CHANGES IN WATER QUALITY IN DECKERS CREEK FROM 1974 TO 1999

By

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Abstract: The Deckers Creek drainage basin covers approximately 16,600 ha in Monongalia and Preston Counties of West Virginia. The purpose of this study was to evaluate water quality changes over 25 years from samples taken in 1974 and 1999. A 1974 study examined the water chemistry in Deckers Creek over a six-month period at 29 sample points. Water samples from the same sites were collected monthly and analyzed in 1999. Most of the tributaries sampled in 1999 showed improved chemistry compared to 1974, as did the main stem of Deckers Creek above the town of Richard. Decreased mining activity, stricter reclamation standards, and improved deep mine discharge qualities have led to improved water conditions in the upper portion of Deckers Creek. A large-volume deep mine discharge near Richard, located 3 km upstream of the mouth, has degraded the lower portion of Deckers Creek since 1974. Below Richard, the water in the creek is of very poor quality because of the excessive acid and metals input at Richard, even though good quality tributaries also enter downstream. With the improvement in chemical properties in the majority of the creek, biological contamination in the form of fecal coliform bacteria will become more apparent and present a new water quality problem.

Additional keywords: reclamation, underground mining, acidity, iron, fecal coliforms

Introduction

Before 1900, the Deckers Creek watershed exhibited an expansive hardwood forest, native fish and wildlife species, and clean water. The beginning of the 20th century saw rapid economic growth throughout all of northern West Virginia, but especially in the coalfields of Monongalia and Preston Counties. The construction of the Morgantown and Kingwood Railroad in 1899 opened much of the Deckers Creek drainage basin to timber harvesting and coal mining. By the 1930's this was one of the most active areas in West Virginia for underground and surface mining. While the impacts of logging have become less obvious with time, the removal of coal, piling of waste materials, and subsequent exposure of acid-generating strata to oxidizing conditions has caused long-term environmental problems.

The study area is located in a high-sulfur coal region of West Virginia, where the coal and associated strata contain high levels of sulfur as pyrite. When exposed to water and atmospheric oxygen, pyrite undergoes a series of chemical reactions, ultimately resulting in the production of sulfate, proton acidity, and ferric hydroxide (Banks et al. 1997). The acid and iron serve to accelerate normal geochemical weathering in a self-perpetuating sequence of reactions, and much of the metal oxyhydroxides precipitate out of solution upon contacting natural waters (Younger 1998). These precipitates form coatings in stream channels, interfering with native biology (Gray 1995). The accompanying increase in weathering can also lead to the dissolution of silicate minerals, causing the release of metals such as aluminum and manganese into the environment in more reactive forms (Younger 1998).

Another geochemical reaction seen throughout the Deckers Creek watershed is the dissolution of calcium carbonate. In its upper

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reaches, the creek flows through limed agricultural fields, which are subject to runoff during rain events. Housing developments are scattered throughout the watershed, most having driveways and foundations employing crushed limestone gravel. The largest and most influential limestone input to the creek comes from an active limestone quarry, Greer Limestone, which stores alkaline tailings along a 500 m section of floodplain about halfway between the headwaters and the confluence of the creek with the Monongahela River at Morgantown. The presence and subsequent dissolution of this material is particularly important to Deckers Creek because of its capacity to generate acid-neutralizing anions such as hydroxide, carbonate, and bicarbonate (Donovan 1999). The alkaline additions at this point are largely responsible for the improved nature of the stream from the town of Greer down to the inflow of untreated mine water near the town of Richard. Below Richard, the creek displays the extreme effects of acid mine drainage and metal precipitation.

Another observable effect on Deckers Creek is the input of fecal bacteria from agricultural fields and bordering residential areas. High counts of fecal coliforms are directly linked to sewage inputs and indicate the possible presence of other, more harmful bacteria, protozoans, and viruses (Edwards et al. 1997). Surface run-off from agricultural fields can also carry harmful microbes into streamwater. Fecal material from livestock and the land application of sewage sludge increase the levels of indicator organisms in streams and may create bacterial reservoirs in soils. These reservoirs could possibly serve as sources of bacterial contamination when temperature and moisture conditions are favorable (Hunter et al. 1999).

In 1974, James Teti, a graduate student in the Geology Department of West Virginia University, conducted a water quality study of Deckers Creek (Teti 1974). He located 29 sampling points along the creek and collected water samples during a six-month period. The purpose of the present study was to revisit the sites that were sampled 25 years ago and, after conducting water quality analyses, determine the changes in water quality that have occurred between 1974 and 1999.

