Summary of Environmental Monitoring and Assessment Program (EMAP) Activities in South Dakota, 2000–2004

By Allen J. Heakin, Kathleen M. Neitzert, and Jeffrey S. Shearer

Prepared in cooperation with the
South Dakota Department of Game, Fish and Parks and the
U.S. Environmental Protection Agency

Scientific Investigations Report 2006-5007

U.S. Department of the Interior
U.S. Geological Survey

U.S. Department of the Interior
Gale A. Norton, Secretary

U.S. Geological Survey
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Suggested citation:
Heakin, A.J., Neitzert, K.M., and Shearer, J.S., 2006, Summary of Environmental Monitoring and Assessment Program (EMAP) activities in South Dakota, 2000–2004: U.S. Geological Survey Scientific Investigations Report 2006–5007, 45 p.

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Conversion Factors and Datums

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter (cm)
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Area	
square foot (ft^2)	929.0	square centimeter (cm^2)
square foot (ft^2)	0.09290	square meter (m^2)
square mile (mi^2)	259.0	hectare (ha)
square mile (mi^2)	2.590	square kilometer (km^2)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F=(1.8×°C)+32$$

Temperature in degrees Fahrenheit (°F) may be converted to degrees Celsius (°C) as follows:

$$°C=(°F-32)/1.8$$

Vertical coordinate information is referenced to the North Geodetic Vertical Datum of 1929 (NGVD 88).

Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).

Other abbreviations and acronyms used:

L	liters
mL	milliliters
µS/cm	microsiemens per centimeter at 25 degrees Celsius
µm	micron
DENR	South Dakota Department of Environment and Natural Resources
EMAP	Environmental Monitoring and Assessment Program
EMAP-West	Environmental Monitoring and Assessment Program-West
GF&P	South Dakota Department of Game, Fish and Parks
GPS	Global Positioning System
NERL	National Exposure Research Laboratory
NHEERL	National Health and Environmental Effects Research Laboratory
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey
WED	Western Ecology Division

Summary of Environmental Monitoring and Assessment Program (EMAP) Activities in South Dakota, 2000–2004

By Allen Heakin[1], Kathleen M. Neitzert[1], and Jeffrey S. Shearer[2]

Abstract

The U.S. Environmental Protection Agency (USEPA) initiated data-collection activities for the Environmental Monitoring and Assessment Program-West (EMAP-West) in South Dakota during 2000. The objectives of the study were to develop the monitoring tools necessary to produce unbiased estimates of the ecological condition of surface waters across a large geographic area of the western United States, and to demonstrate the effectiveness of those tools in a large-scale assessment.

In 2001, the U.S. Geological Survey (USGS) and the South Dakota Department of Game, Fish and Parks (GF&P) established a cooperative agreement and assumed responsibility for completing the remaining assessments for the perennial, wadable streams of the EMAP-West in the State. Stream assessment sites were divided into two broad categories—the first category of sites was randomly selected and assigned by the USEPA for South Dakota. The second category consisted of sites that were specifically selected because they appeared to have reasonable potential for representing the best available physical, chemical, and biological conditions in the State. These sites comprise the second category of assessment sites and were called “reference” sites and were selected following a detailed evaluation process. Candidate reference site data will serve as a standard or benchmark for assessing the overall ecological condition of the randomly selected sites.

During 2000, the USEPA completed 22 statewide stream assessments in South Dakota. During 2001–2003, the USGS and GF&P completed another 42 stream assessments bringing the total of randomly selected stream assessments within South Dakota to 64. In addition, 18 repeat assessments designed to meet established quality-assurance/quality-control requirements were completed at 12 of these 64 sites. During 2002–2004, the USGS in cooperation with GF&P completed stream assessments at 45 candidate reference sites. Thus, 109 sites had stream assessments completed in South Dakota for EMAP-West (2000–2004).

Relatively early in the EMAP-West stream-assessment process, it became apparent that for some streams in south-central South Dakota, in-stream conditions varied considerably over relatively short distances of only a few miles. These changes appeared to be a result of geomorphic changes associated with changes in the underlying geology. For these streams, moving stream assessment sites short distances upstream or downstream had the potential to provide substantially different bioassessment data. In order to obtain a better understanding of how geology influences stream conditions, two streams located in south-central South Dakota were chosen for multiple stream sampling at sites located along their longitudinal profile at points where notable changes in geomorphology were observed. Subsequently, three sites on Bear-in-the-Lodge Creek and three sites on Black Pipe Creek were selected for multiple stream sampling using EMAP-West protocols so that more could be learned about geologic influences on stream conditions.

Values for dissolved oxygen and specific conductance generally increased from upstream to downstream locations on Bear-in-the-Lodge Creek. Values for pH and water temperature generally decreased from upstream to downstream locations. Decreasing water temperature could be indicative of ground-water inflows.

