile River West Branch.



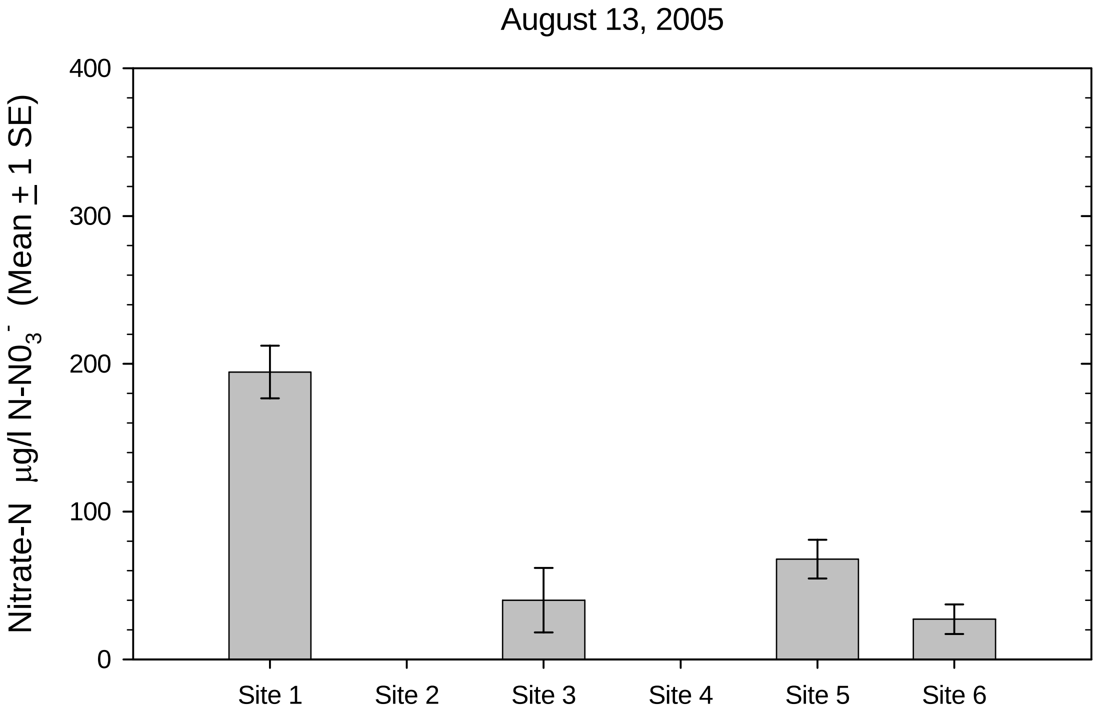
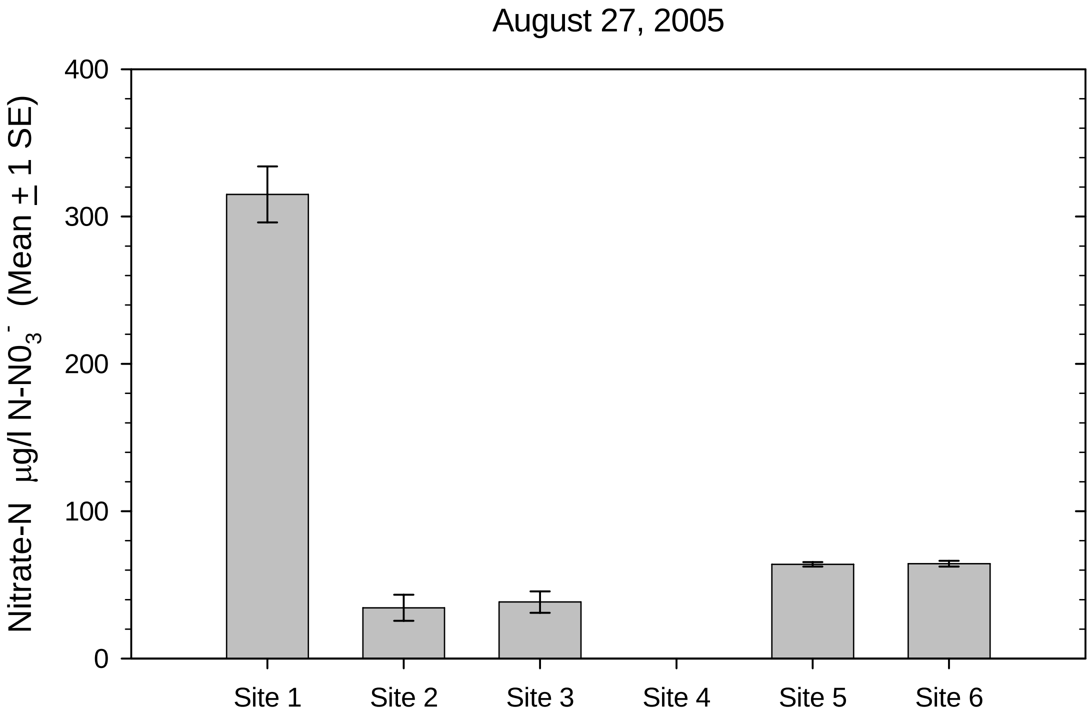


Figure E28. Nitrate-N (N-NO_3^- µg/l, mean + 1 SE) for collection dates August 27 and September 10, 2005, for all collection sites on the Eightmile River West Branch.



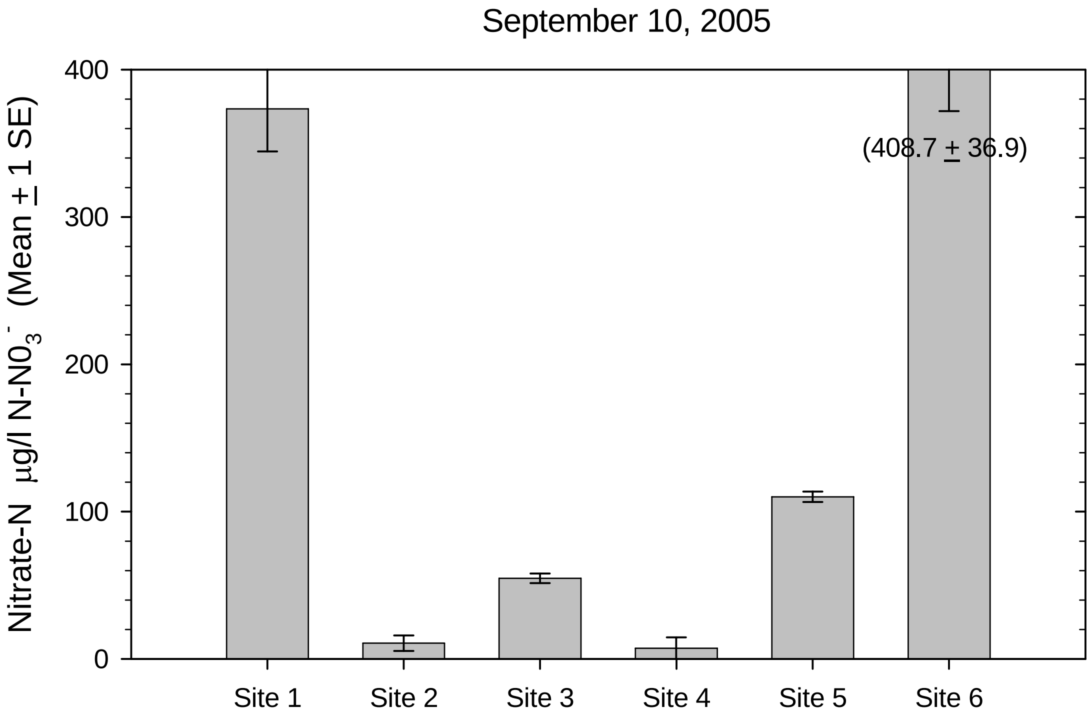
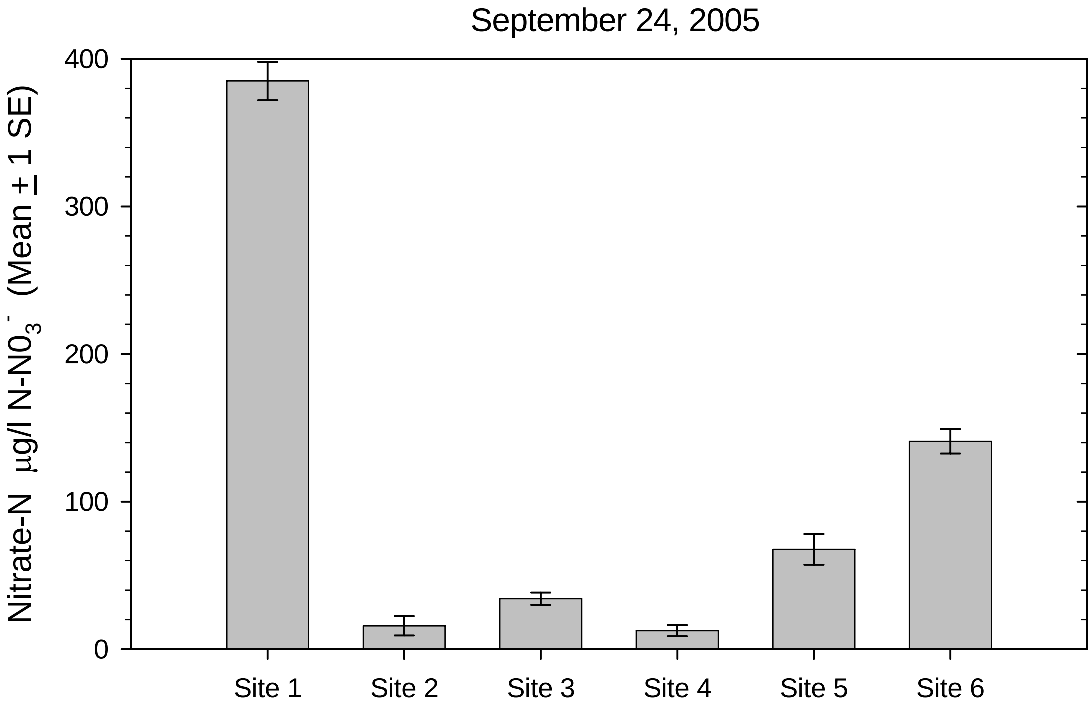


Figure E29. Nitrate-N (N-NO_3^- µg/l, mean $\underline{+}$ 1 SE) for collection dates September 24 and October 7, 2005, for all collection sites on the Eightmile River West Branch.



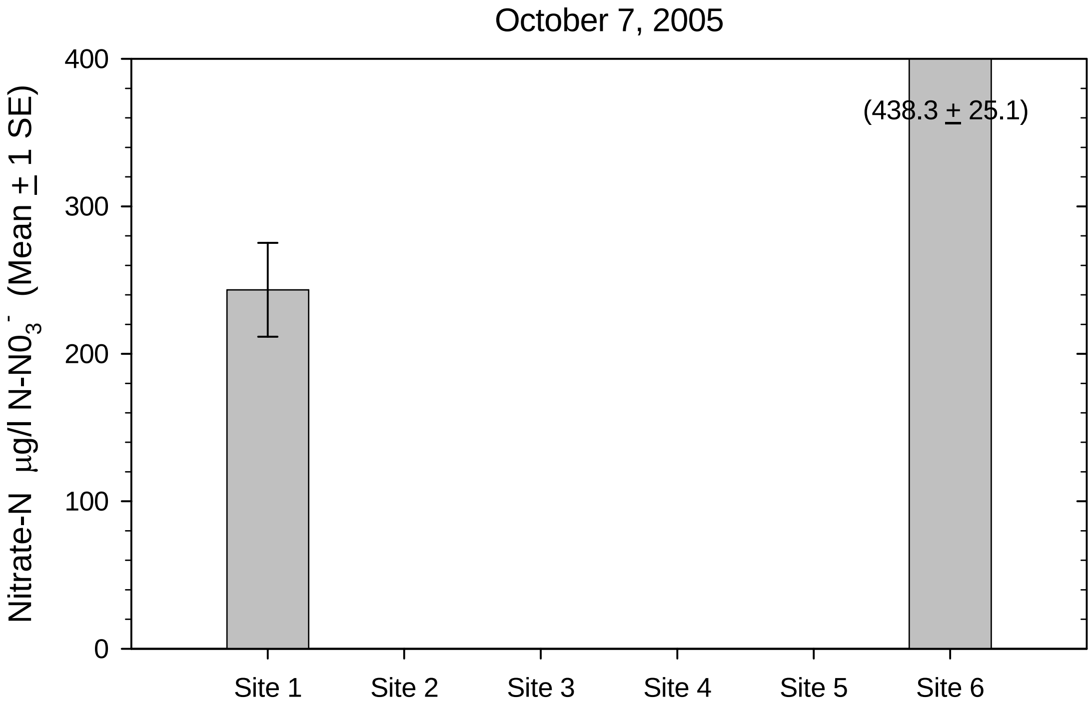


Figure E30. Nitrate-N (N-NO_3^- µg/l, mean ± 1 SE) for collection date October 22, 2005, for all collection sites on the Eightmile River West Branch.

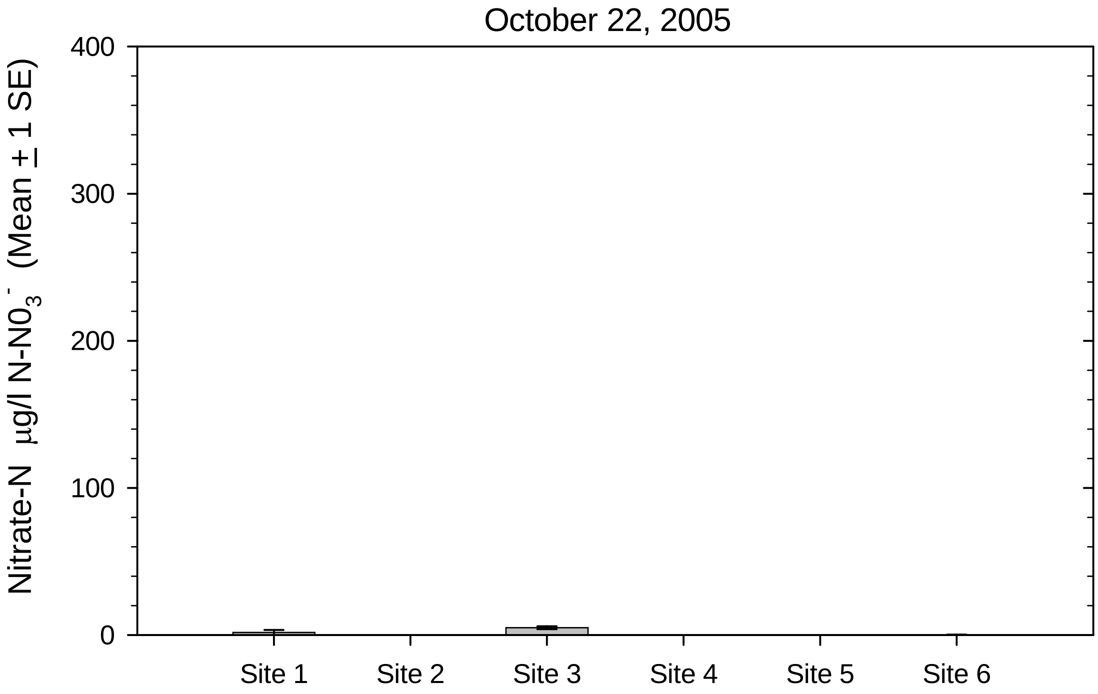


Figure E31. Nitrite-N (N-NO_2^- µg/l, mean ± 1 SE) for collection dates June 4 and June 18, 2005, for all collection sites on the Eightmile River West Branch.

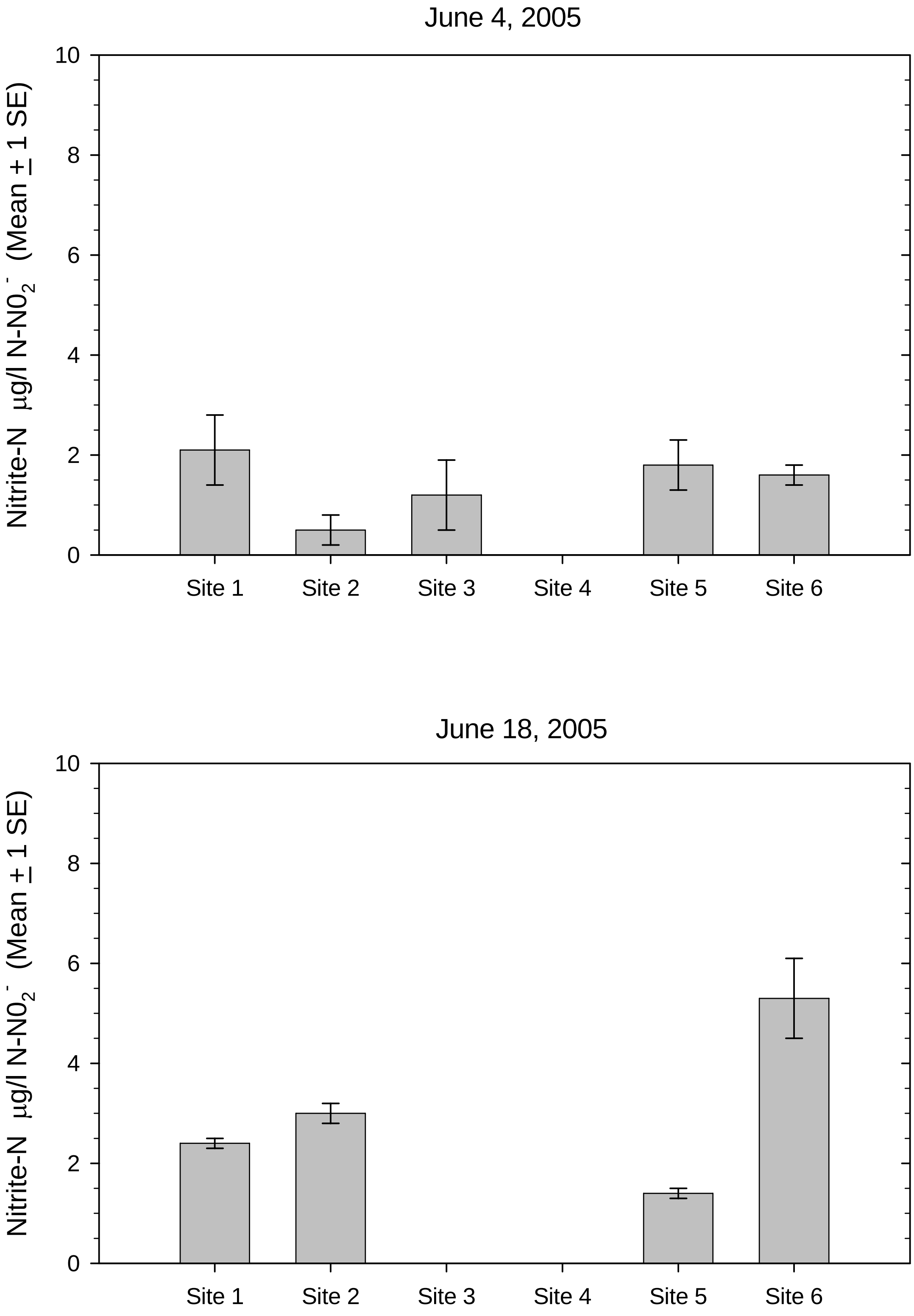
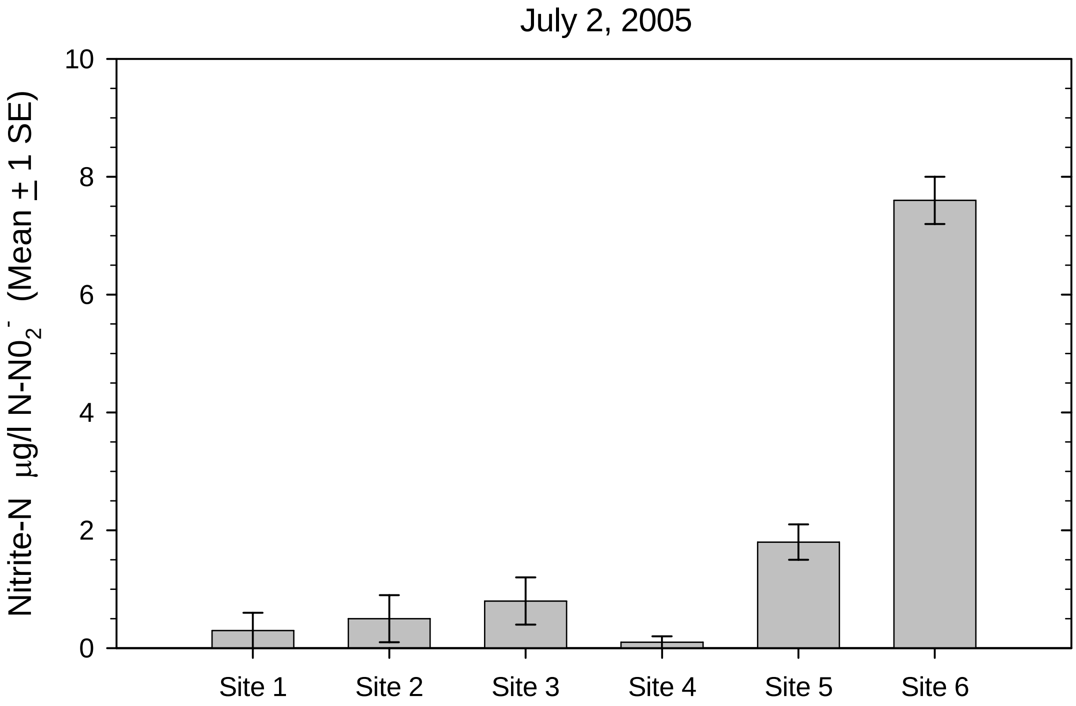


Figure E32. Nitrite-N (N-NO_2^- µg/l, mean ± 1 SE) for collection dates July 2 and July 16, 2005, for all collection sites on the Eightmile River West Branch.