Methods

Chemistry Procedures

Beginning in March of 1999, water samples were collected at 31 sites, corresponding to sites originally sampled by Teti, along Deckers Creek and several of its tributaries on a monthly basis (Figure 1). A YSI 3500 Water Quality Meter was used to measure temperature, electrical conductivity, and pH in the field. Two water samples were collected at each site. The first sample was collected in a 250-mL plastic bottle and was neither filtered, nor acidified. A second sample of 50 mL was filtered with a 0.45um filter and acidified to pH 2.0 with hydrochloric acid. Both samples were placed on ice and transported to the laboratory. The first sample was analyzed for pH, acidity, and alkalinity using a TitraLab Autotitrator (Radiometer/Copenhagen, Denmark), while the second sample was analyzed for Fe, Al, Mn, Mg, and Ca by ICP (Plasma 400 ICP Spectrometer, Model P400,). All titrations were performed within six hours of sample collection.

Flow determinations were also made at the same time water samples were taken. At the beginning of the study at each point, the bottom of the stream channel was delineated from the high water mark on one bank to the corresponding mark on the opposite bank. A reference point was chosen near the center of this transect in the stream. The point was marked either by driving a steel post into the streambed or by placing a brightly colored brick. At subsequent sampling times, the depth of the water measured at this reference point was used to calculate depths across the stream transect and a water velocity measurement was taken. Water velocity readings were taken using a Global Water Flow Probe FP101 (Global Water, Gold River CA). Multiplying the cross-sectional area of the water in the stream by velocity provided a good estimate of flow. Acid and metal loading (calculated from flow and concentration) were then determined.

Microbiological Procedures

A separate water sample was collected and tested for the presence of fecal coliform bacteria by the membrane filtration technique using 0.7 um filters instead of .45 um filters. The larger-sized filters allow for improved recovery of organisms possibly damaged by acidic conditions in the stream (Bissonnette 1999). The filters were then plated onto membrane fecal coliform (mfc) media and incubated at 44.5^{0}C for 24 hours. The plates were

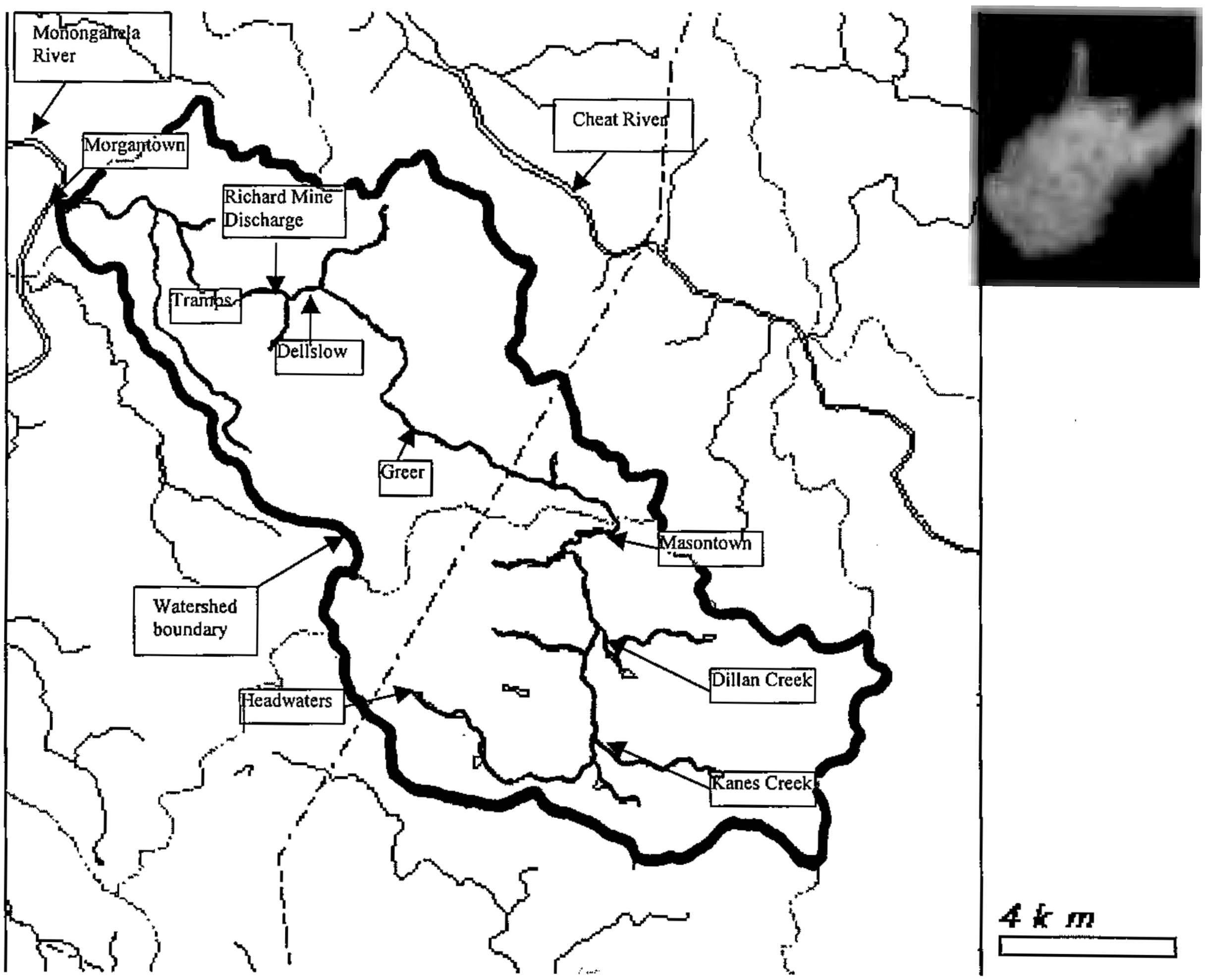

Figure 1. Deckers Creek from the headwaters to its confluence with the Monongahela River at Morgantown. Eight sampling sites, along with the Cheat and Monongahela Rivers, are shown which represent different sections of the stream.

