BACKGROUND

Recreational water quality is based primarily on the presence and pervasiveness of pathogens in the water that can pose risks to human health through body contact or ingestion. Since it is not practical to analyze for every possible pathogen found in human waste, indicator bacteria typically are used. Concentrations of these bacteria are relatively easy and cost effective to analyze and are good indicators of fecal contamination. Indicator bacteria results provide regulators with a means to determine the likelihood that human pathogens may be present in recreational waters. Historically, many states have used total fecal coliform as the indicator bacteria for determining the sanitary condition of recreational waters to protect human health. Fecal coliform primarily are found in the waste of humans or other warm-blooded animals; however, at least one type has non-fecal sources, including the effluent of paper mills, textile processing plants, and cotton mills (Wilhelm and Maluk, 1998).

In 1986, the U.S. Environmental Protection Agency (USEPA) published updated recommendations for states based on better knowledge of which indicator bacteria best correlated with gastrointestinal illness in humans. The USEPA recommends that states use either *Escherichia coli (E. coli)* or enterococci as indicators in freshwater and enterococci for saltwater (USEPA, 1986; USEPA, 2002). The presence of *E. coli* and enterococci in recreational waters is direct evidence that fecal contamination from humans or other warm-blooded animals has occurred (USGS, 2006).

The USEPA-recommended criteria are intended to control pathogens by keeping concentrations of indicator organisms at a level that corresponds with acceptable risks of acute gastrointestinal illness to recreational water users (USEPA, 2002). Gastroenteritis is a term for a variety of diseases that affect the gastrointestinal tract and are rarely life-threatening. Symptoms include vomiting, diarrhea, stomach ache, nausea, headache, and fever. Most people affected by gastroenteritis will experience these flu-like symptoms several days after exposure but rarely associate their illness with the ingestion of pathogen contaminated water. Other illnesses or conditions affecting the eyes, ears, skin, and upper respiratory tract can be contracted from contaminated water as well. Although people are affected differently, certain subgroups, such as children and the elderly, are more susceptible to contracting waterborne illnesses. In some studies, gastroenteritis was linked more closely to enterococci exposure, while skin rashes and ear ailments were linked to fecal and total coliform (Noble et al., 2000).

Ongoing research on which types of indicator bacteria are correlated most closely with outbreaks of gastroenteritis in humans continues to show that *E. Coli* and enterococci are both better indicators than fecal coliform (USEPA, 2002). Enterococci typically are used as the indicator bacteria in marine systems because they have a longer life in saltwater then do *E. coli*. However, some studies show that enterococci are a more sensitive indicator in freshwater, resulting in many more recreational closings due to high levels of bacteria (Kinzelman et al., 2003; John and Rose, 2005). In a California study, researchers found that one out of every three indicator bacteria violations was for enterococci alone and that fewer than half of the enterococci violations were paired with an exceedance of another indicator bacteria type. This suggests enterococci are a more sensitive indicator of bacteriological water quality than either total or fecal coliform (Noble et al., 2000). In another study, children who drank from private wells that tested positive for coliform were not at risk for diarrheal disease. However, children who drank from private wells that contained enterococci were six times as likely to become ill with diarrhea (Borchardt et al., 2003).

Some states have replaced their fecal coliform criteria with water quality criteria for *E. coli* and/or enterococci; however, many states, including Pennsylvania, have not yet made the transition (USEPA, 2002). In this study of the Yellow Breeches Creek Watershed, all three of the indicator bacteria (*E. coli*, enterococci, and fecal coliform) were sampled and the results were compared.

METHODS

DATA COLLECTION

SRBC staff collected bacteriological samples using standard PADEP protocol (PADEP, 2006). Four 30-day periods were sampled during the 2006 calendar year: February and early March, May, August, and November. Bacteria samples were collected by hand at eleven sites in 125-ml screw-capped polypropylene wide-mouth bottles that had been pre-sterilized and contained sodium thiosulfate. Samples were collected from the middle of the channel, and any sediment disturbed by the collector was allowed to settle before the sample was collected. Bottles were submersed approximately eight inches under the surface of the water, facing upstream, and filled with water. Bottles were immediately capped, put into a plastic zip-sealed bag, and placed on ice. Duplicate bacteria samples were collected at a rate of at least one per day and were taken once at each site during the 30-day sampling period. A field blank also was taken at least once per day to test for any kind of field contamination. Samples were delivered to the PADEP laboratory within 24 hours of collection.

The sampling sites (Appendix A) were selected so that data collected during this survey can be utilized as background information by PADEP and other interested parties, including water suppliers in the Yellow Breeches Creek Watershed. Additional sites have been added on tributary streams to provide better coverage of the watershed. The locations for sites were chosen to evaluate the pervasiveness of bacteria pollution along the mainstem and contamination in and from the various tributaries.

In addition to bacteria sampling, during each sampling visit, staff measured stream discharge and completed field