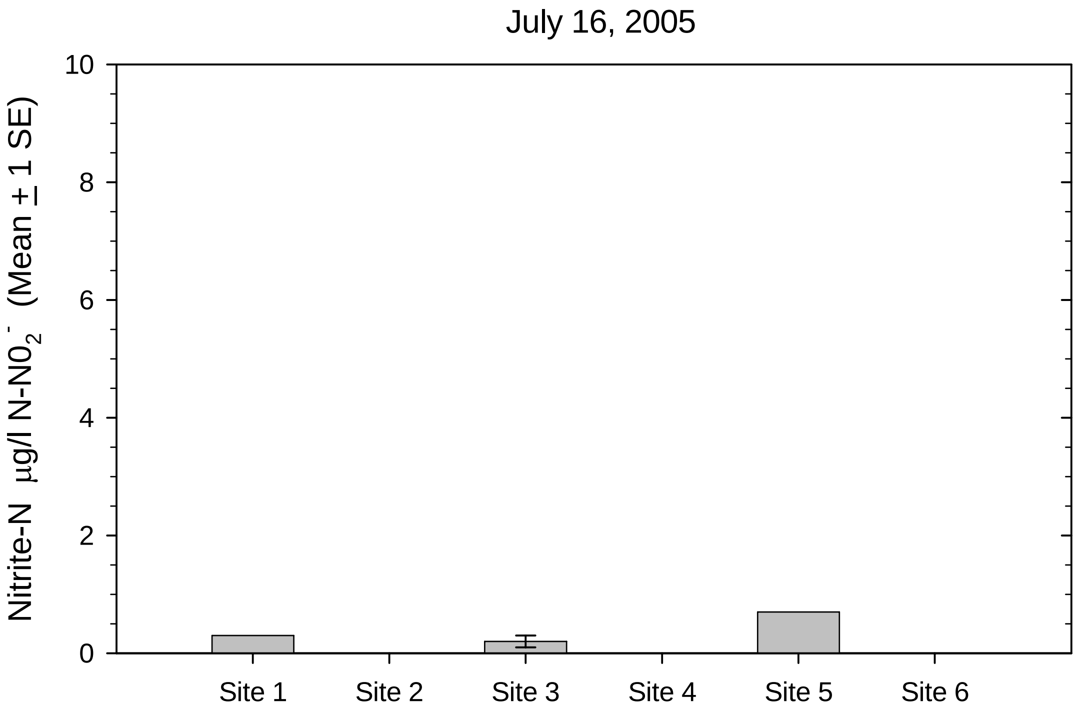
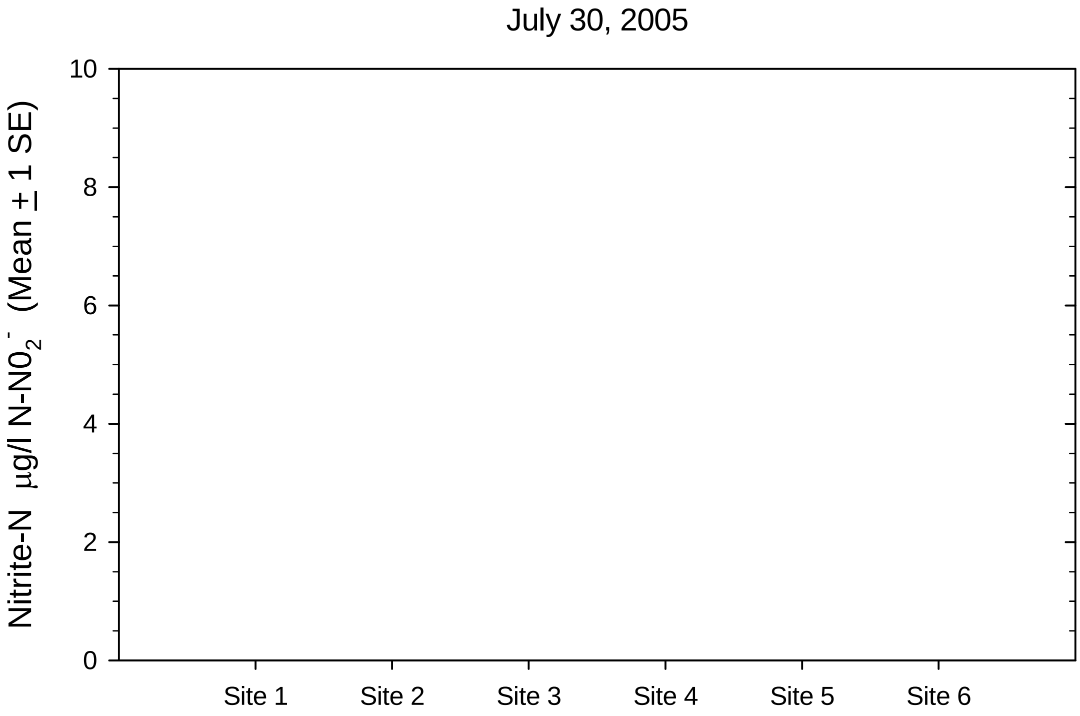


Figure E33. Nitrite-N (N-NO$_2^-$ μg/l, mean ± 1 SE) for collection dates July 30 and August 13, 2005, for all collection sites on the Eightmile River West Branch.



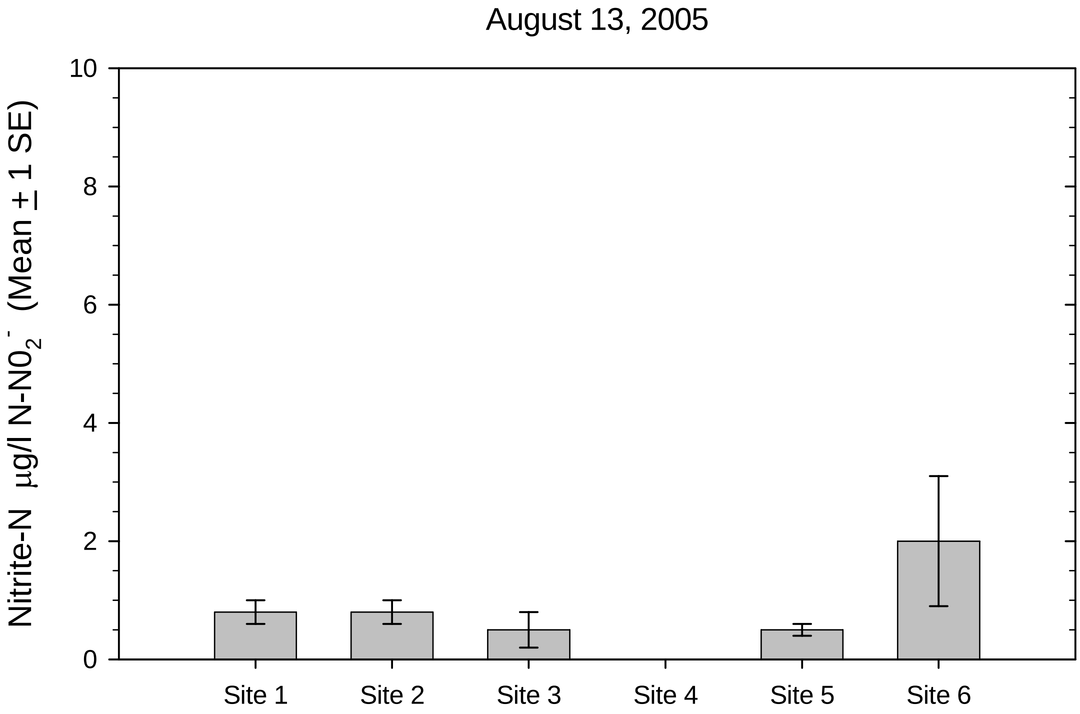
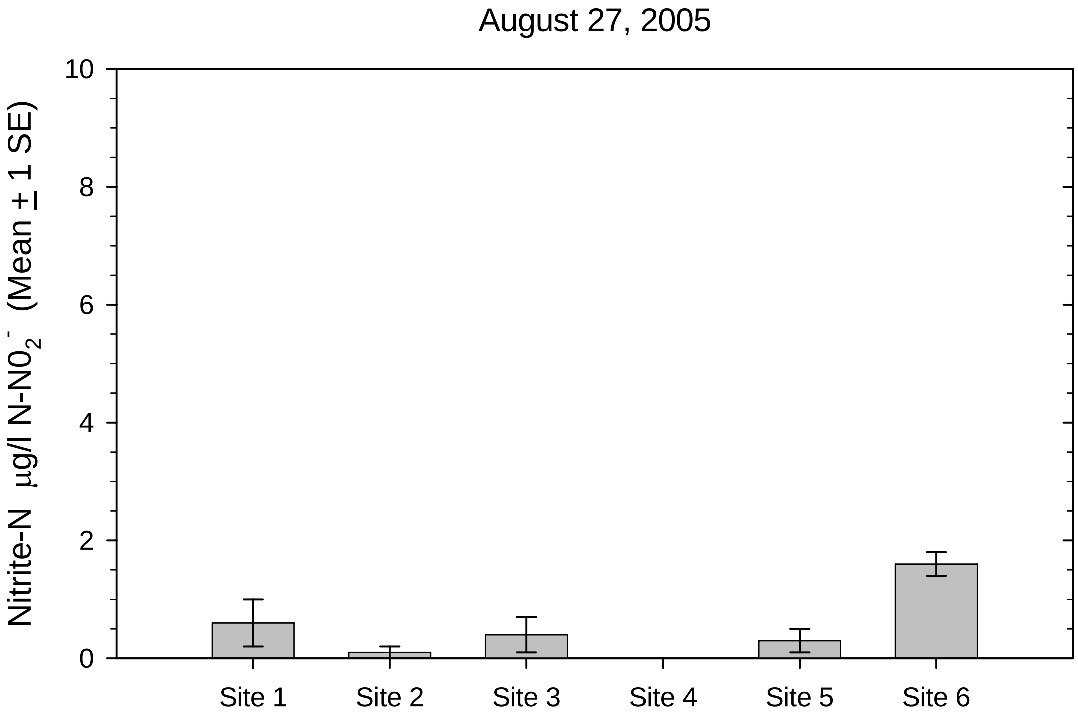


Figure E34. Nitrite-N (N-NO_2^- µg/l, mean ± 1 SE) for collection dates August 27 and September 10, 2005, for all collection sites on the Eightmile River West Branch.



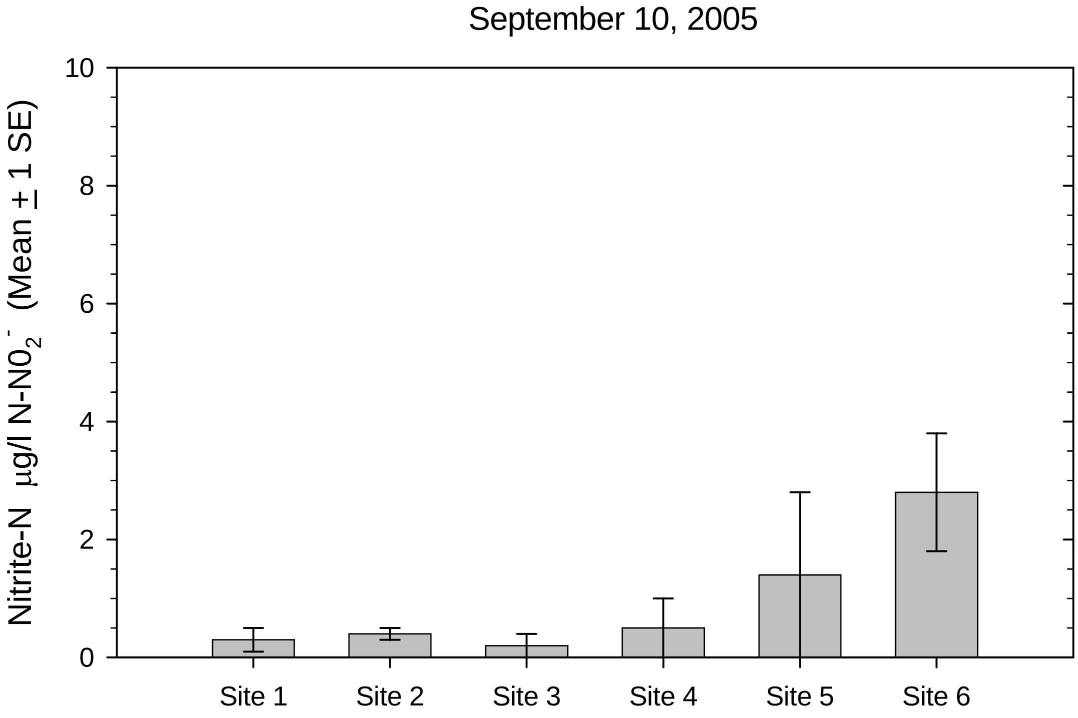
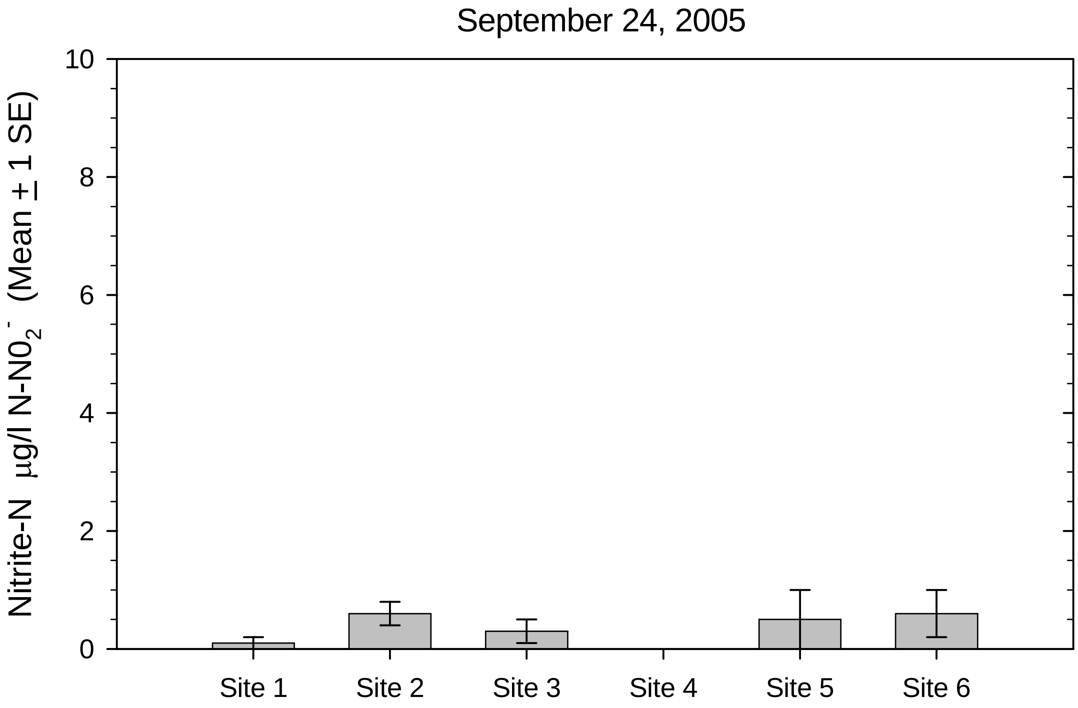


Figure E35. Nitrite-N (N-NO_2^- µg/l, mean ± 1 SE) for collection dates September 24 and October 7, 2005, for all collection sites on the Eightmile River West Branch.


September 24, 2005

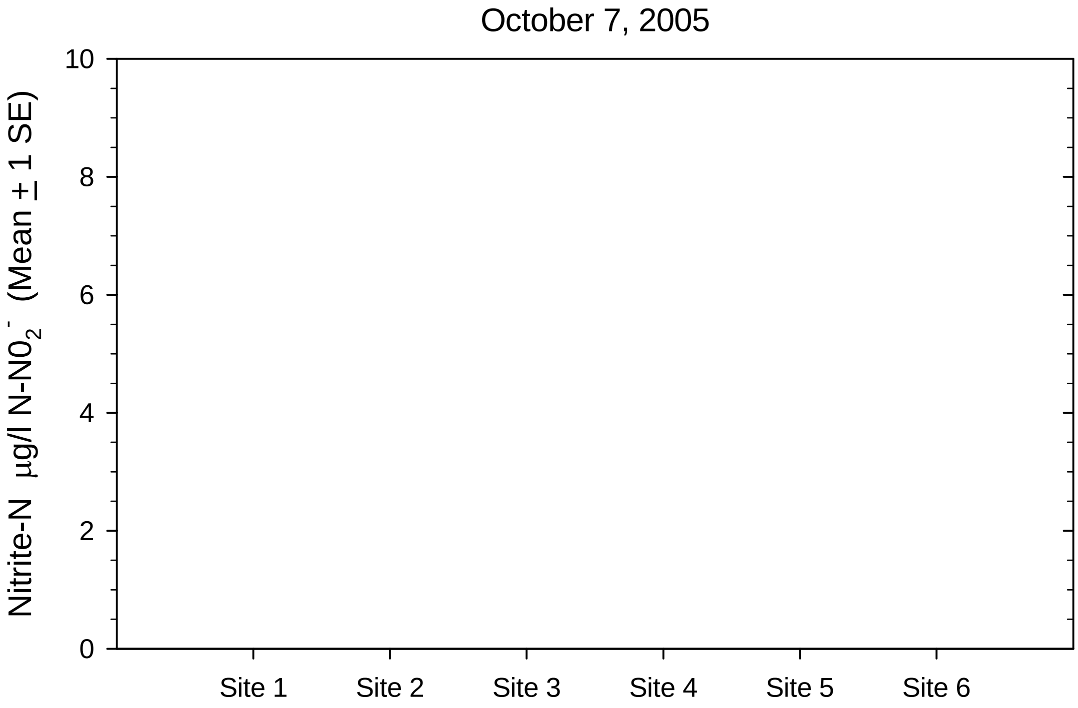

October 7, 2005

Figure E36. Nitrite-N ($N\text{-}NO_2^-$ µg/l, mean ± 1 SE) for collection date October 22, 2005, for all collection sites on the Eightmile River West Branch.

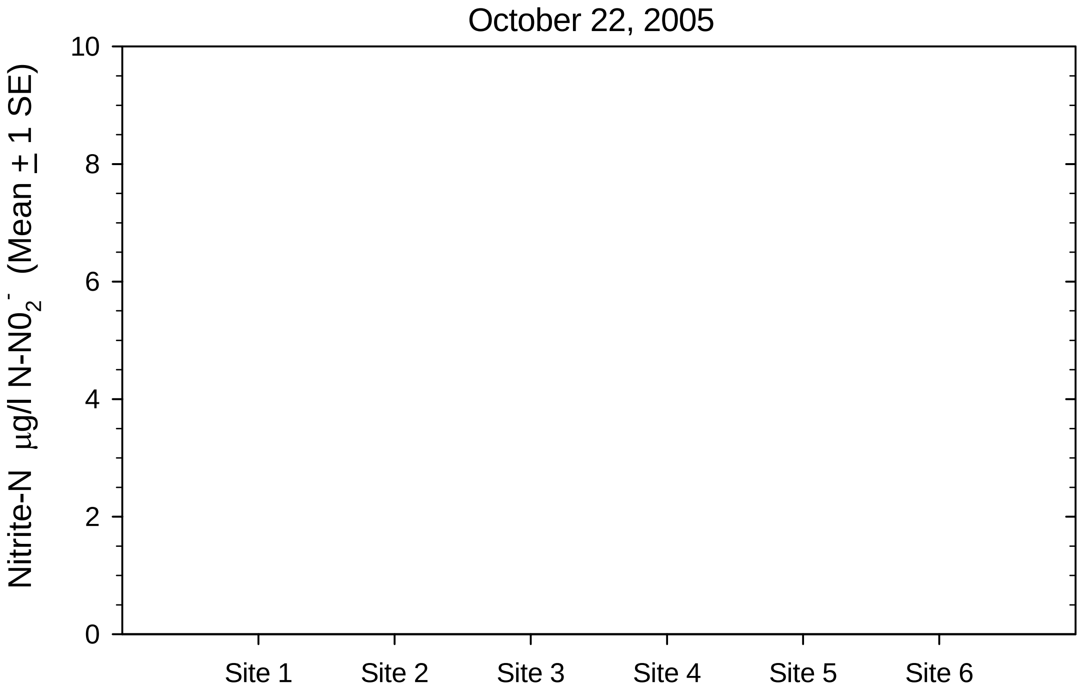
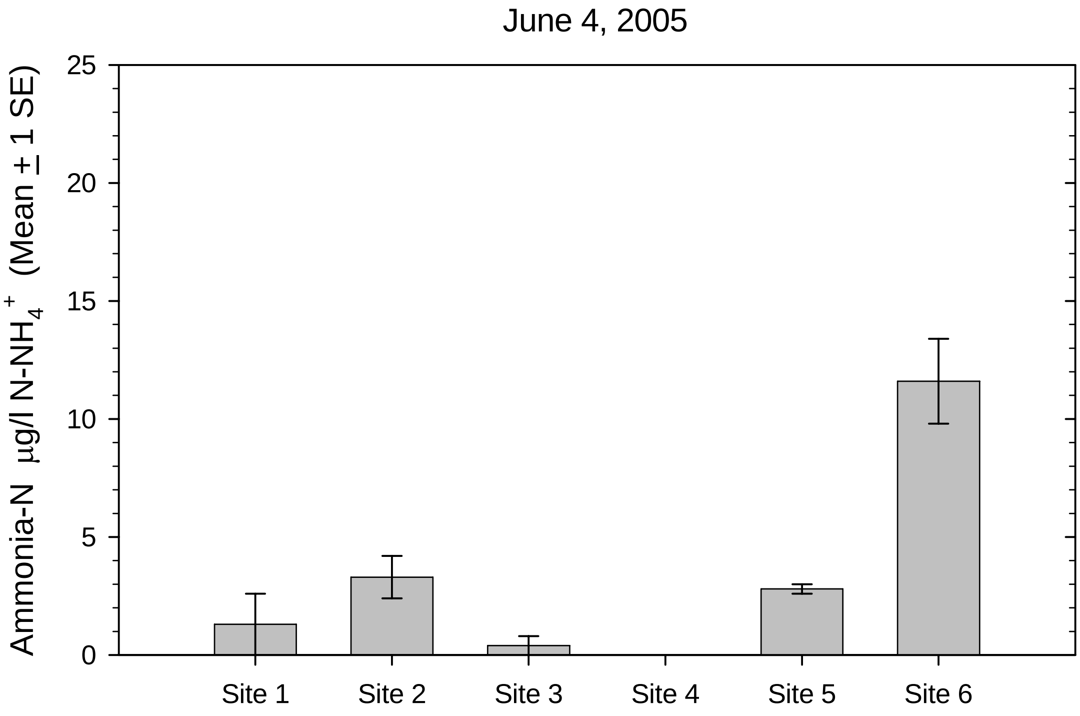


Figure E37. Ammonia-N (N-NH_4^+ µg/l, mean ± 1 SE) for collection dates June 4 and June 18, 2005, for all collection sites on the Eightmile River West Branch.