then counted to determine the number of colony forming units (CFUs) per 100 mL. The fecal coliform limit for secondary use standards (fishing, wading, etc.) for waters of West Virginia is a CFU count of 200 CFUs per 100 ml. The 1974 study did not analyze for fecal coliforms.

The monthly data was divided into seasons to give Spring (March, April, and May), Summer (June, July, and August), and Fall (September and October) water quality data. Data from only eight of the 31 sites were selected to represent specific sections of the stream (Figure 1). The Headwater sampling location was the most upstream sample point and represented an area of limited pollution from households and land disturbances. Two sampling locations were located below the inflow of two major tributaries draining areas heavily surface mined in the 1970s and 80s (Kanes and Dillan Creek). The Masontown sample point was located just below the town of Masontown where untreated sewage enters the creek. Greer is the location of a limestone aggregate quarry. Limestone materials of various sizes are introduced into the stream. At Dellslow, the limestone and water have mixed and several more good quality tributaries have entered the creek. But most important, this site is upstream of a major acid mine drainage input from the Richard Mine. Tramps is immediately downstream from the Richard acid mine drainage input to Deckers Creek, while the Morgantown site is near the mouth just before Deckers Creek enters the Monongahela River.

Results and Discussion

The Spring averages for these eight representative sites are presented for six parameters; pH, acidity, iron, alkalinity, calcium, and fecal coliforms. Spring 1999 data were chosen because the 1974 study only had sampling data for a three-month period during the Spring. Data from 1999 and 1974 are plotted on the same graph for each parameter so as to illustrate the change in water quality over time (Figures 2 to 7). The graphs indicate that levels of acidity and total iron have decreased throughout the stream, while alkalinity, pH, and calcium, have increased.

The 1999 pH levels are in all cases 1 to 2 pH units greater than in 1974 (Figure 2). Acidity levels have declined, averaging a 65% decrease across all sites, with the smallest decrease occurring below the Richard Mine discharge (12%) (Figure 3). Total iron levels dropped as much as 97% at Dellslow, with an average decrease of 82% across the eight sites (Figure 4). Alkalinity levels have increased throughout the entire watershed, with the largest increase coming after the limestone input at the Greer Limestone Quarry (Figure 5). Calcium decreased slightly in the Headwaters, then exhibited an average increase of 47% between Kanes Creek and Morgantown.

By comparing the acidity and total iron values at the Dillan Creek site, much of the measured acidity cannot be attributed solely to iron. High aluminum concentrations are also present in the water and can possibly explain this observation. Manganese concentrations were also higher at this point (0.5 mg/L) than at any other for the Spring period. A combination of iron, aluminum, manganese, and hydrogen result in the high acidity levels.

Calcium was similar in the Headwaters between 1974 and 1999, then exhibited an average increase of 47% between Kanes Creek and Morgantown. A change in the calcium concentration trend has been detected. Instead of a gradual increase from Masontown to Morgantown as was observed in 1974, calcium levels now remain about the same or slightly decrease over the same stretch. Calcium levels overall are higher now, but the concentrations relative to sampling site have changed. This may be due to a drought during the 1999 sampling period, which caused many tributaries to dry up. Had these streams been flowing, calcium would likely have increased toward Morgantown due to runoff from areas that had been limed and from calcium inputs from Greer.

Fecal coliform levels have been averaged for the entire sampling period and presented on a logarithmic scale (Figure 7). The Masontown site dominates the values in the figure, with levels that are orders of magnitude higher than any other location. Fecal coliform determinations and visual inspection indicate the presence of numerous point sources of sewage, most likely single home discharges, except at Masontown. One large volume flow has been identified at Masontown. Fecal coliform levels at this site vastly exceed all standards for any type of water use. A municipal sewage system, slated for completion in the Summer of 2001, should alleviate most of the sewage pollution problem in this section of the stream.

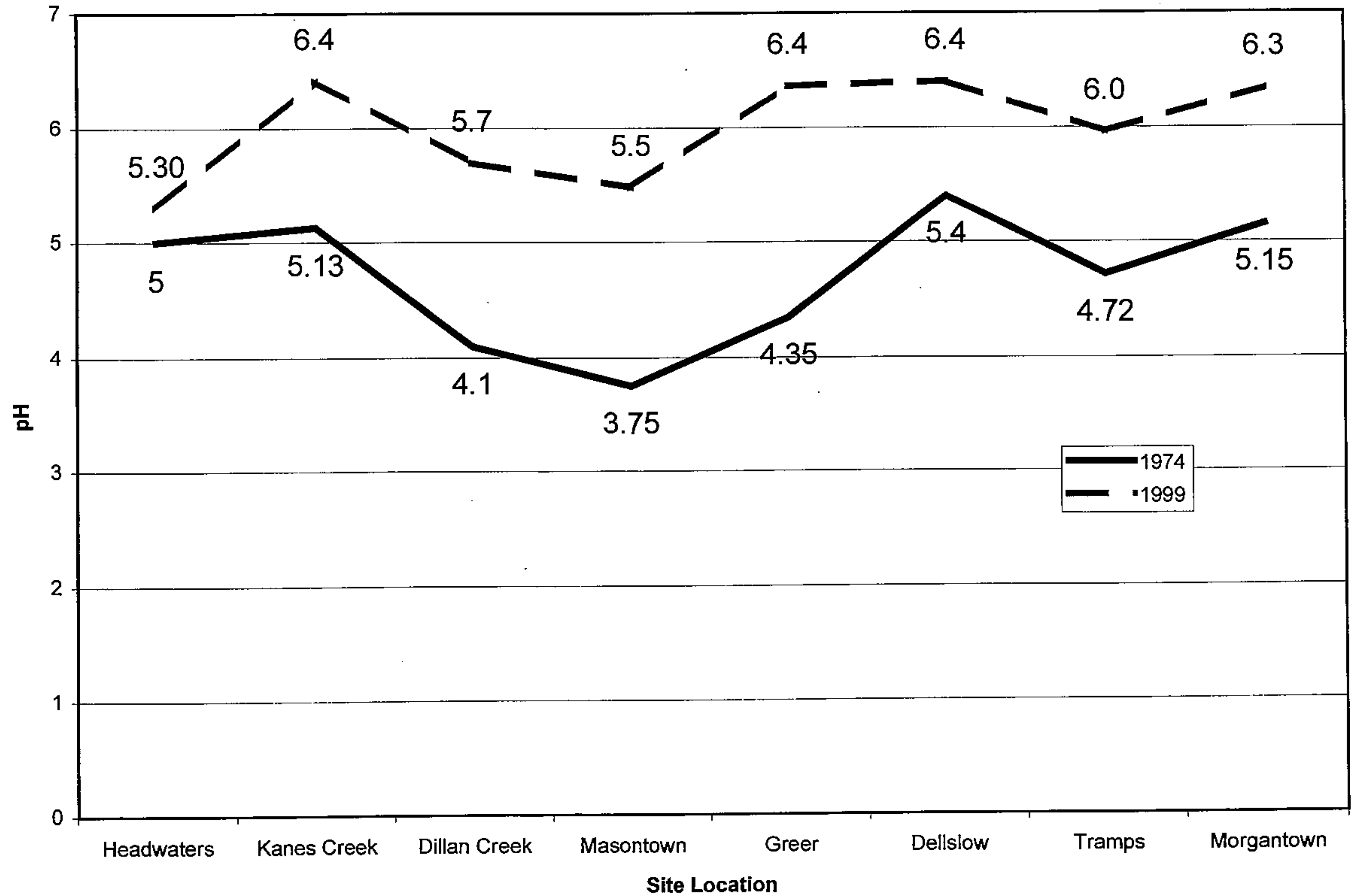

Figure 2. Spring averages for pH in 1974 and 1999 at eight sampling points in Deckers Creek.