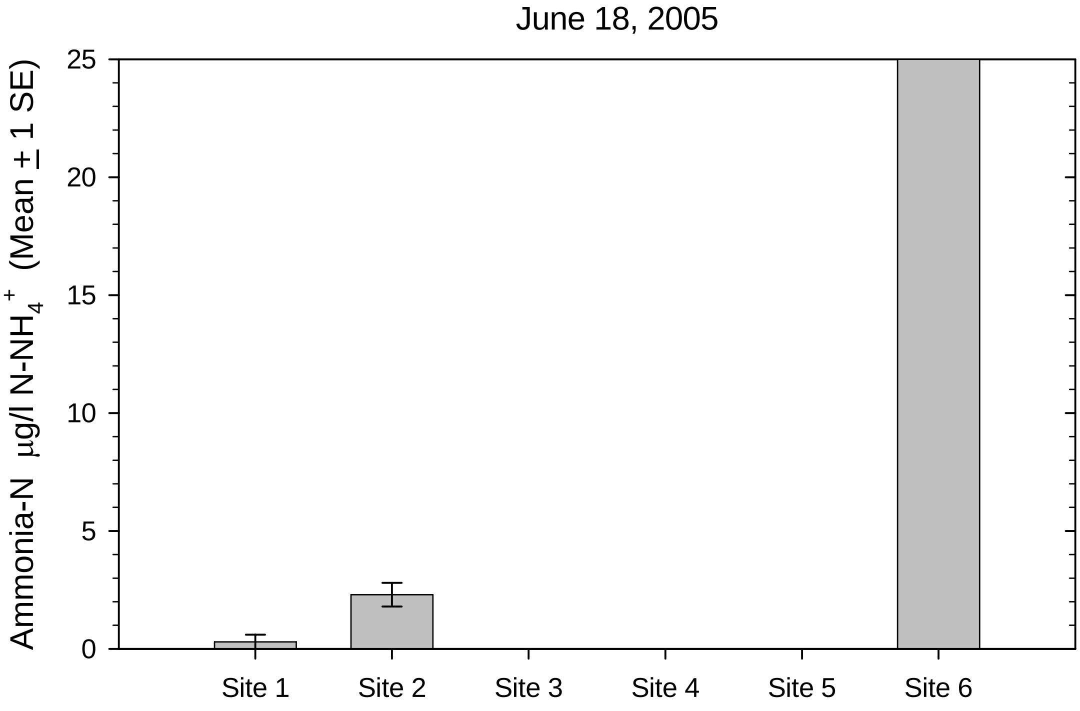
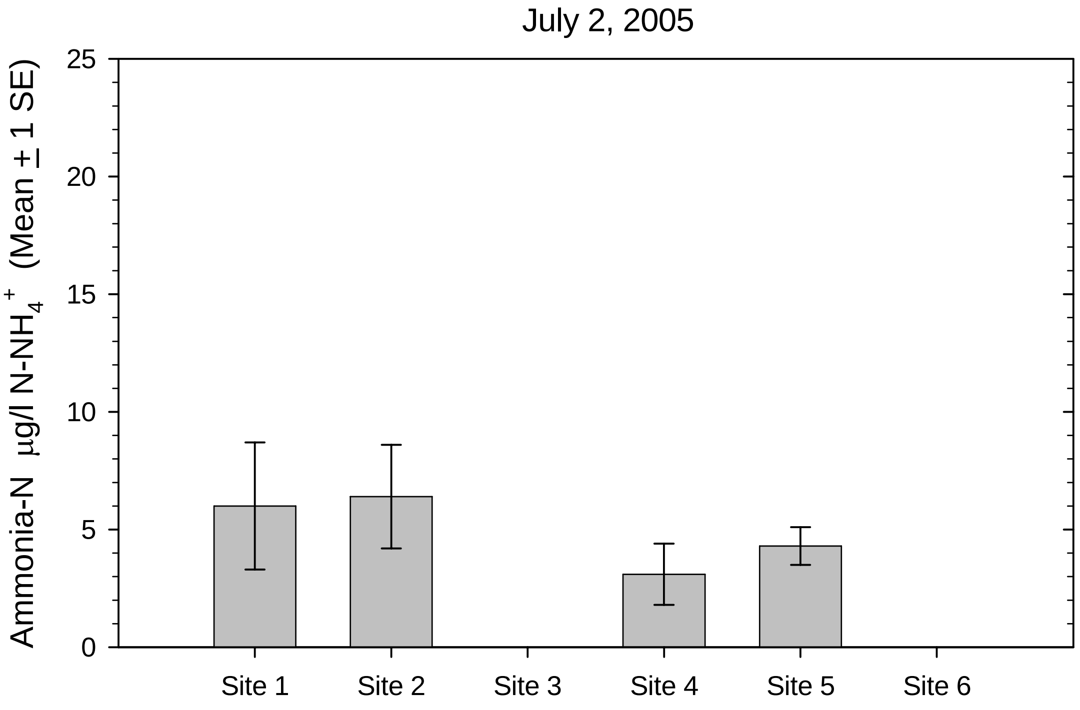


Figure E38. Ammonia-N (N-NH_4^+ µg/l, mean ± 1 SE) for collection dates July 2 and July 16, 2005, for all collection sites on the Eightmile River West Branch.



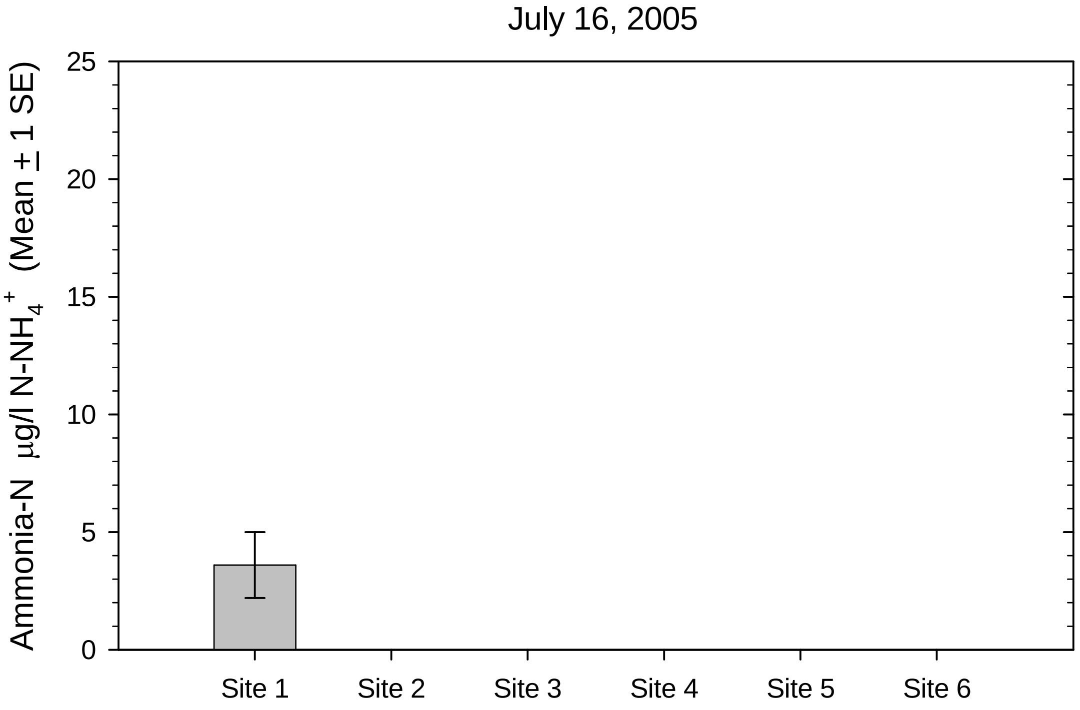
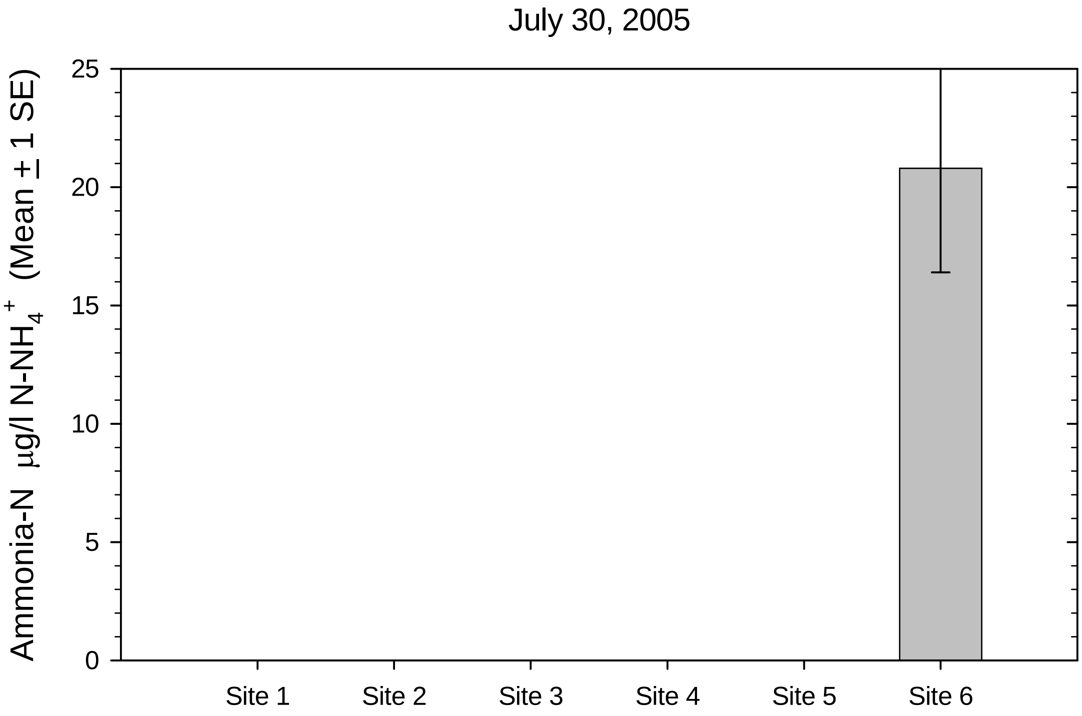


Figure E39. Ammonia-N (N-NH_4^+ μg/l, mean ± 1 SE) for collection dates July 30 and August 13, 2005, for all collection sites on the Eightmile River West Branch.



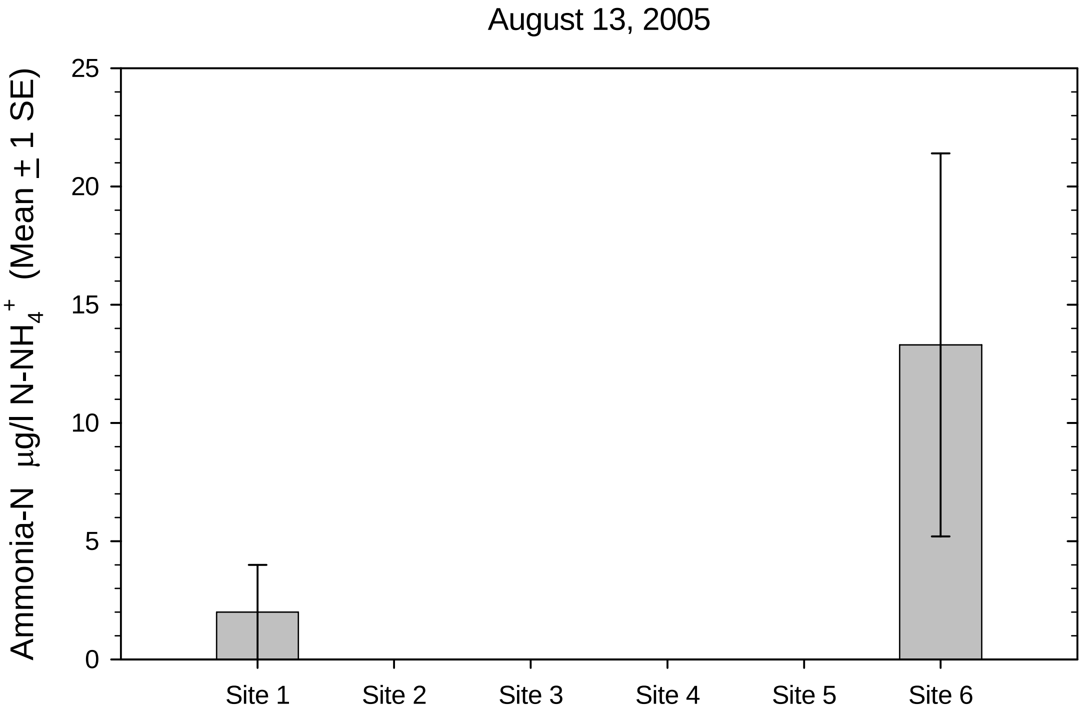
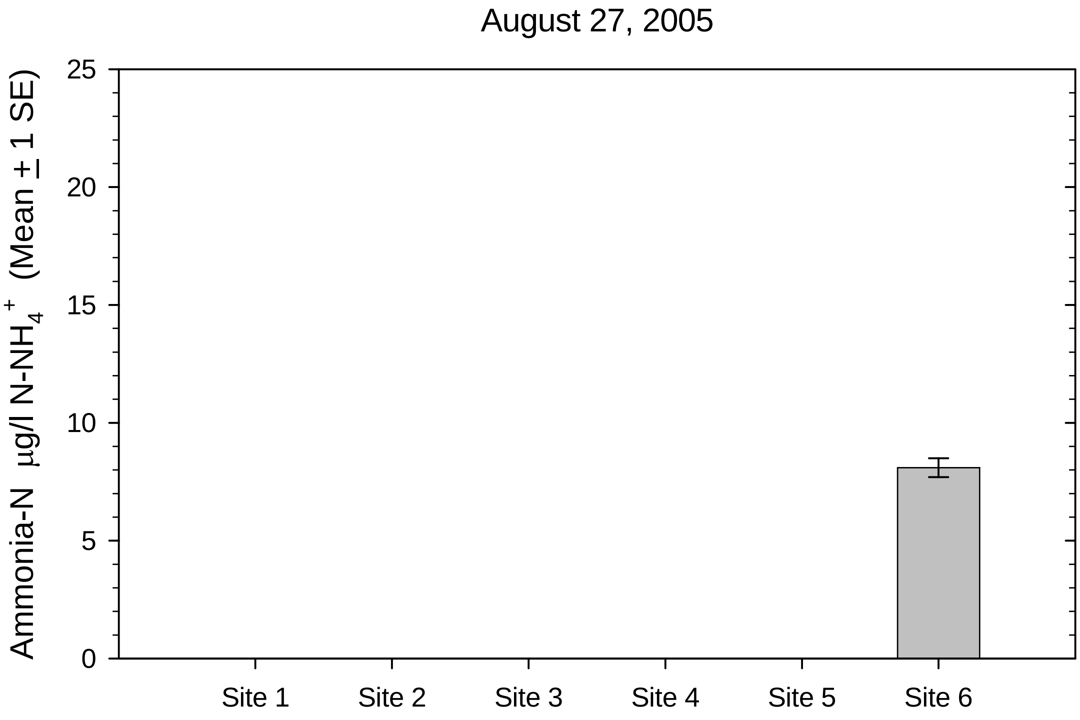


Figure E40. Ammonia-N (N-NH$_4^+$ μg/l, mean ± 1 SE) for collection dates August 27 and September 10, 2005, for all collection sites on the Eightmile River West Branch.



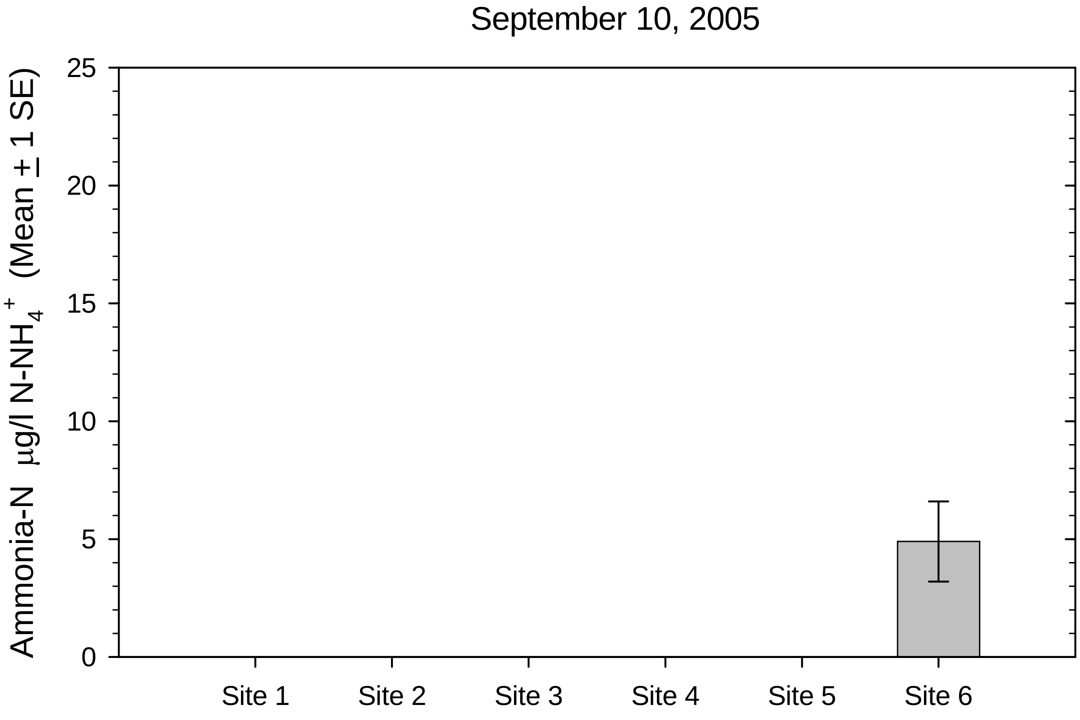
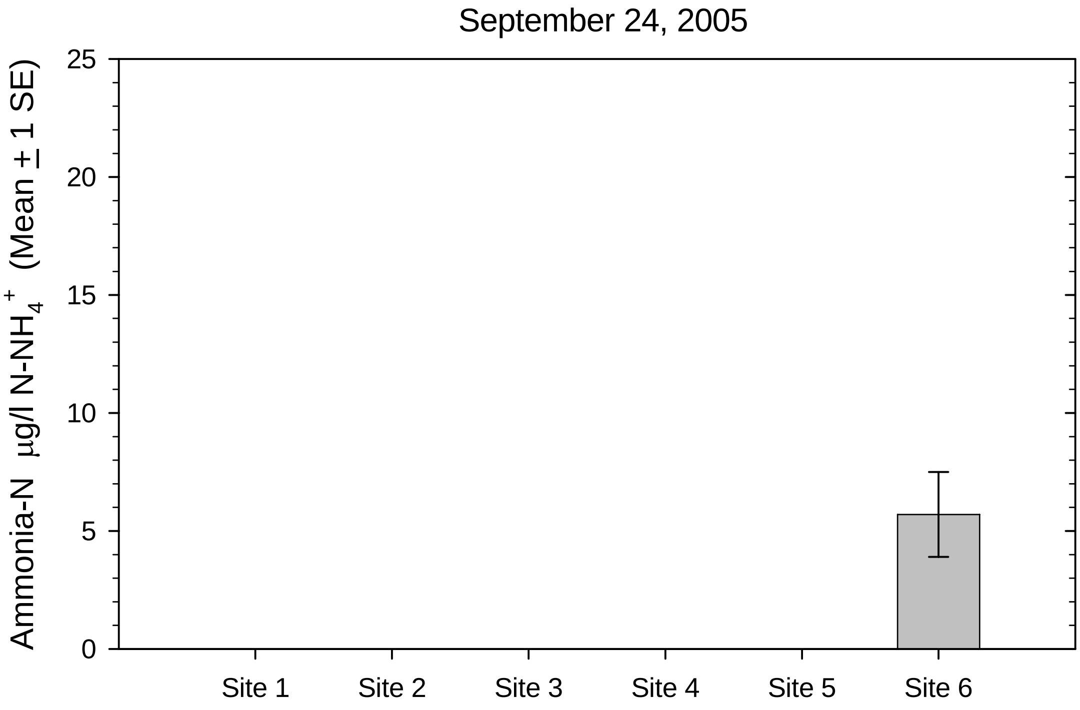


Figure E41. Ammonia-N (N-NH$_4^+$ μg/l, mean ± 1 SE) for collection dates September 24 and October 7, 2005, for all collection sites on the Eightmile River West Branch.



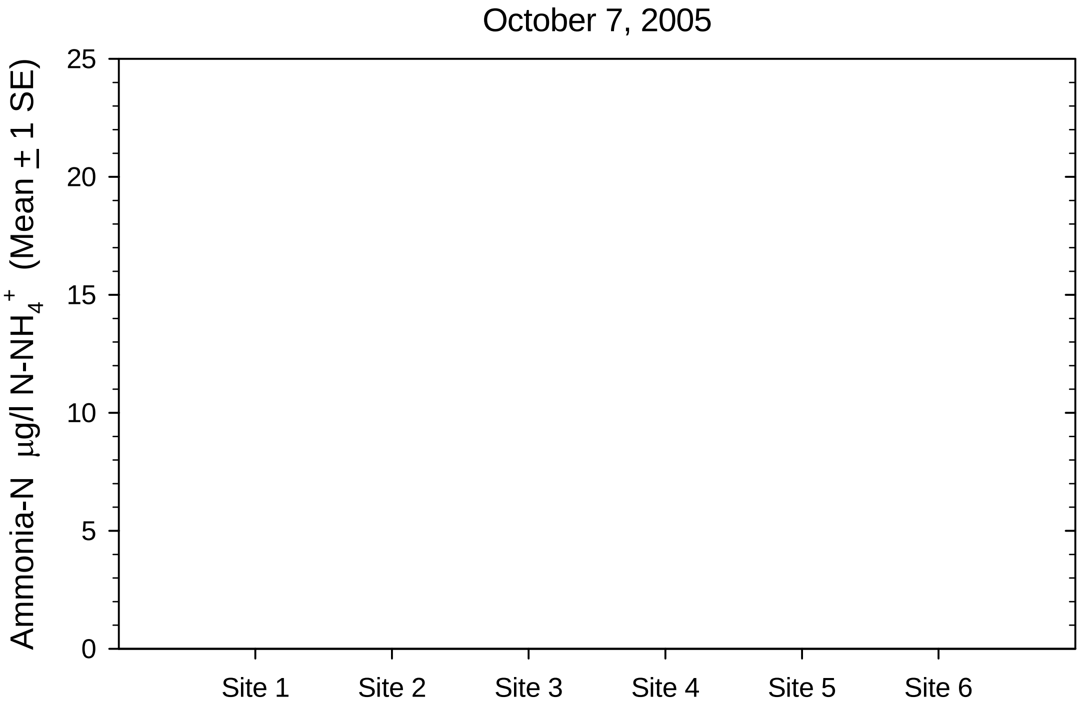
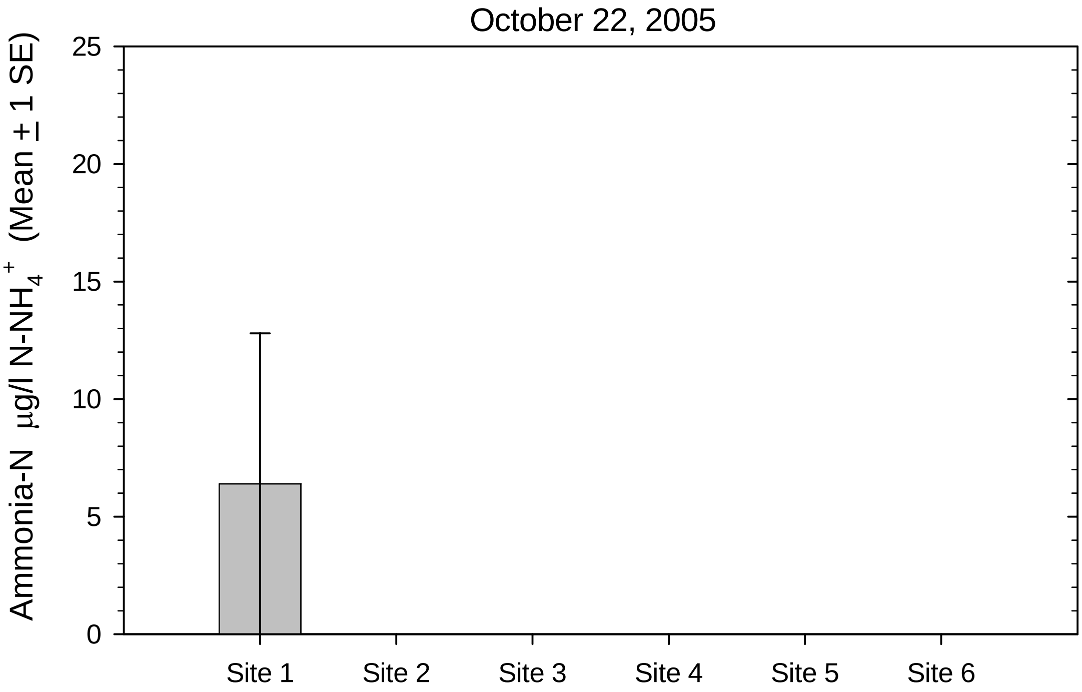
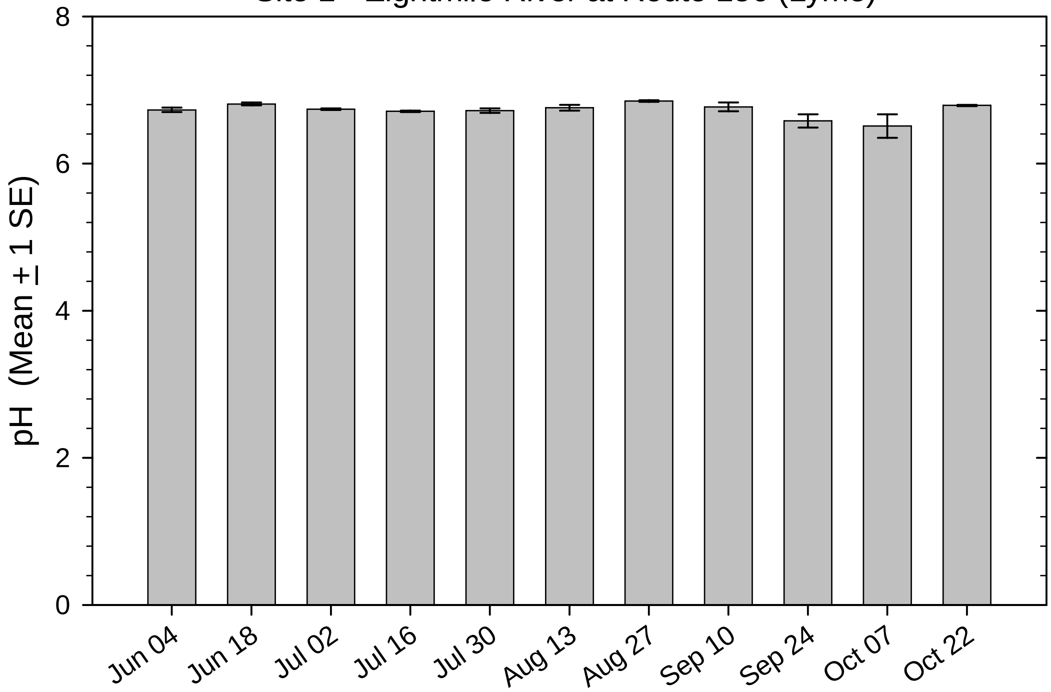


Figure E42. Ammonia-N (N-NH_4^+ μg/l, mean ± 1 SE) for collection date October 22, 2005, for all collection sites on the Eightmile River West Branch.



Appendix F

Figure F1. pH (mean ± 1 SE) at Site 1, Eightmile River at Route 156 (Lyme) and Site 2, West Branch of Eightmile River at Hopyard Road (East Haddam) for all collection dates.


Site 1 - Eightmile River at Route 156 (Lyme)

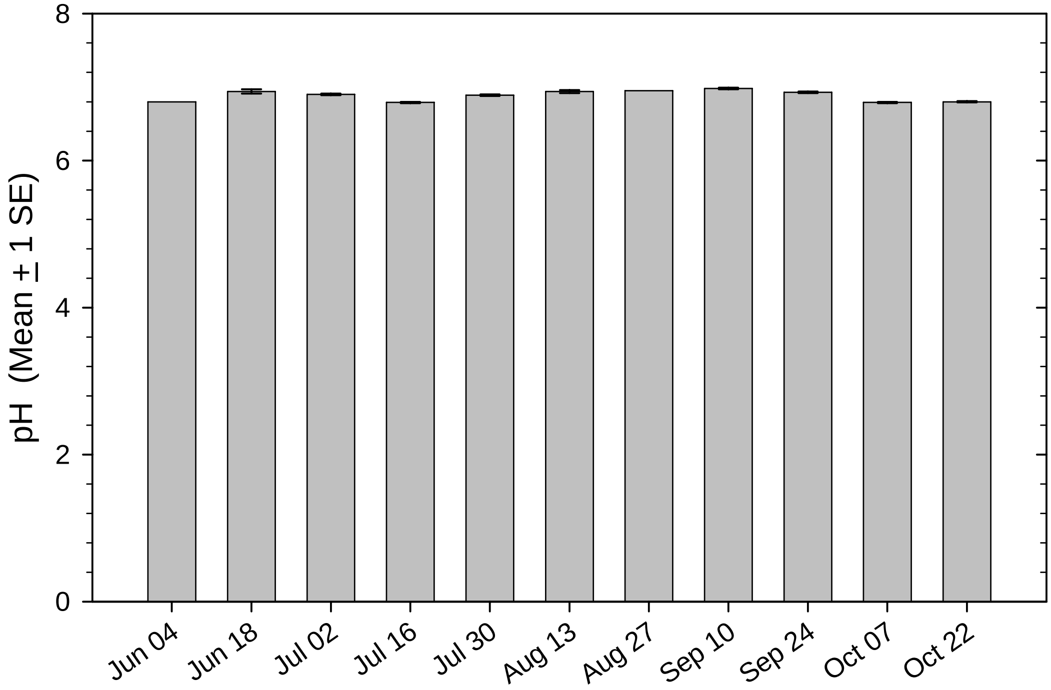
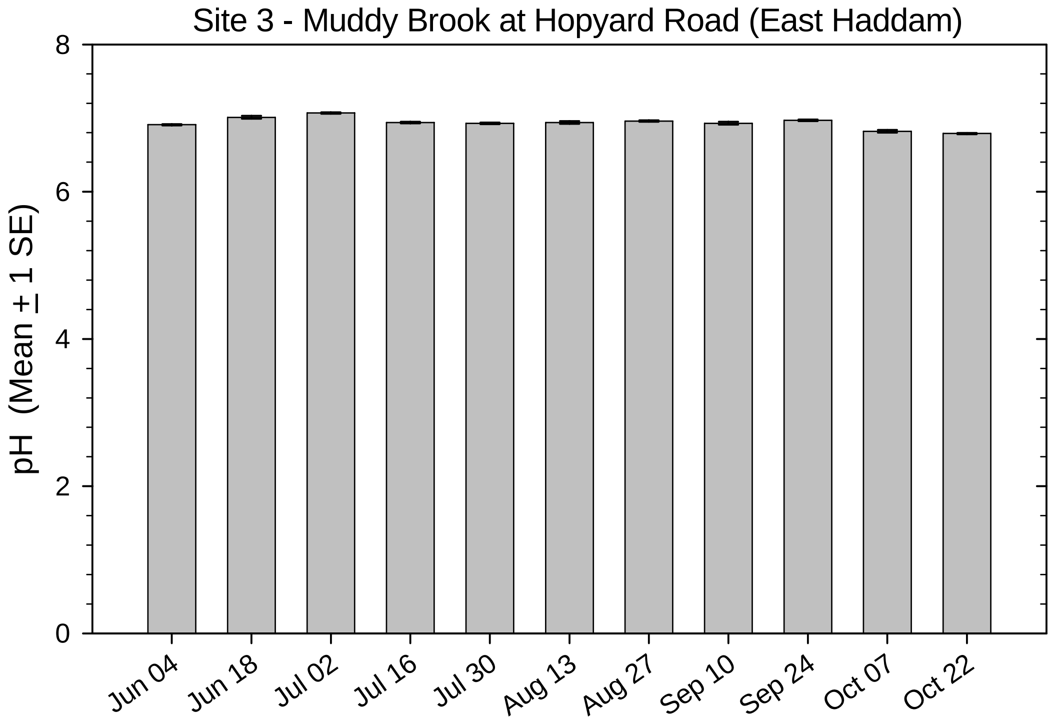

Site 2 - West Branch of Eightmile River at Hopyard Road (East Haddam)

Figure F2. pH (mean ± 1 SE) at Site 3, Muddy Brook at Hopyard Road (East Haddam) and Site 4, West Branch of Eightmile River at Haywardville Road (East Haddam) for all collection dates.



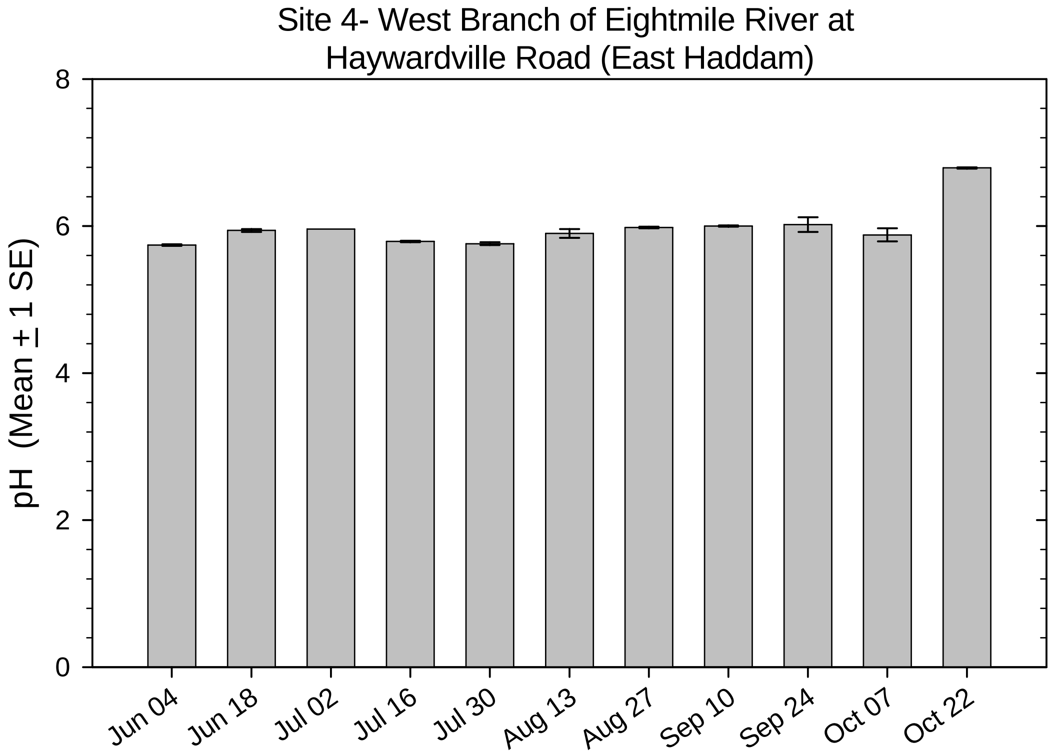
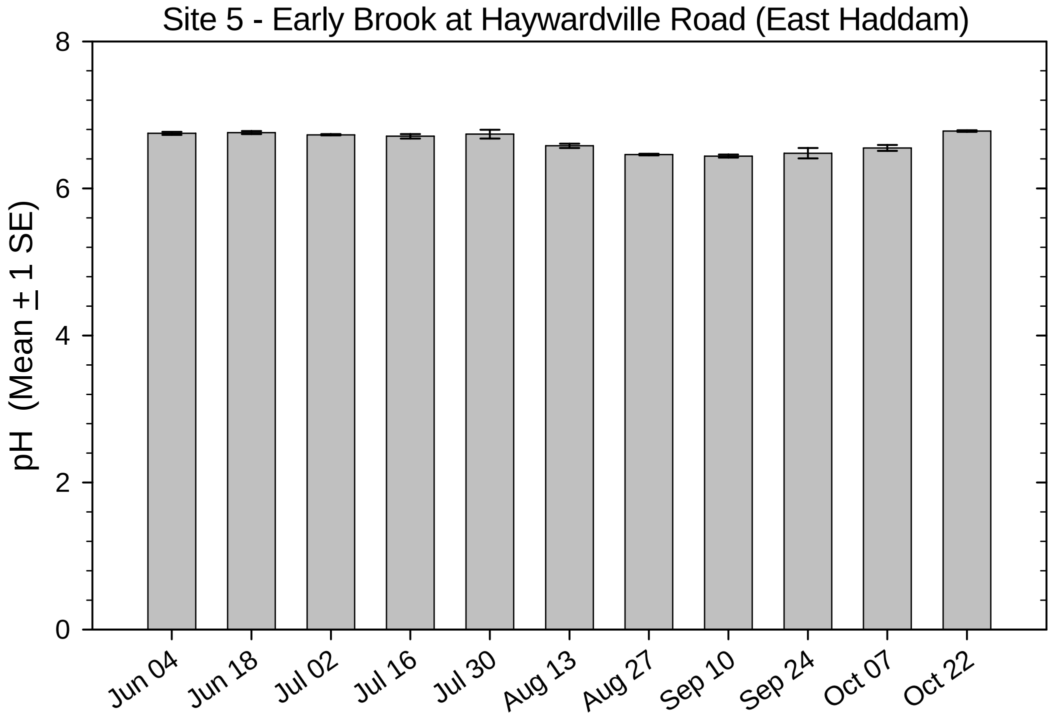


Figure F3. pH (mean ± 1 SE) at Site 5, Early Brook at Haywardville Road (East Haddam) and Site 6, Lake Hayward Brook at Mill Lane for all collection dates.



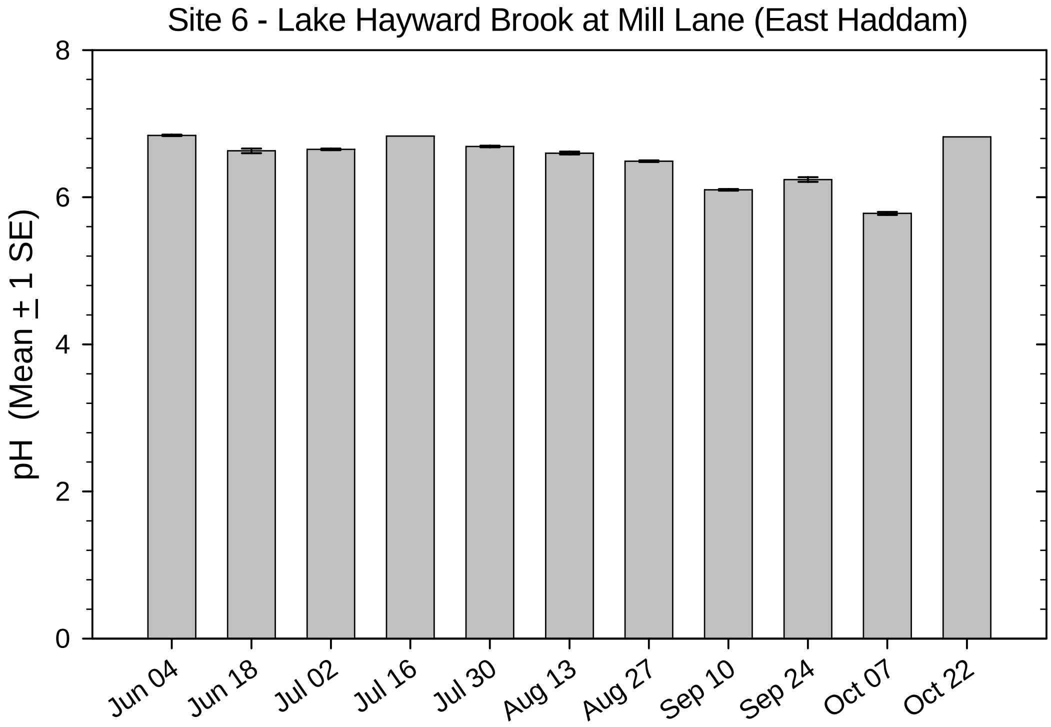
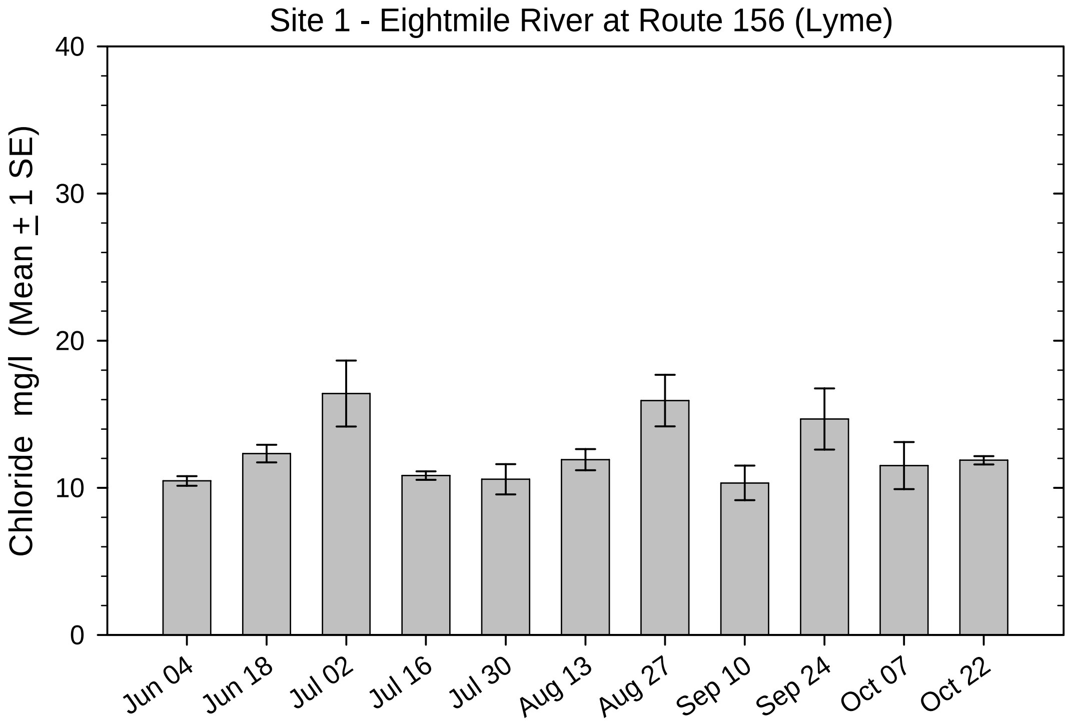


Figure F4. Chloride (mg/l, mean ± 1 SE) at Site 1, Eightmile River at Route 156 (Lyme) and Site 2, West Branch of Eightmile River at Hopyard Road (East Haddam) for all collection dates.