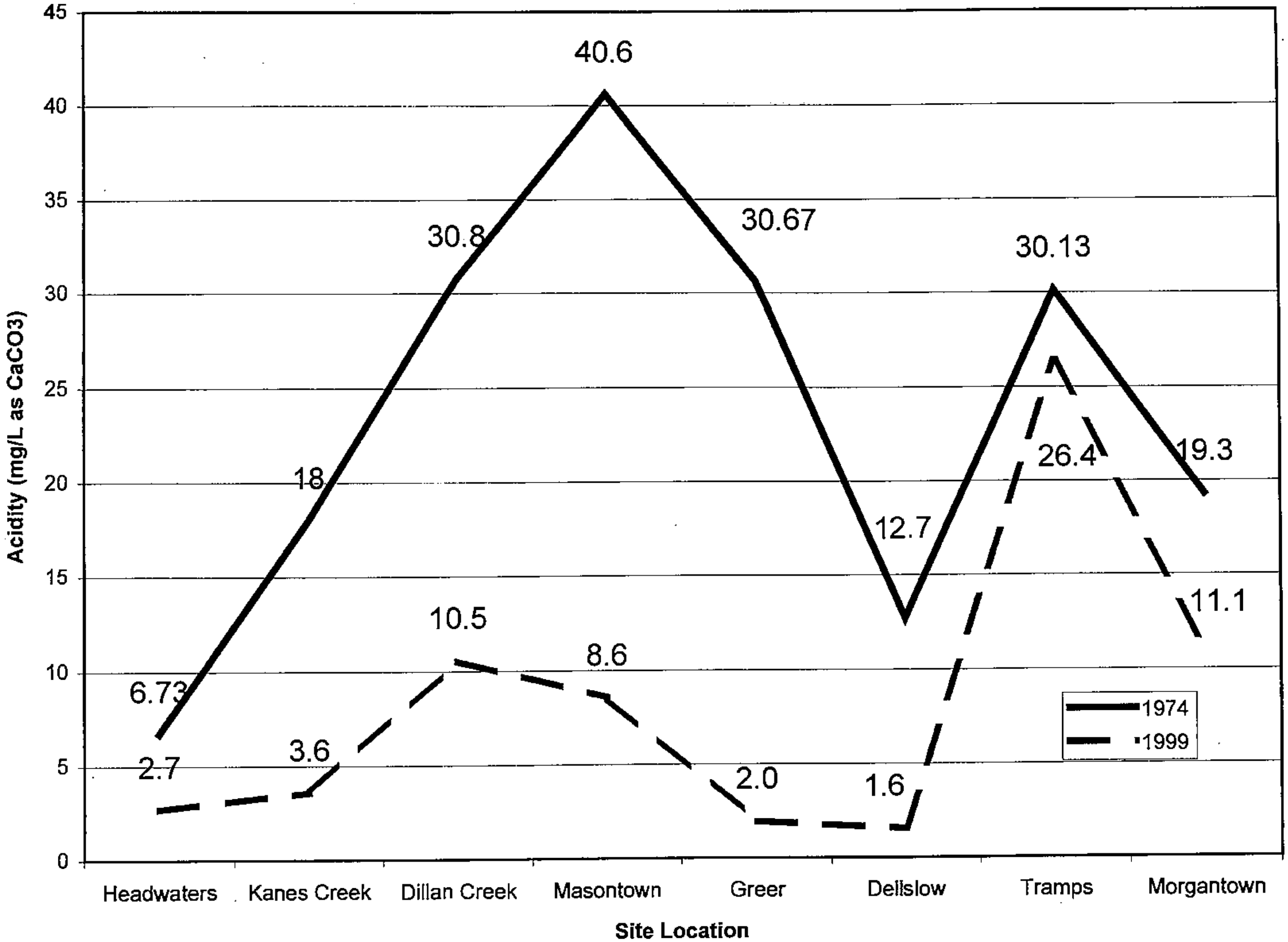

Figure 3. Spring averages for acidity in 1974 and 1999 at eight sampling points in Deckers Creek