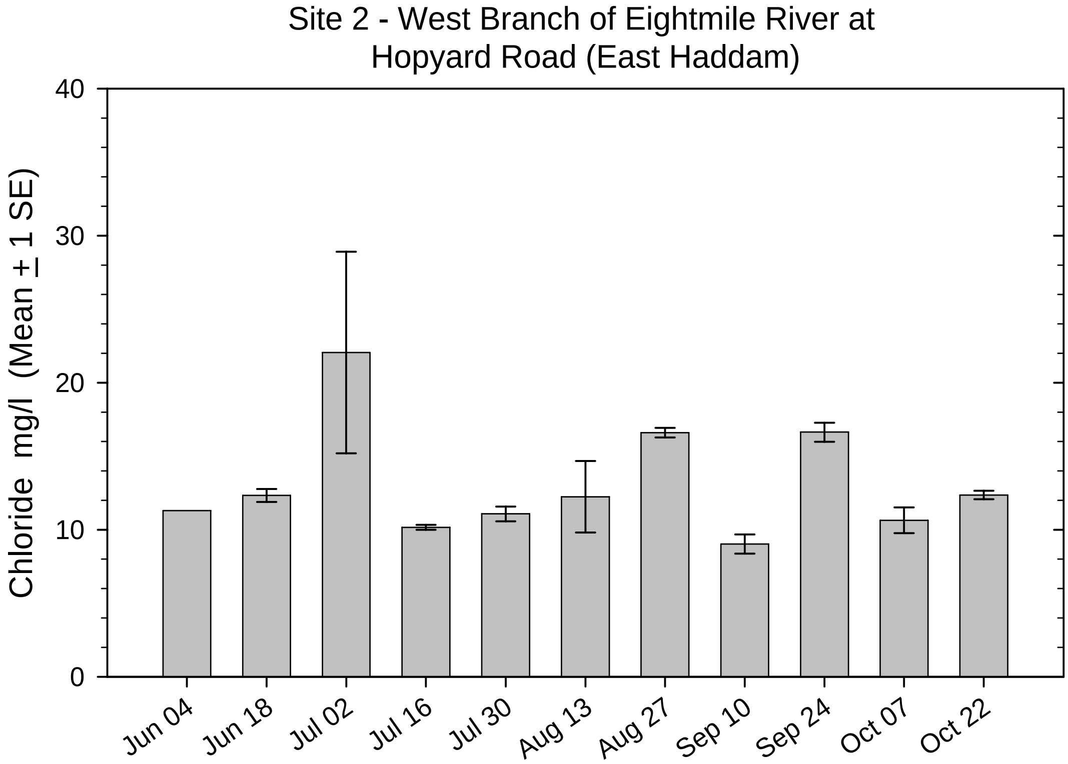
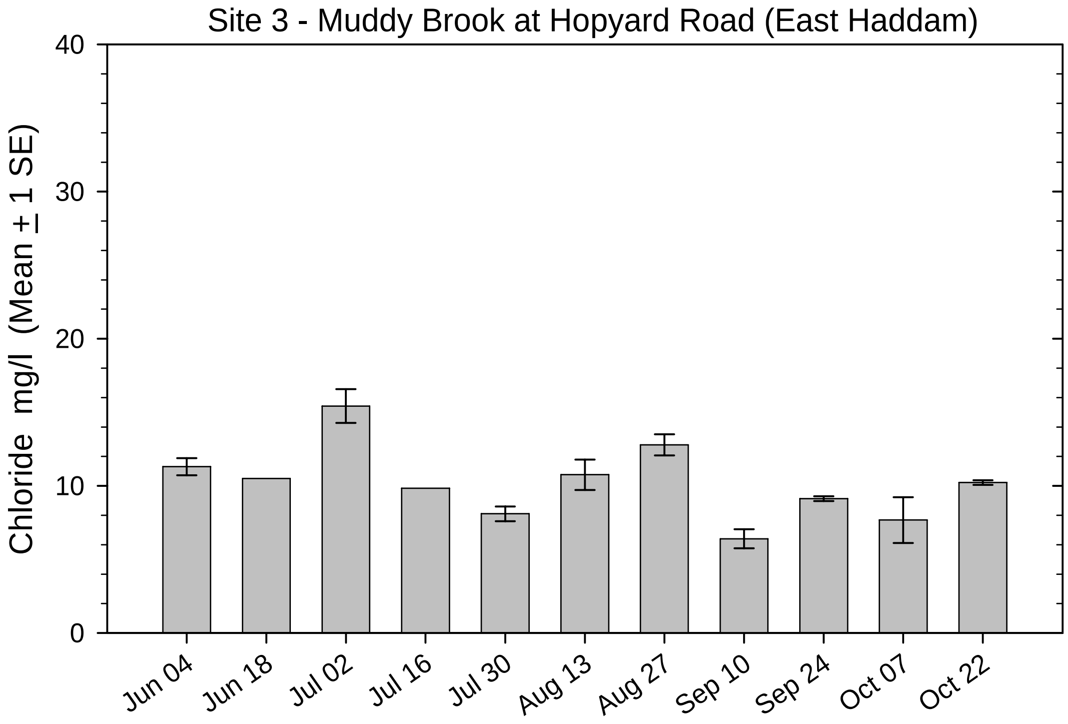


Figure F5. Chloride (mg/l, mean ± 1 SE) at Site 3, Muddy Brook at Hopyard Road (East Haddam) and Site 4, West Branch of Eightmile River at Haywardville Road (East Haddam) for all collection dates.



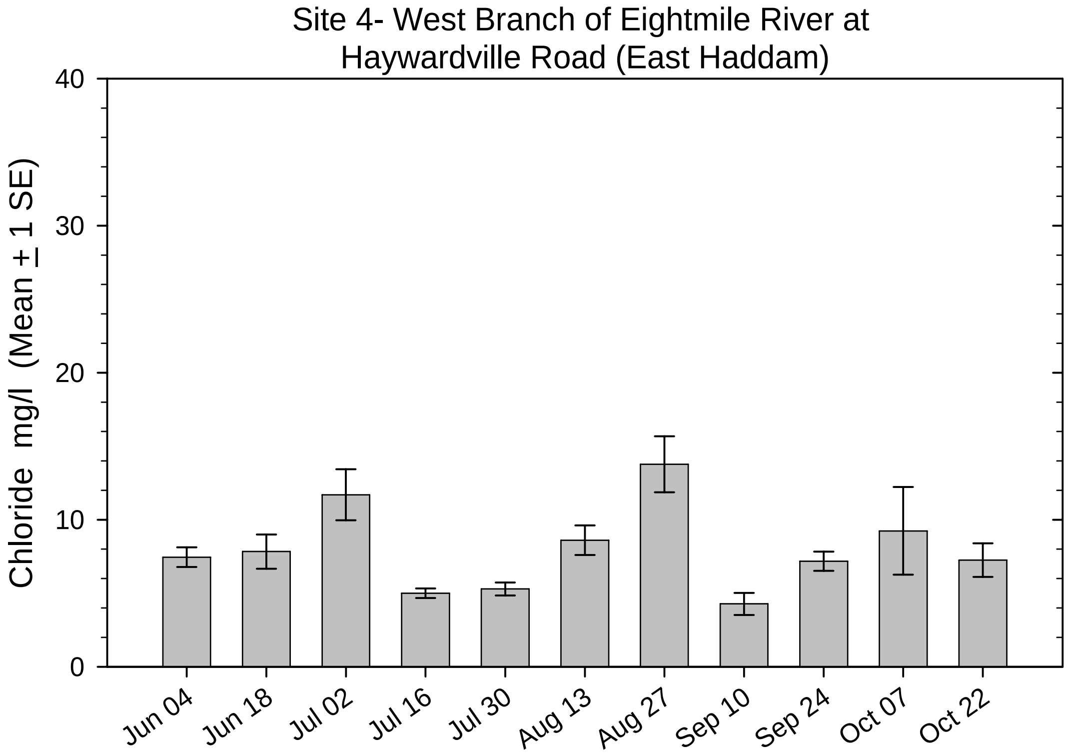
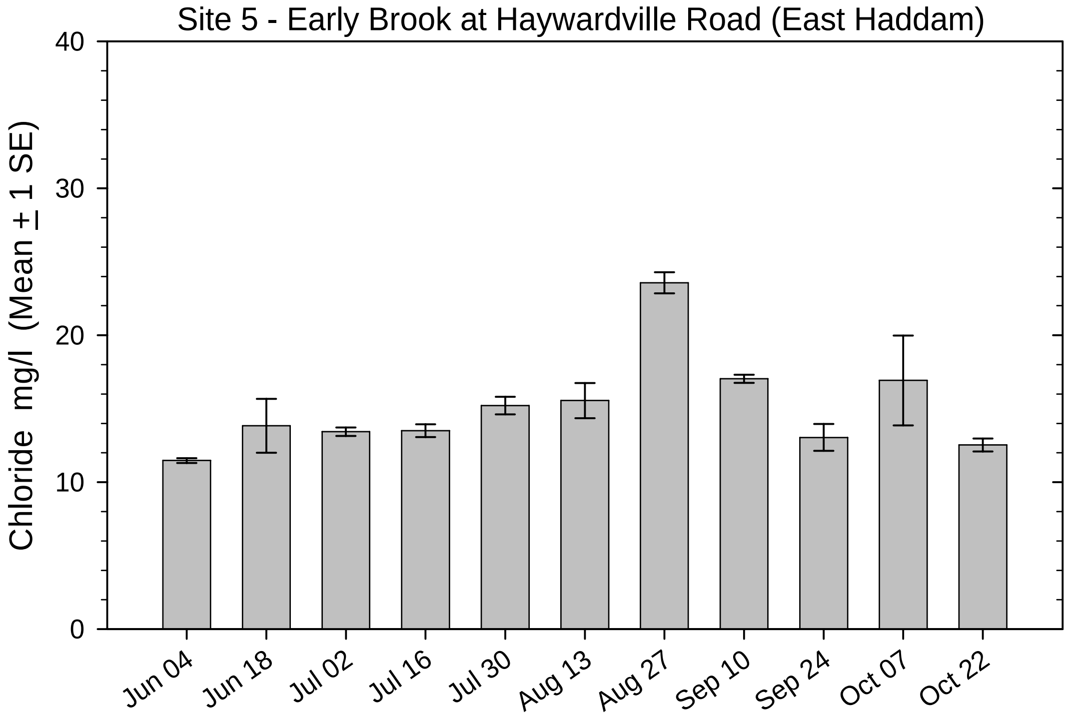


Figure F6. Chloride (mg/l, mean ± 1 SE) at Site 5, Early Brook at Haywardville Road (East Haddam) and Site 6, Lake Hayward Brook at Mill Lane for all collection dates.



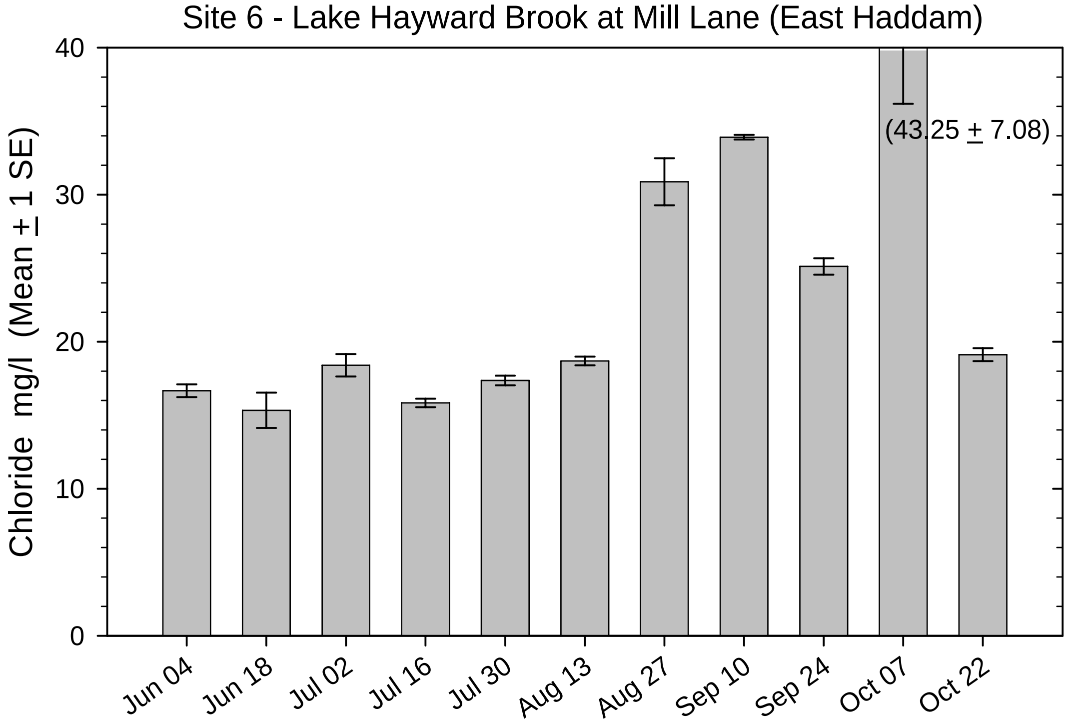
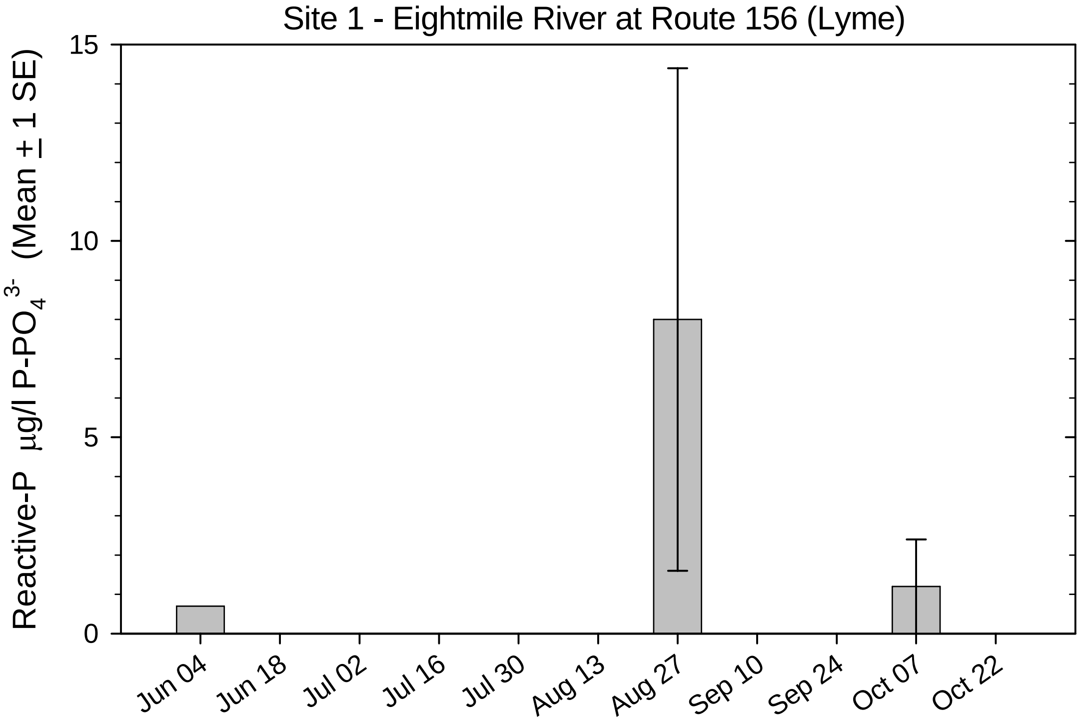


Figure F7. Reactive phosphate (P-PO_4^{3-} µg/l, mean ± 1 SE) at Site 1, Eightmile River at Route 156 (Lyme) and Site 2, West Branch of Eightmile River at Hopyard Road (East Haddam) for all collection dates.



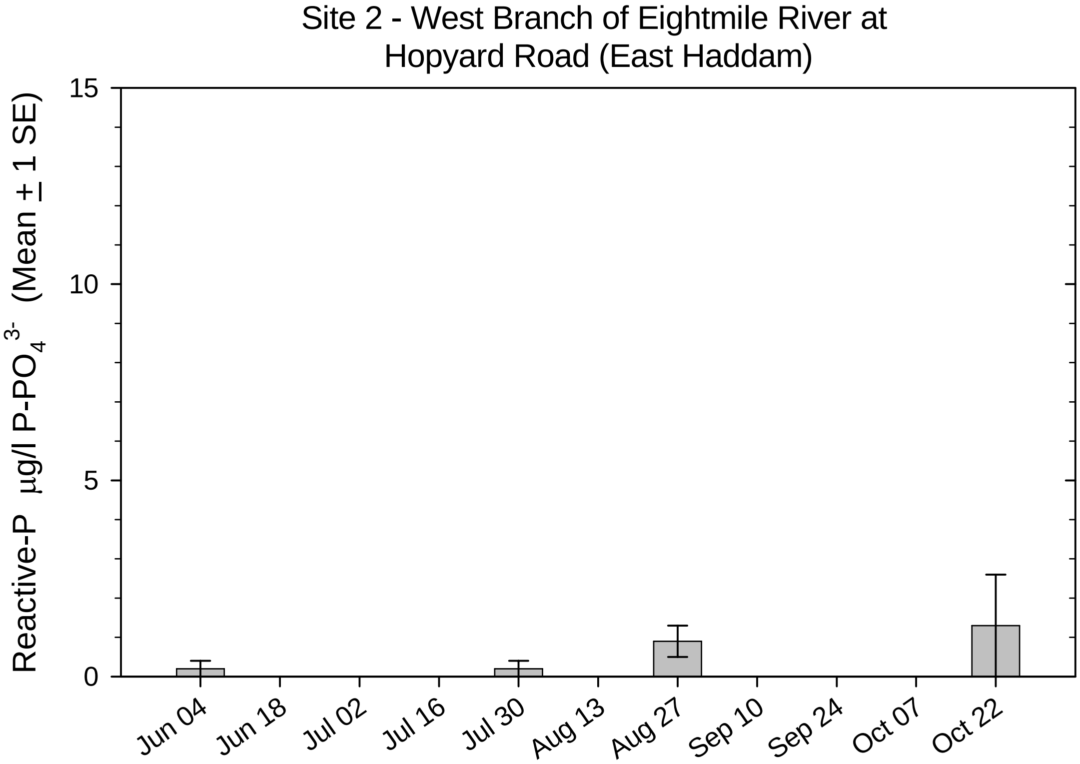
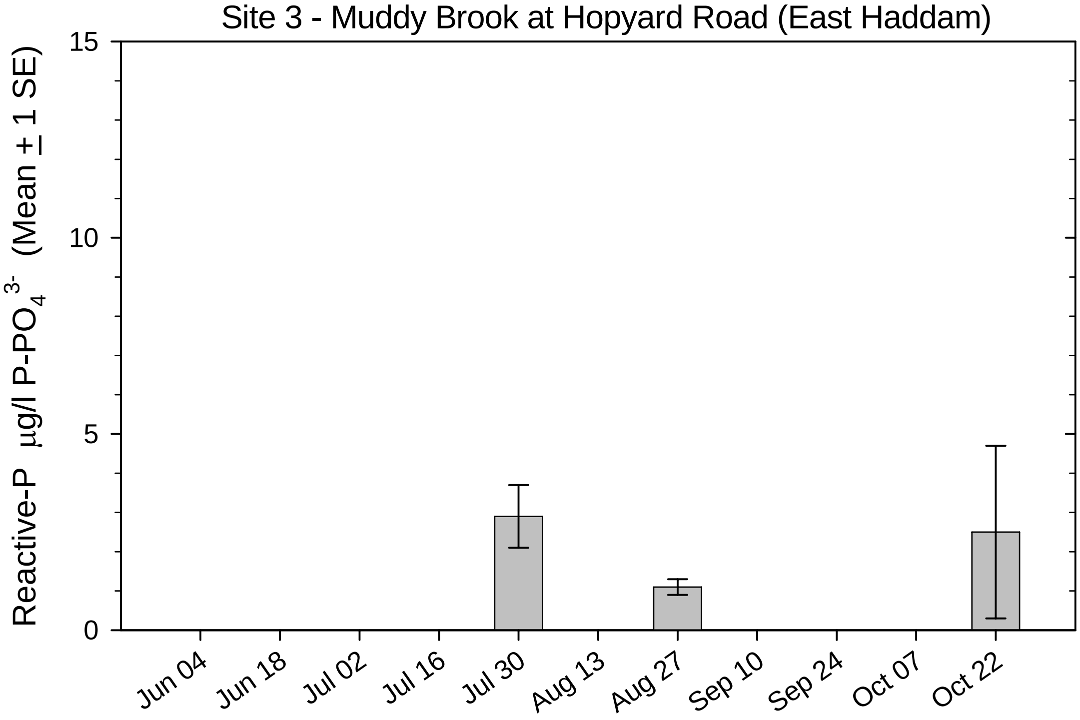


Figure F8. Reactive phosphate (P-PO_4^{3-} µg/l, mean ± 1 SE) at Site 3, Muddy Brook at Hopyard Road (East Haddam) and Site 4, West Branch of Eightmile River at Haywardville Road (East Haddam) for all collection dates.



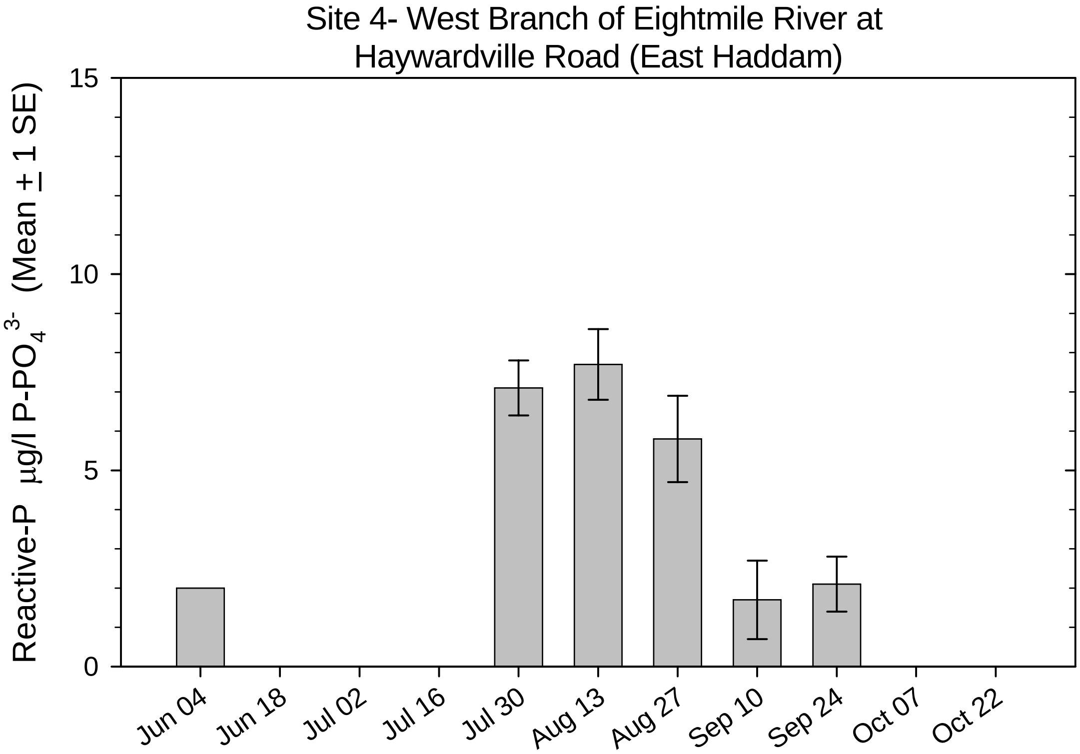
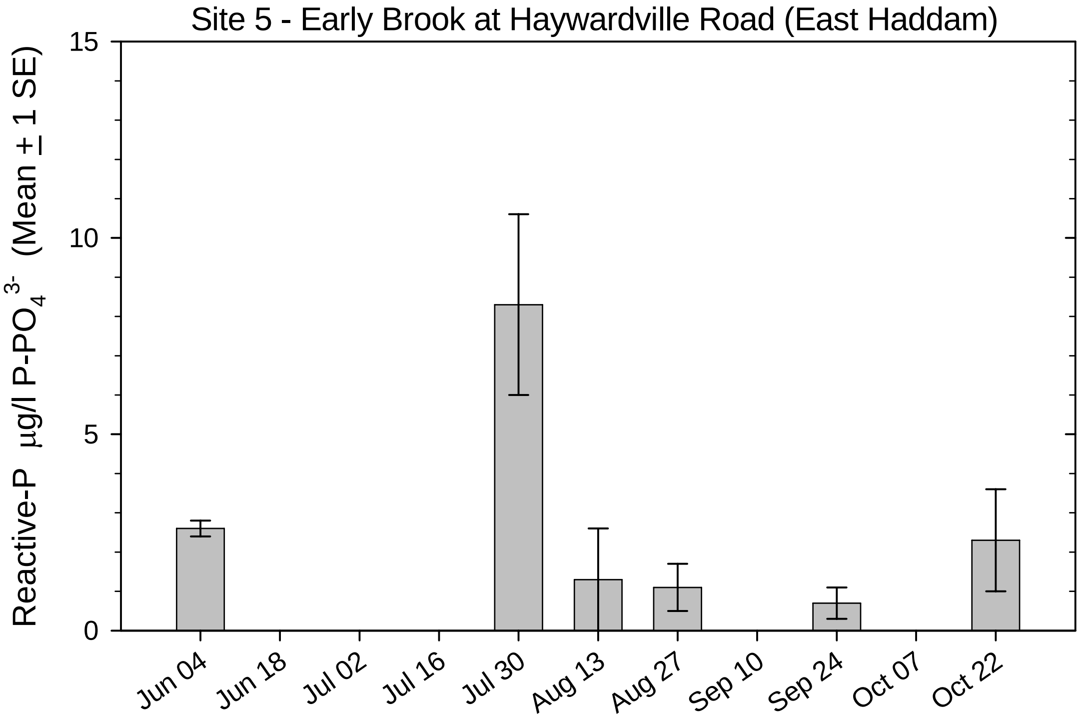


Figure F9. Reactive phosphate (P-PO_4^{3-} µg/l, mean ± 1 SE) at Site 5, Early Brook at Haywardville Road (East Haddam) and Site 6, Lake Hayward Brook at Mill Lane for all collection dates.



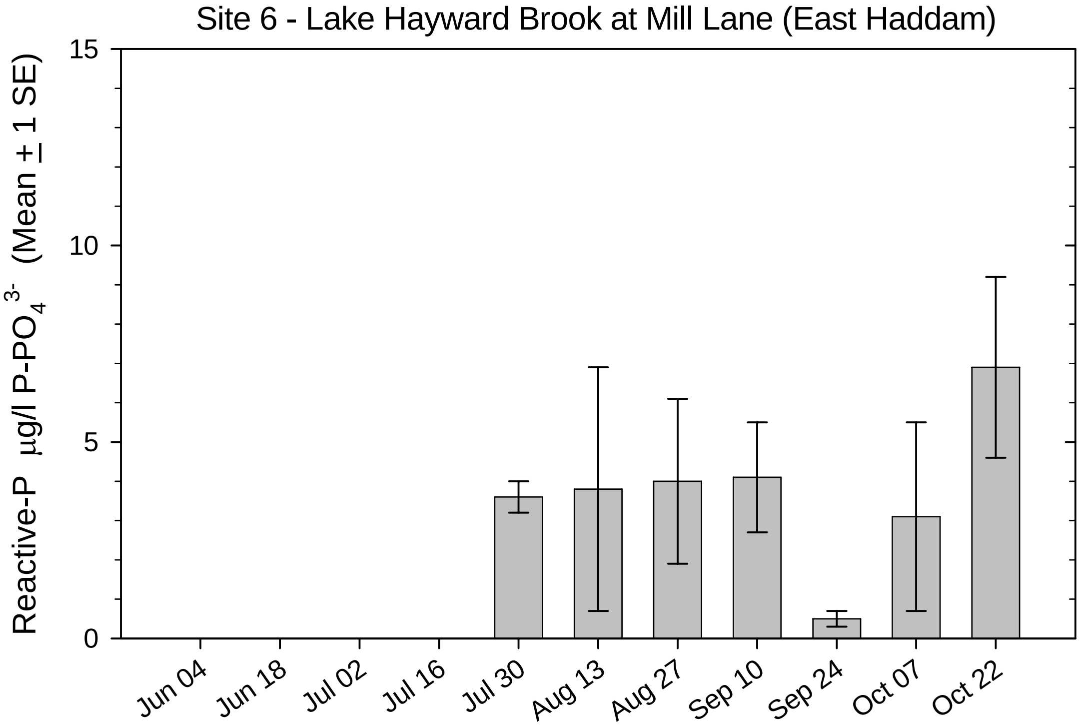
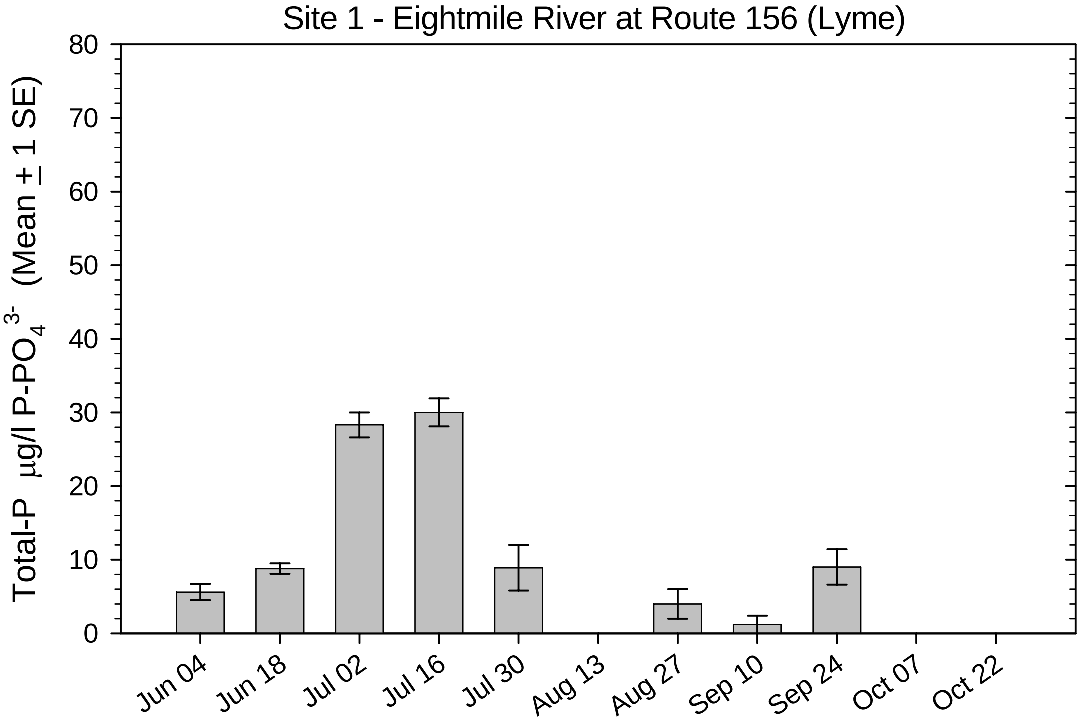


Figure F10. Total phosphate ($P\text{-}PO_4^{3-}$ µg/l, mean ± 1 SE) at Site 1, Eightmile River at Route 156 (Lyme) and Site 2, West Branch of Eightmile River at Hopyard Road (East Haddam) for all collection dates.



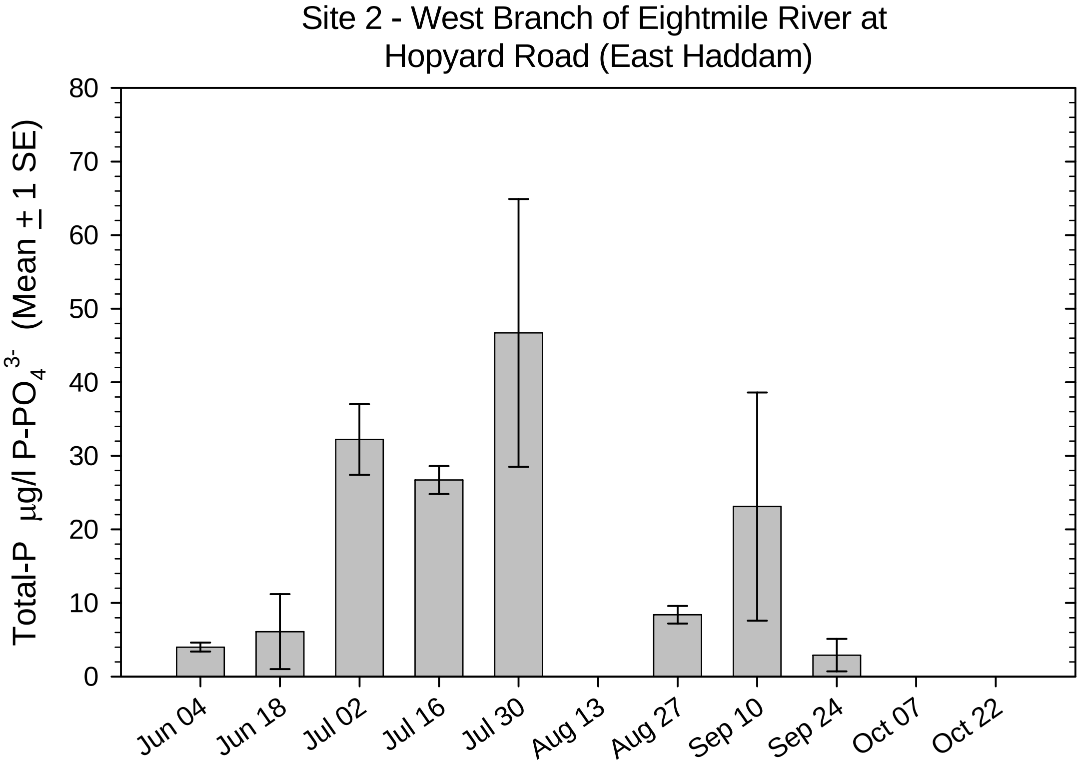
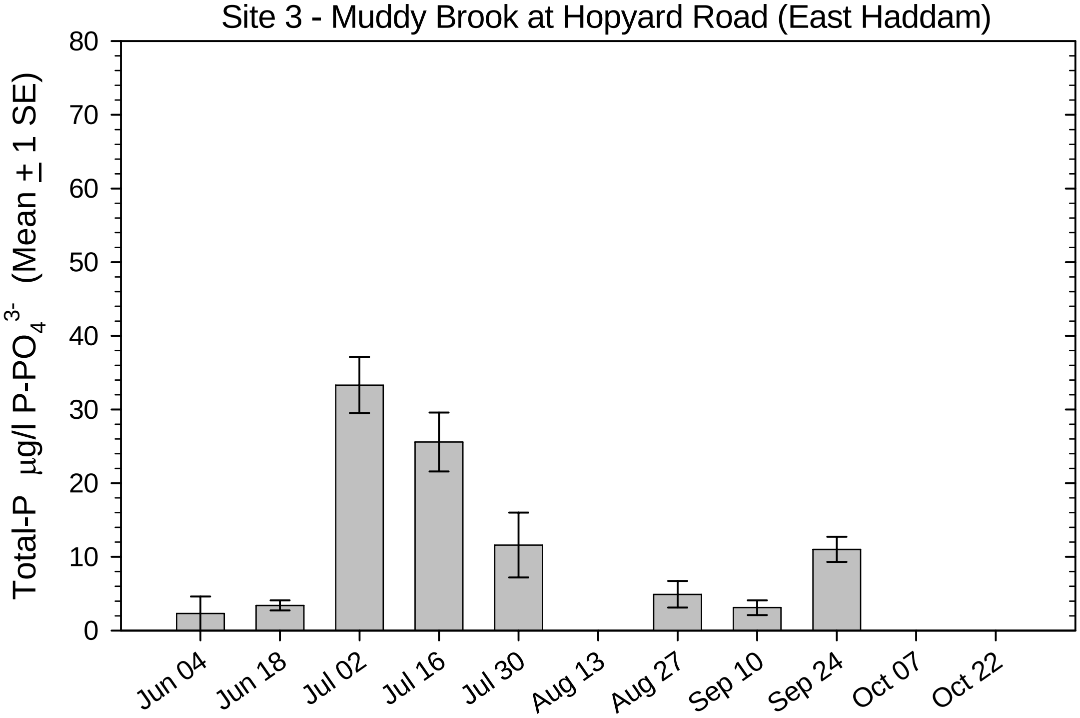


Figure F11. Total phosphate (P-PO_4^{3-} µg/l, mean ± 1 SE) at Site 3, Muddy Brook at Hopyard Road (East Haddam) and Site 4, West Branch of Eightmile River at Haywardville Road (East Haddam) for all collection dates.



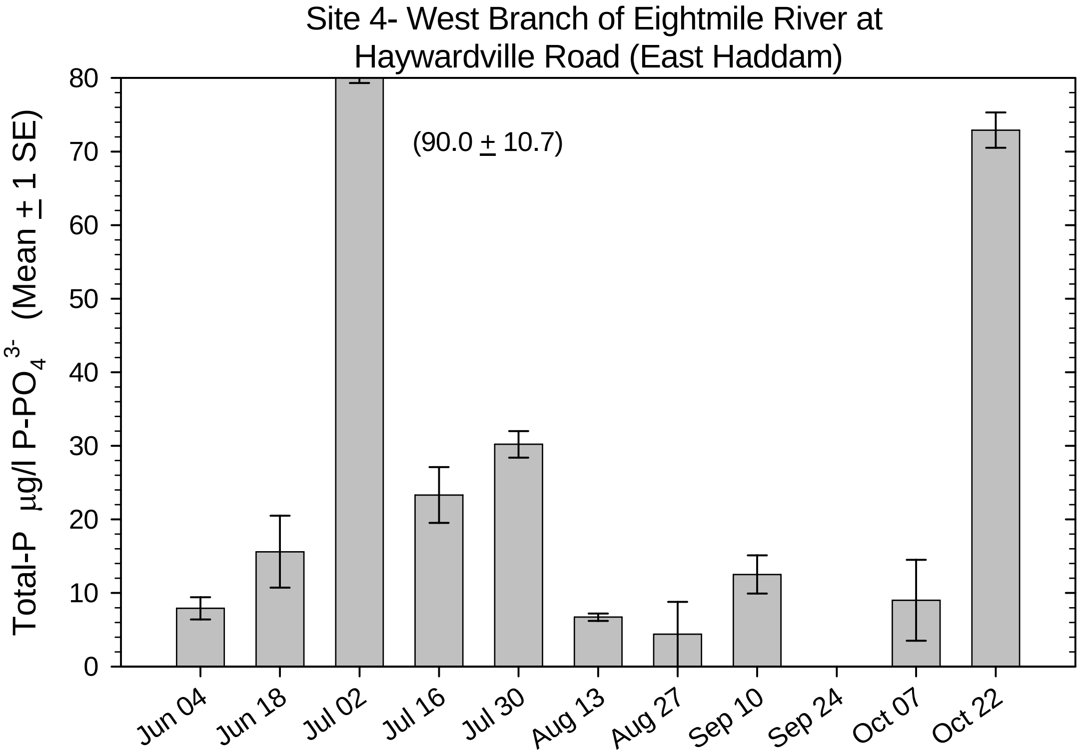
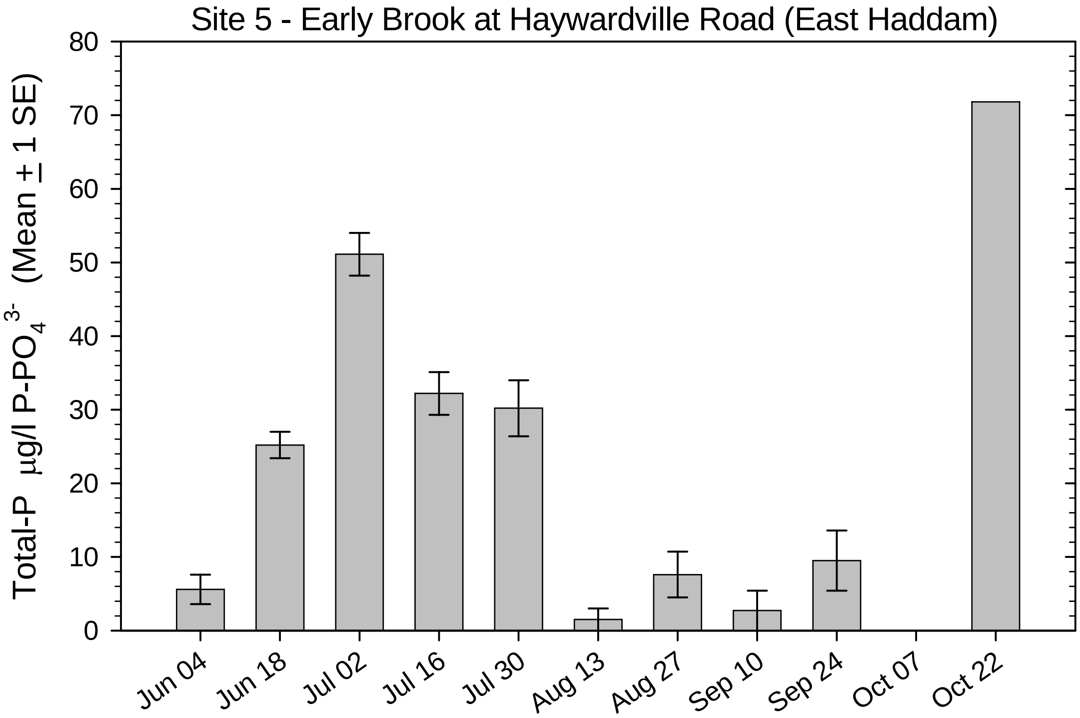


Figure F12. Total phosphate (P-PO_4^{3-} µg/l, mean ± 1 SE) at Site 5, Early Brook at Haywardville Road (East Haddam) and Site 6, Lake Hayward Brook at Mill Lane for all collection dates.