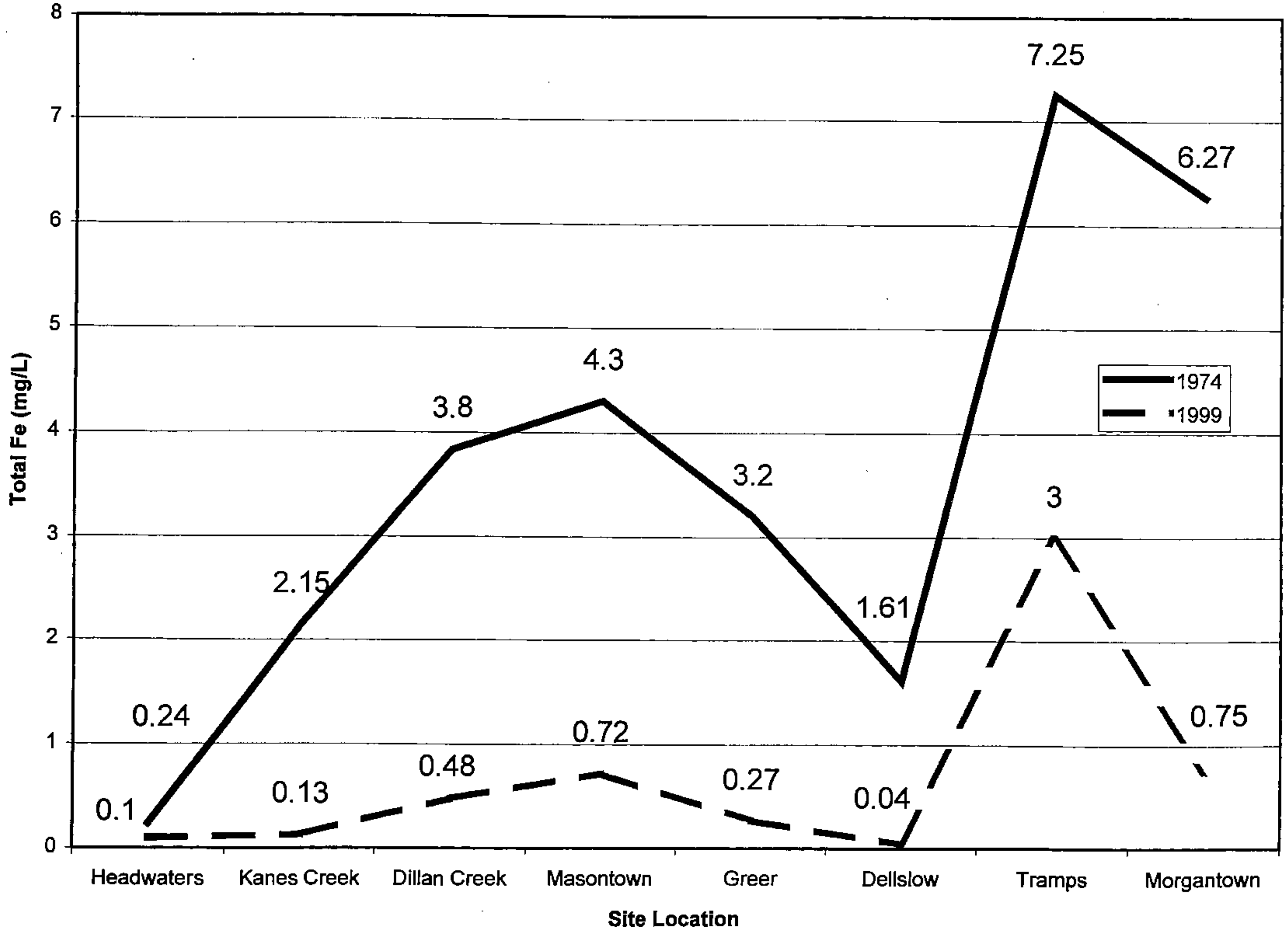

Figure 4. Spring averages for total iron in 1974 and 1999 at eight sampling points in Deckers Creek