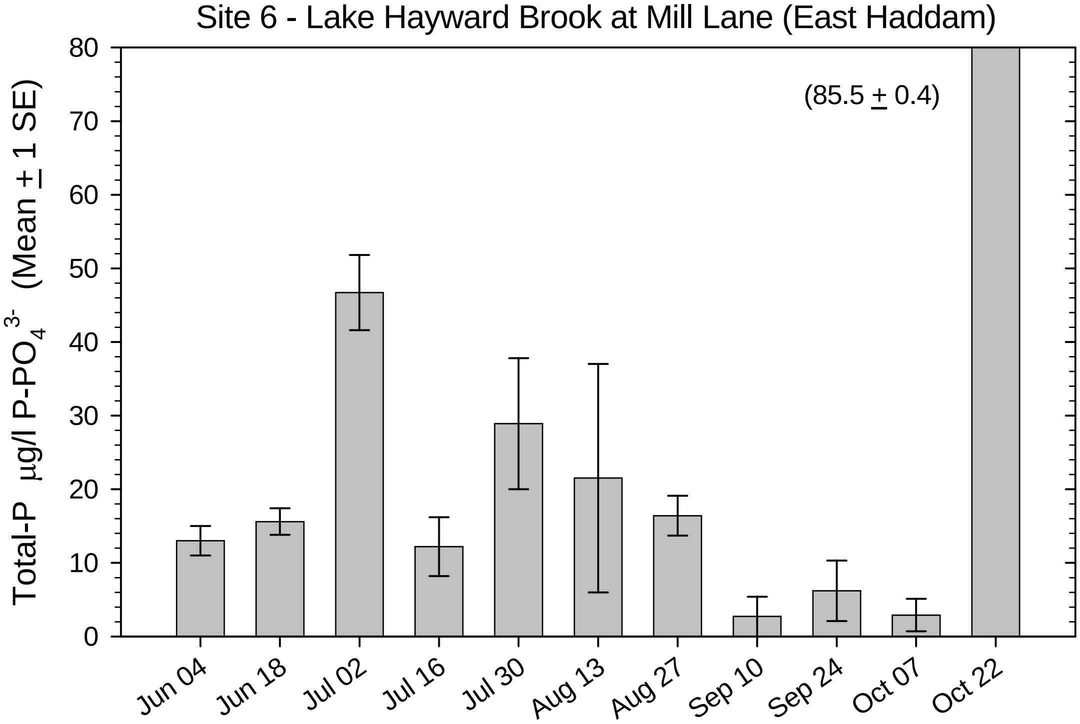
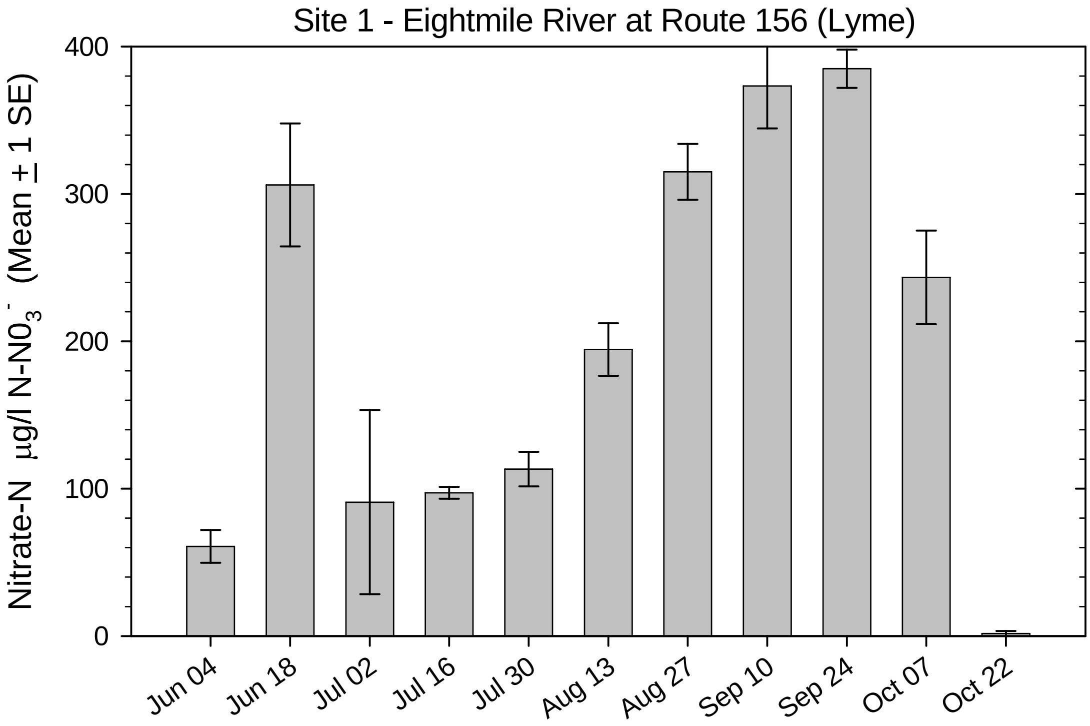


Figure F13. Nitrate-N (N-NO_3^- µg/l, mean ± 1 SE) at Site 1, Eightmile River at Route 156 (Lyme) and Site 2, West Branch of Eightmile River at Hopyard Road (East Haddam) for all collection dates.



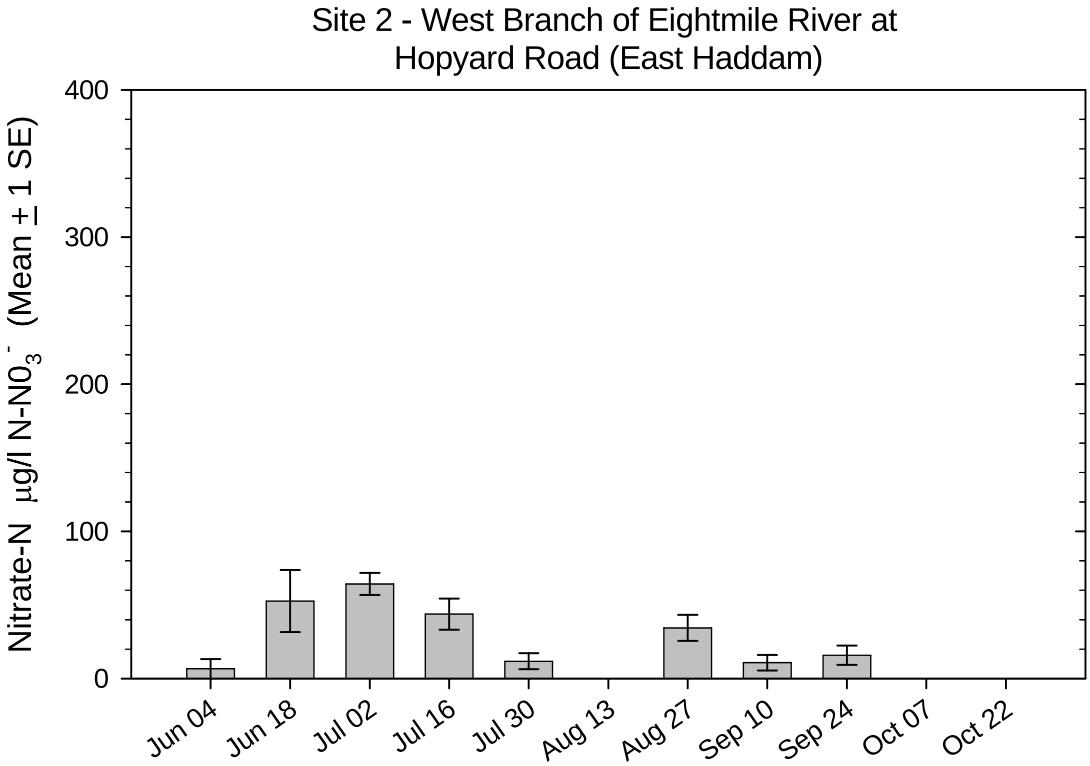
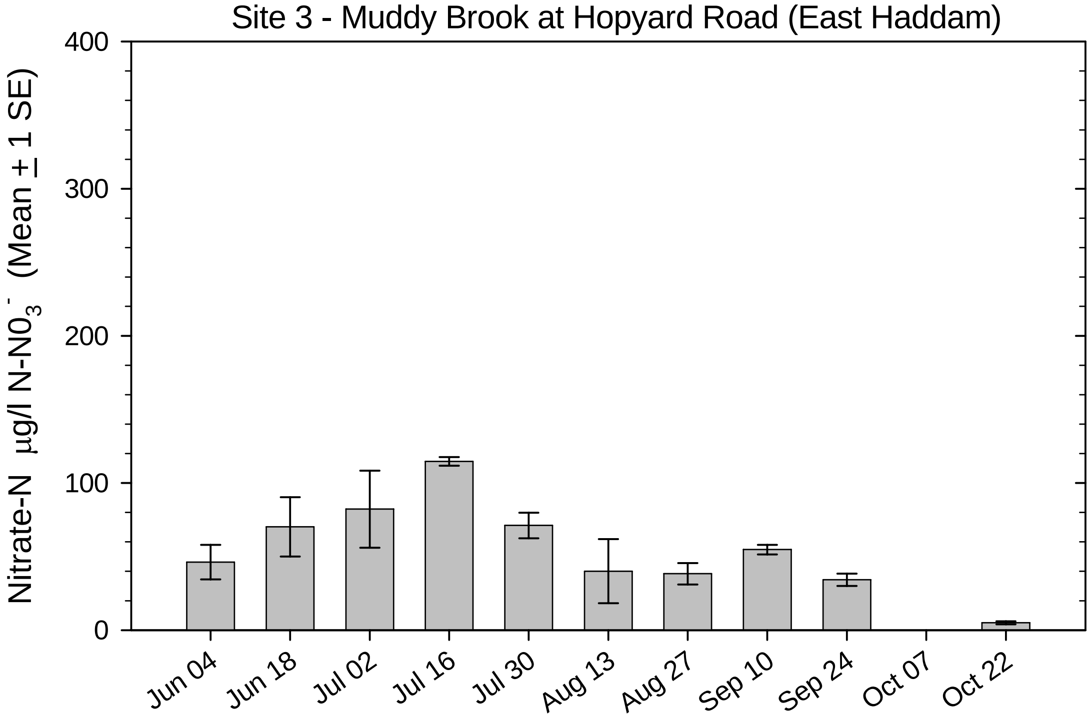


Figure F14. Nitrate-N (N-NO_3^- µg/l, mean ± 1 SE) at Site 3, Muddy Brook at Hopyard Road (East Haddam) and Site 4, West Branch of Eightmile River at Haywardville Road (East Haddam) for all collection dates.



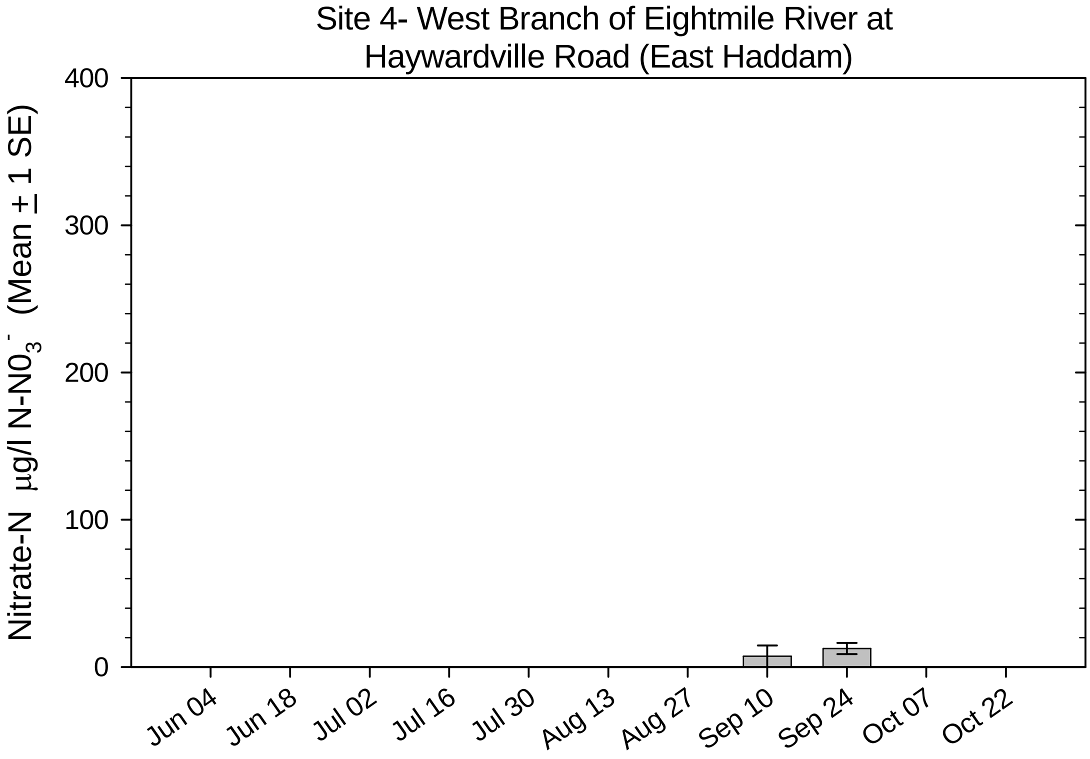
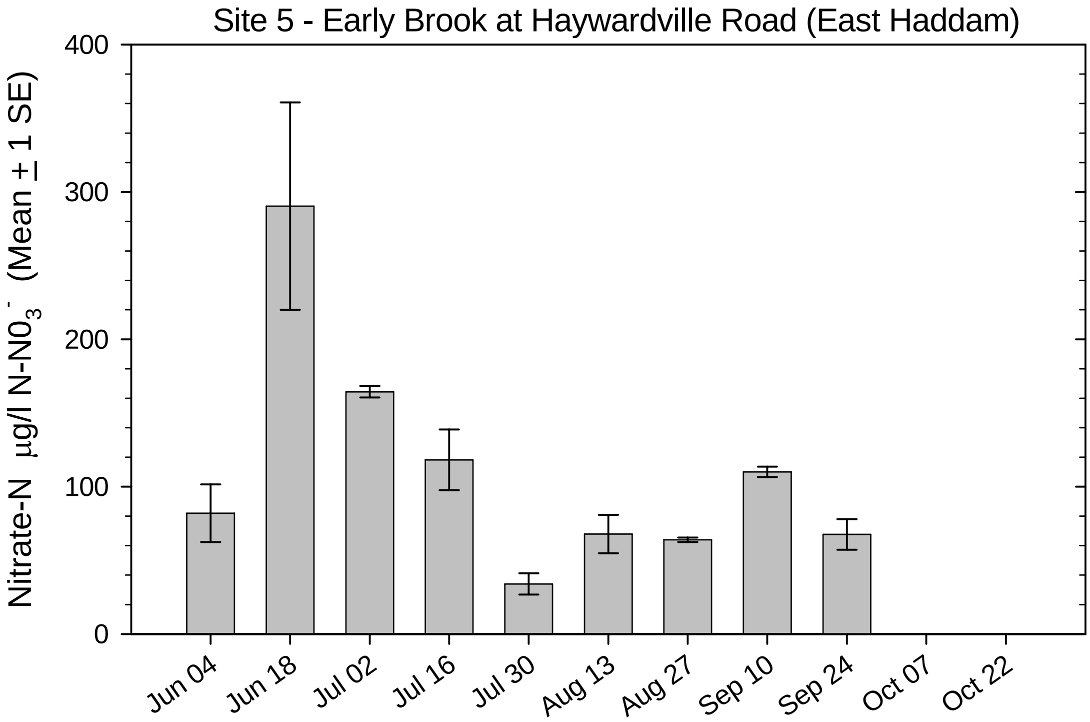


Figure F15. Nitrate-N (N-NO$_3^-$ µg/l, mean ± 1 SE) at Site 5, Early Brook at Haywardville Road (East Haddam) and Site 6, Lake Hayward Brook at Mill Lane for all collection dates.


Site 5 - Early Brook at Haywardville Road (East Haddam)

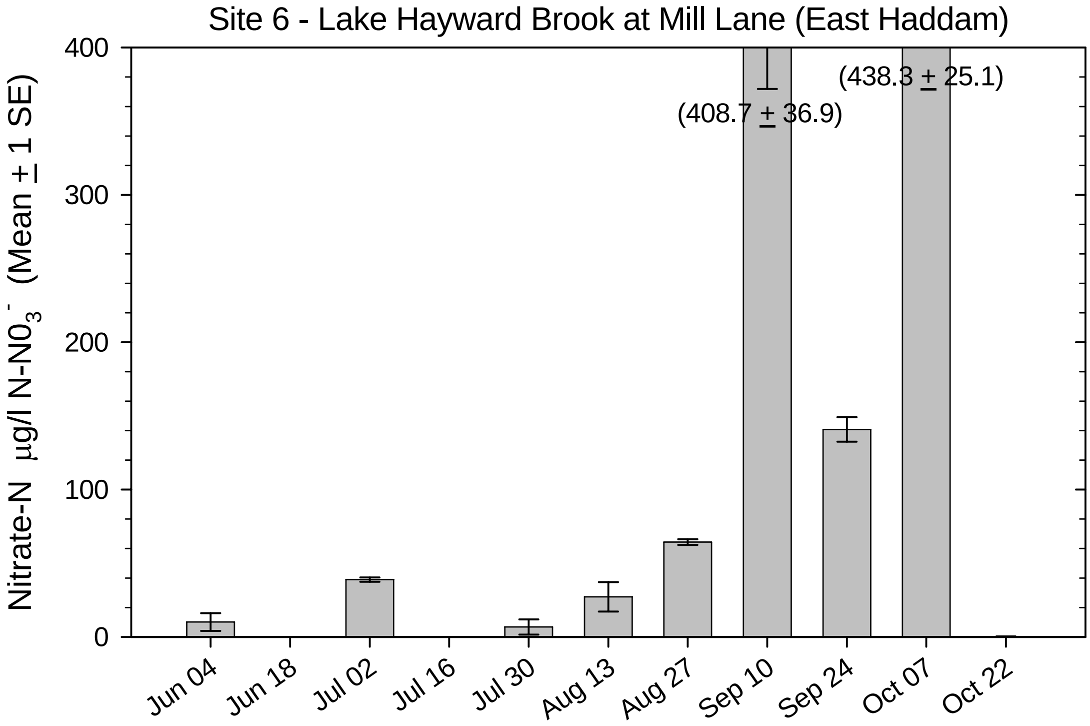
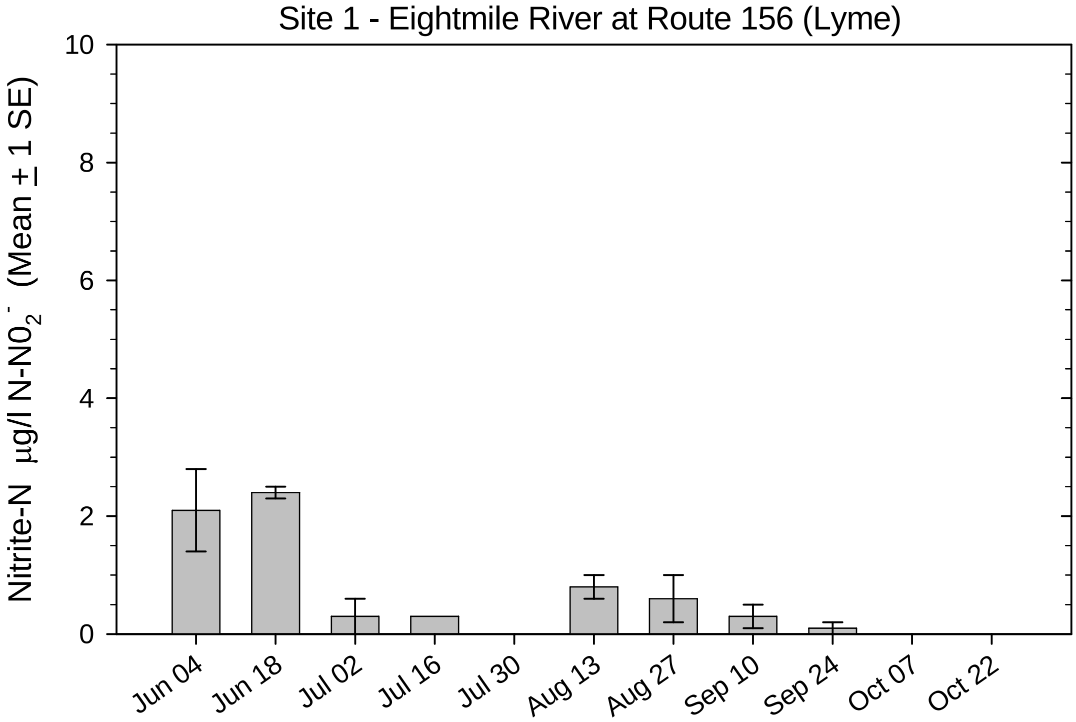

Site 6 - Lake Hayward Brook at Mill Lane (East Haddam)

Figure F16. Nitrite-N (N-NO_2^- µg/l, mean ± 1 SE) at Site 1, Eightmile River at Route 156 (Lyme) and Site 2, West Branch of Eightmile River at Hopyard Road (East Haddam) for all collection dates.