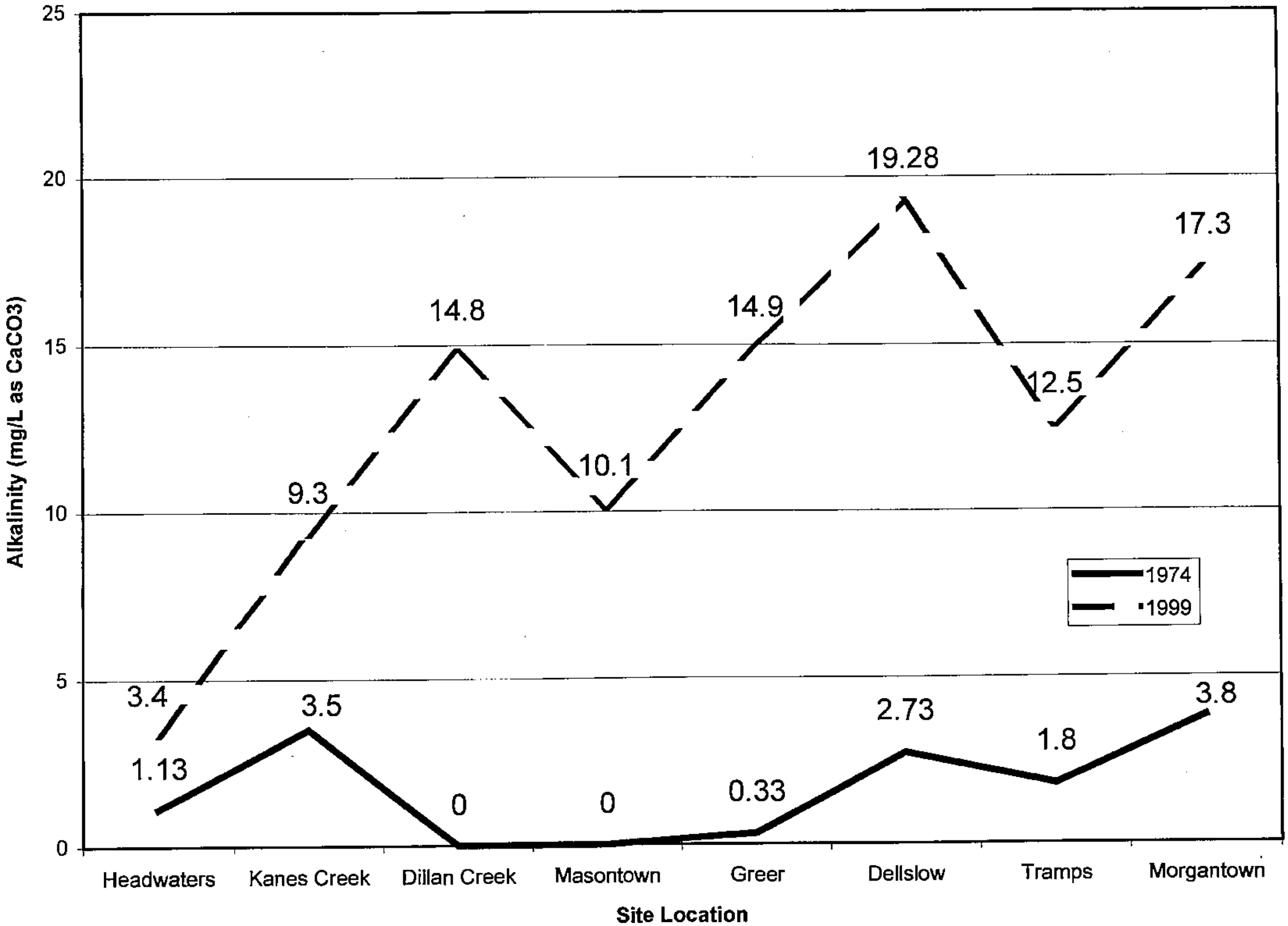

Figure 5. Spring averages for alkalinity in 1974 and 1999 at eight sampling points in Deckers Creek.

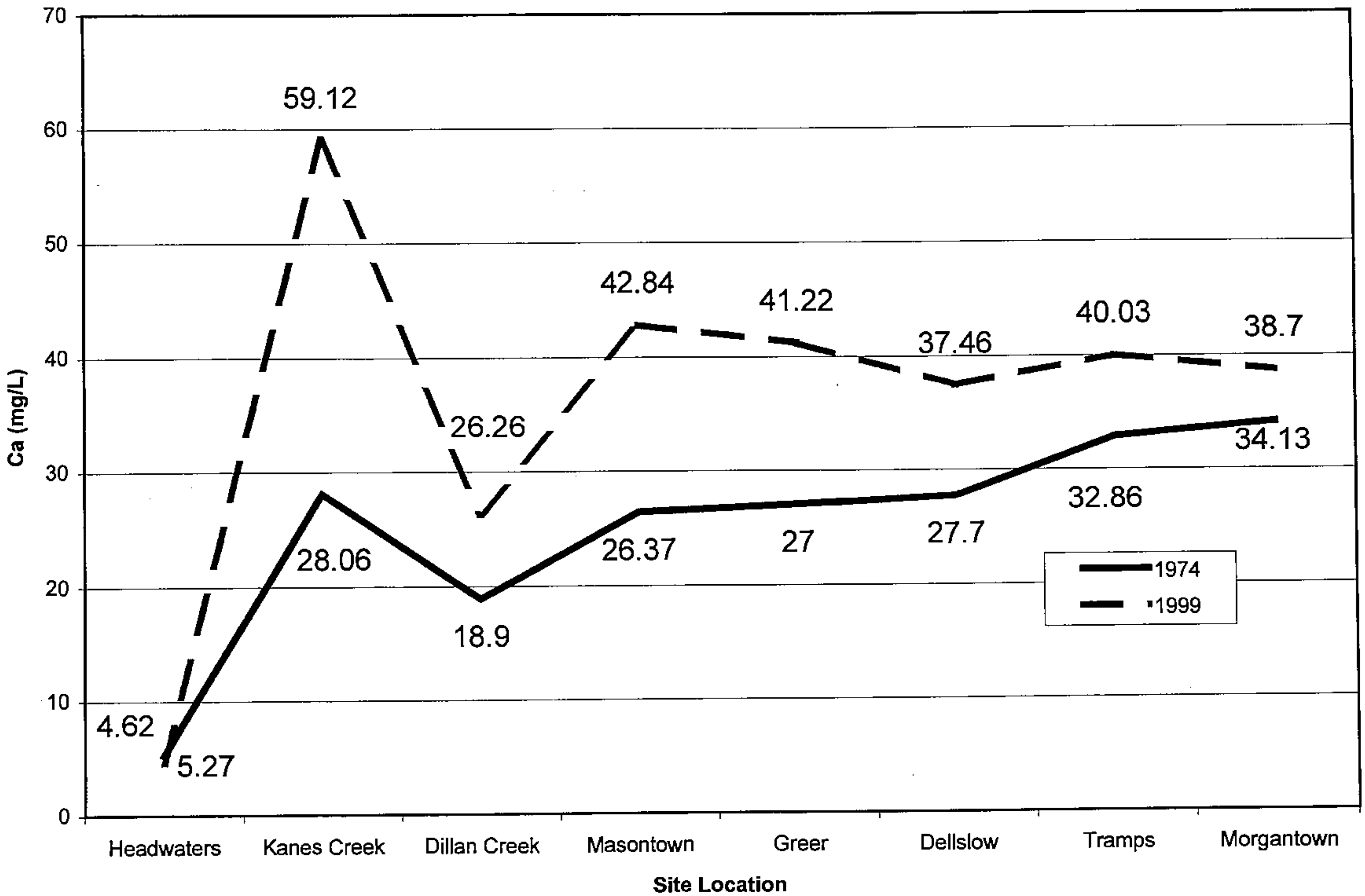

Figure 6. Spring averages for calcium in 1974 and 1999 at eight sampling points in Deckers Creek.

Note: Dashed line represents USEPA standards for bacterial contamination of secondary use water (200 cfu/100ml).

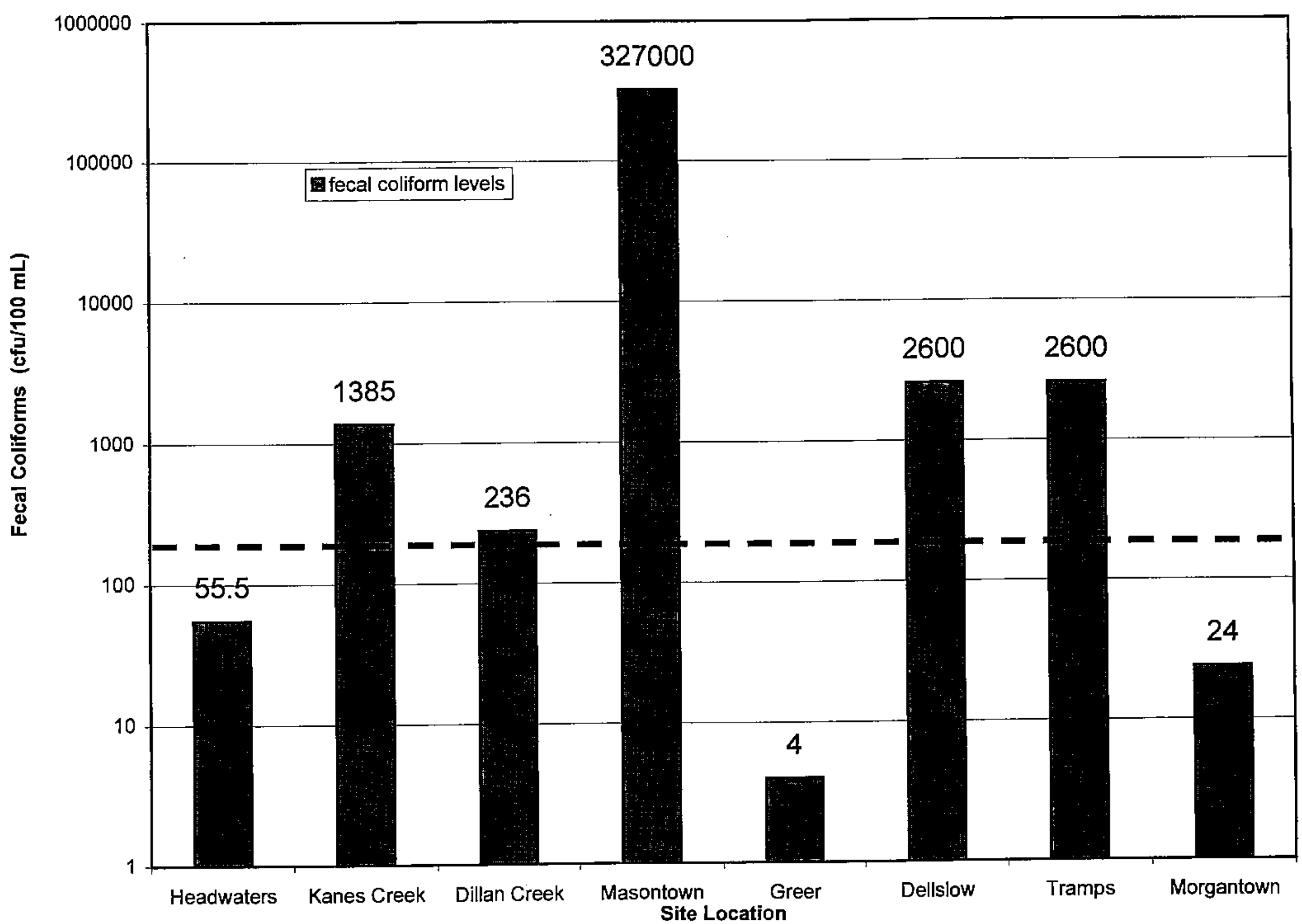

Figure 7. Average fecal coliform levels for 1999 in Deckers Creek at eight sampling points

Conclusions

Based on Spring averages for 1974 and 1999, water quality has improved in Deckers Creek during the past 25 years. Decreased mining activity, higher additions of alkaline materials to the creek, and reclamation of abandoned mines in the Dillan and Kanes Creek areas have led to improved chemical quality of Deckers Creek. Possibly the most important factor behind the water quality improvements in Deckers Creek is natural healing that comes with time. With less mining activity in the watershed and improved reclamation on the few remaining active mining sites, water quality can continue to improve. Natural reclamation of abandoned sites and better treatment and control of water on active sites also facilitates this improvement. Wood et al. (1999) indicates that mine water pollution is most severe in the first few decades after a discharge begins and that discharges from large mining complexes improve in quality after 40 years. As oxidizable pyrite supplies diminish, the overall quality of mine drainage improves, contributing to improvements in receiving streams. Fecal coliforms in Deckers Creek will become a larger problem as acidity and metals continue to decrease in the water.

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