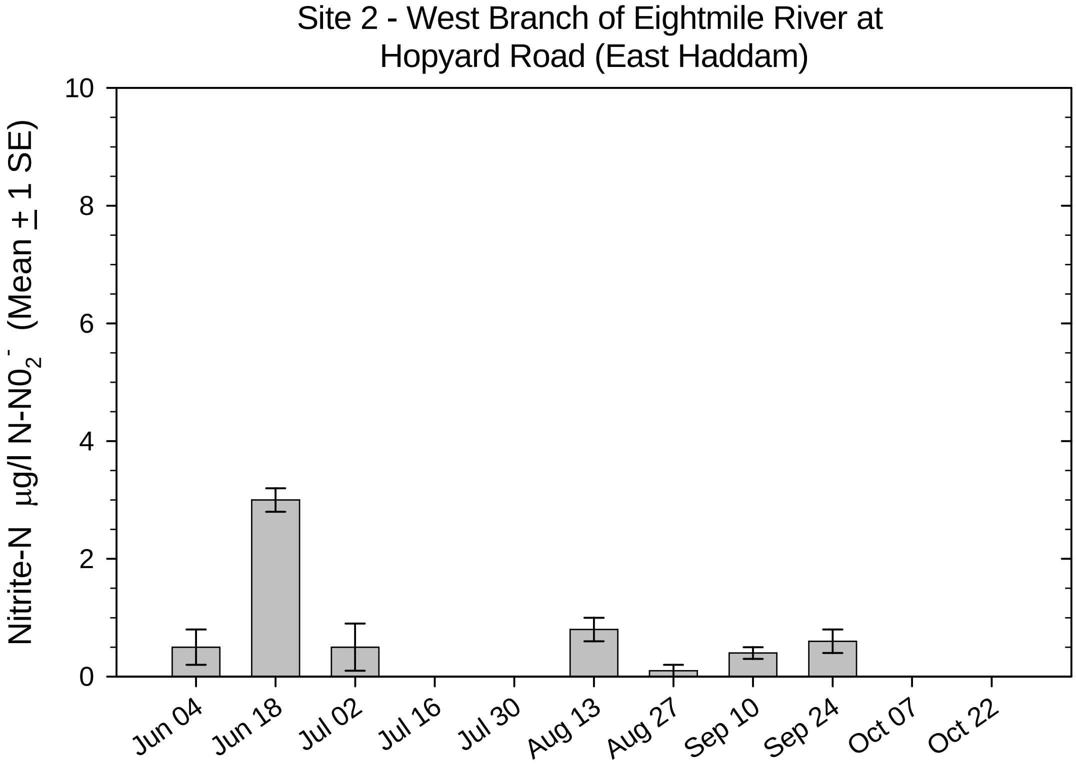
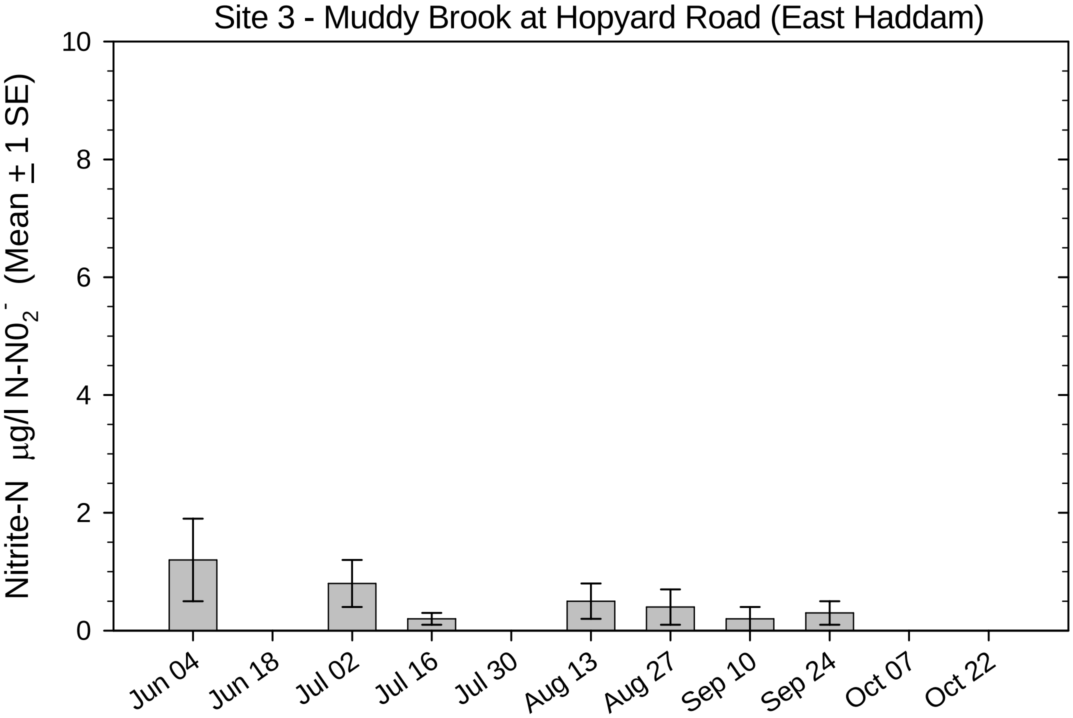


Figure F17. Nitrite-N (N-NO$_2^-$ µg/l, mean ± 1 SE) at Site 3, Muddy Brook at Hopyard Road (East Haddam) and Site 4, West Branch of Eightmile River at Haywardville Road (East Haddam) for all collection dates.



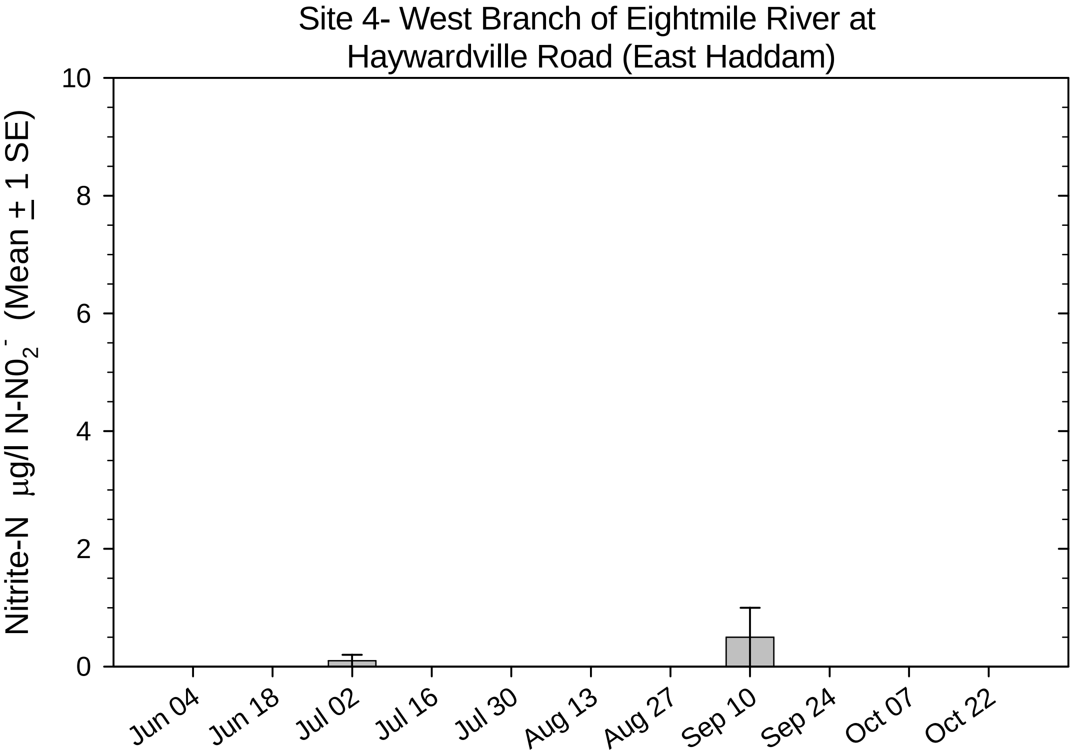
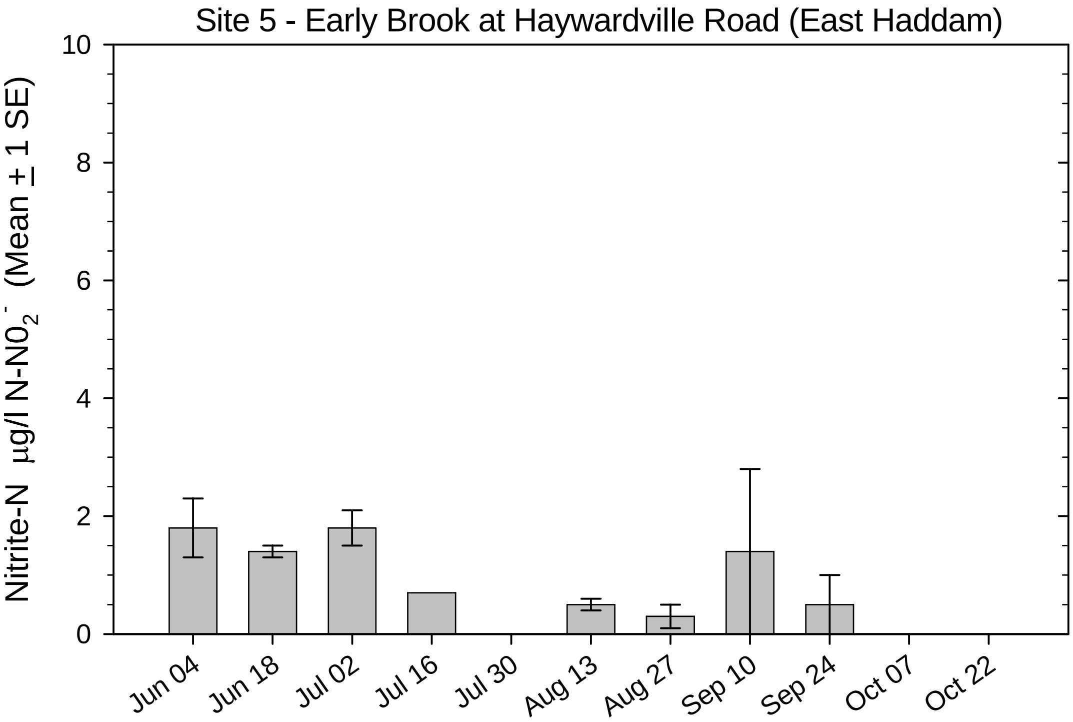


Figure F18. Nitrite-N (N-NO_2^- µg/l, mean + 1 SE) at Site 5, Early Brook at Haywardville Road (East Haddam) and Site 6, Lake Hayward Brook at Mill Lane for all collection dates.



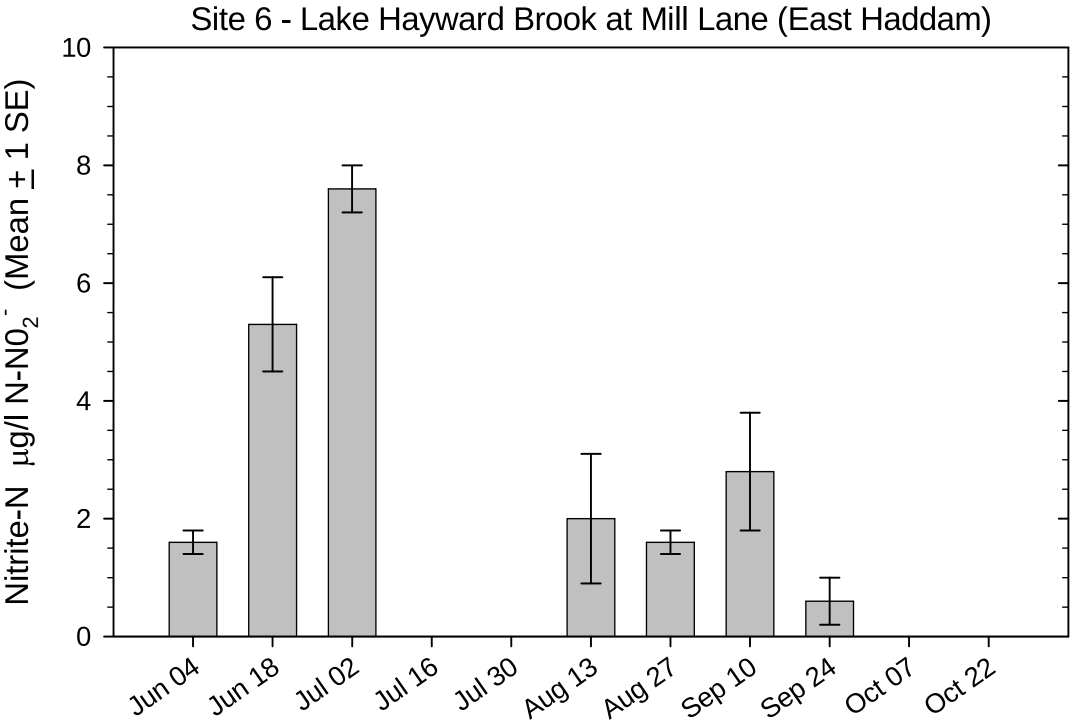
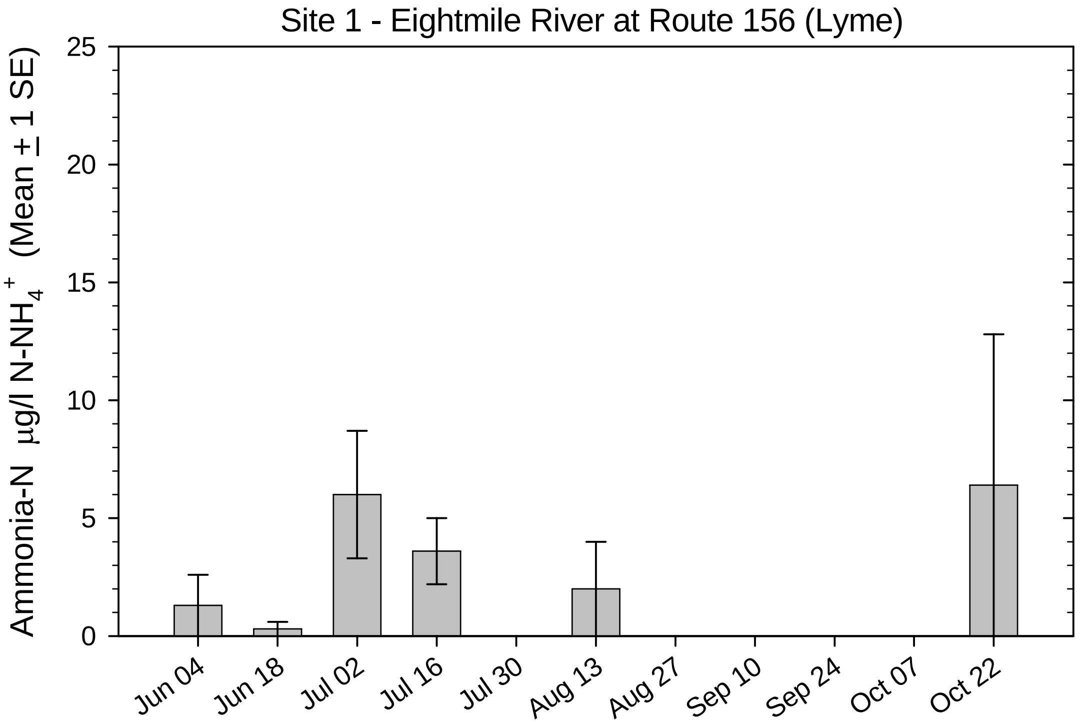


Figure F19. Ammonia-N (N-NH_4^+ µg/l, mean ± 1 SE) at Site 1, Eightmile River at Route 156 (Lyme) and Site 2, West Branch of Eightmile River at Hopyard Road (East Haddam) for all collection dates.



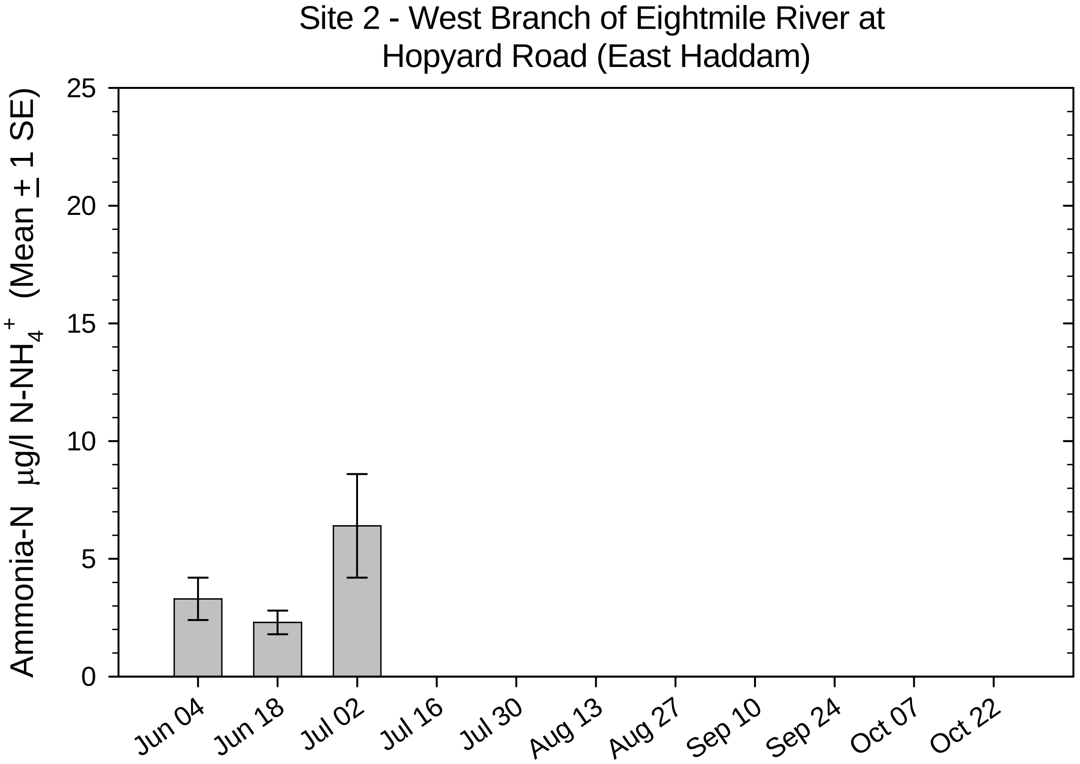
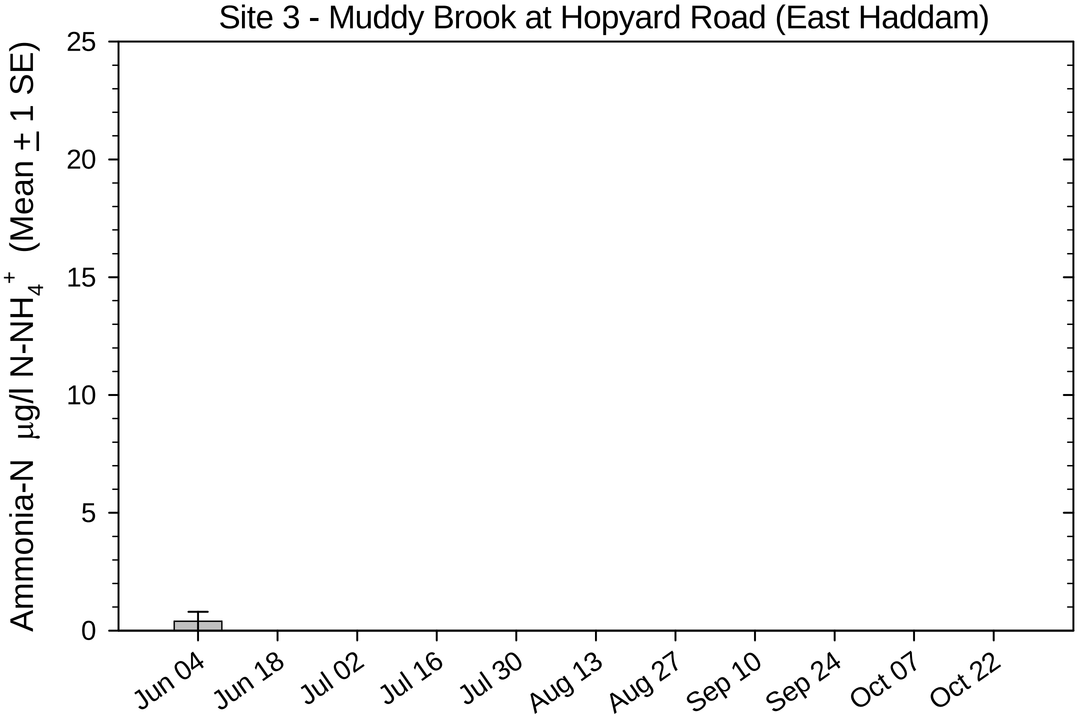


Figure F20. Ammonia-N (N-NH_4^+ µg/l, mean + 1 SE) at Site 3, Muddy Brook at Hopyard Road (East Haddam) and Site 4, West Branch of Eightmile River at Haywardville Road (East Haddam) for all collection dates.



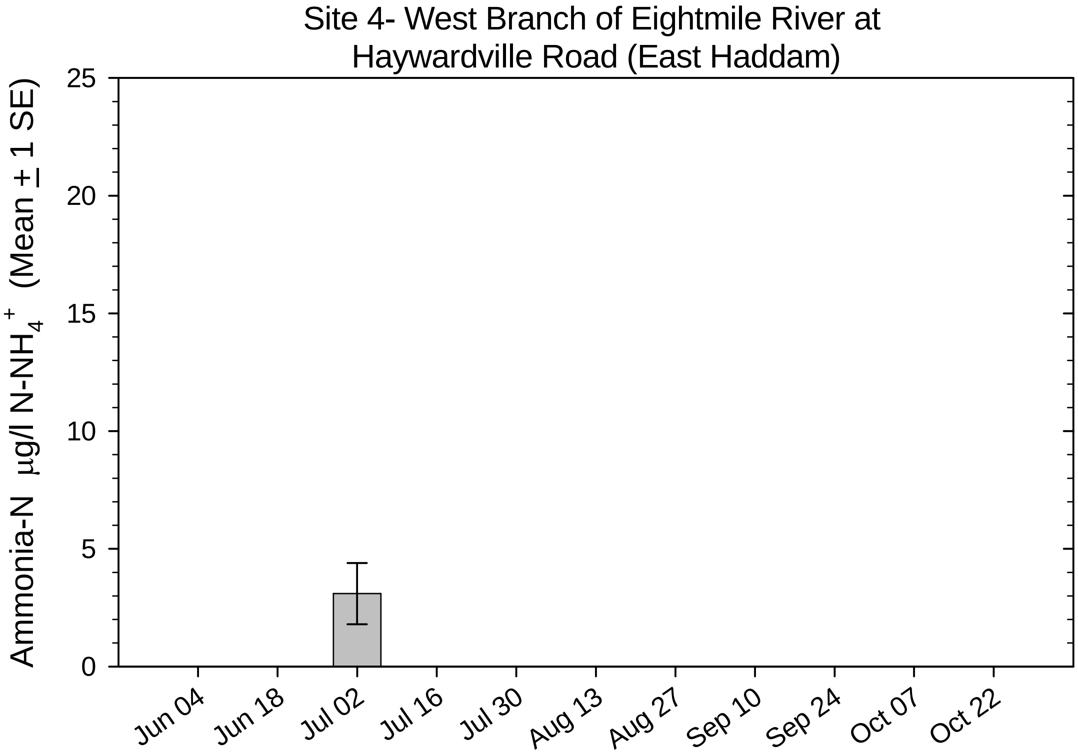


Figure F21. Ammonia-N (N-NH$_4^+$ µg/l, mean ± 1 SE) at Site 5, Early Brook at Haywardville Road (East Haddam) and Site 6, Lake Hayward Brook at Mill Lane for all collection dates.