Values for dissolved oxygen, pH, and water temperature generally increased from upstream to downstream locations on Black Pipe Creek. The increase in temperature at the lower sites is a result of less dense riparian cover, and the warmer water also could account for the lower concentrations of dissolved oxygen found in the lower reaches of Black Pipe Creek. Values for specific conductance were more than three times greater at the lower site (1,342 microsiemens per centimeter (µS/cm)) than at the upper site (434 µS/cm). The increase probably occurs when the stream transitions from contacting the underlying Arikaree Formation to contacting the underlying Pierre Shale.

Vertebrate richness was found to be slightly higher for Bear-in-the-Lodge Creek than for Black Pipe Creek. On average, reaches on Bear-in-the-Lodge Creek had a deeper thalweg and wider wetted stream width than Black Pipe Creek. This resulted in a larger habitat volume of aquatic vertebrates in Bear-in-the-Lodge Creek than in Black Pipe Creek and prob-

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ably is the reason for the slightly higher vertebrate richness found in Bear-in-the-Lodge Creek.

Average substrate size decreased in a downstream direction for Bear-in-the-Lodge Creek. In-stream fish cover also transitioned from woody debris to macrophytes in a downstream direction for Bear-in-the-Lodge Creek, whereas the predominate riparian cover transitioned from trees to barren dirt in the lower reaches. The stream channel for Bear-in-the-Lodge Creek largely consisted of riffles in the upper stream reaches and transitioned into glide or glide/riffle combinations in the lower reaches. Rapid habitat assessments metrics generally were scored as good except for sediment deposition and riffle frequency.

Average substrate size increased from silt to fine gravel in a downstream direction for Black Pipe Creek. In-stream fish cover was composed of overhanging vegetation and algae in the upper reaches and transitioned to macrophytes in the lower reaches. However, fish cover was sparse throughout all reaches. Riparian cover largely consisted of grasses and woody shrubs in the upper reaches of Black Pipe Creek and transitioned to grasses and bare dirt in the lower reaches. The stream channel was largely a glide in the upper reaches and transitioned to a glide/riffle in the middle reaches and to a series of interconnected pools in the lower reach. No rapid habitat assessments were completed for the upper reach, but the lower reaches were categorized as poor for most in-stream and near-stream conditions.

Introduction

The Environmental Monitoring and Assessment Program-West (EMAP-West) was initiated in South Dakota in 2000 by the U.S. Environmental Protection Agency (USEPA). The two primary objectives of the surface-water component of the EMAP-West were to (1) develop the monitoring tools (biological indicators, stream survey design, and estimates of reference condition) necessary to produce unbiased estimates of the ecological condition of surface waters across a large geographic area of the West; and (2) demonstrate the effectiveness of those tools in a large-scale assessment (U.S. Environmental Protection Agency, 1998). Although not specifically defined as an objective, data collected during the EMAP-West also will help to establish a baseline for comparisons with data obtained from future monitoring efforts and could be used to document changing ecological conditions resulting from changing land-use or land-management practices associated with regulatory or restorative efforts.

Data collection for EMAP-West was generally limited to perennial streams and rivers; that is, those streams that maintain at least minimal flow throughout all but the driest climatic conditions. Two primary components of EMAP-West included assessments on wadeable streams and on larger, deeper rivers that typically cannot be waded. In South Dakota, all data collection on large rivers was completed by USEPA contractors using rafts. During 2000, USEPA employed contractors to collect data on wadeable streams. In 2001, the South Dakota Department of Game, Fish and Parks (GF&P) assumed the responsibility for overseeing Environmental Monitoring and Assessment Program (EMAP) activities that focused on wadable streams. GF&P subsequently initiated a cooperative agreement with the U.S. Geological Survey (USGS) to conduct the remaining assessments.

Through EMAP, USEPA, USGS, and GF&P have gained valuable information collected in a consistent manner that can be used to more accurately assess the condition of our Nation's and South Dakota's aquatic resources. Furthermore, bioassessment data obtained from EMAP may be used by the South Dakota Department of Environment and Natural Resources (DENR) to develop a set of biocriteria for South Dakota's streams. Biocriteria are a set of narrative descriptions or numerical values that States and Tribes can include in their water-quality standards. The standards can be used along with the chemical and physical data routinely collected by States through their monitoring programs to better manage water resources (U.S. Environmental Protection Agency, 2002).

Purpose and Scope

The primary purpose of this report is to provide an overview of EMAP activities conducted in South Dakota during 2000–2004. This report describes the activities and methods used to conduct assessments on wadable, perennial streams and presents information on the location of selected sites in South Dakota. It describes procedures for accessing the data sets, but does not provide a compilation of the exhaustive data sets.

This report also presents data collected as part of a special effort during 2004 for two streams, Bear-in-the-Lodge Creek and Black Pipe Creek, located in south-central South Dakota. Sampling was conducted at three points along each of these streams to demonstrate how changing geology along the longitudinal stream profiles substantially influences geomorphology and other associated stream conditions. Data pertaining to physical habitat, water chemistry, and vertebrate assemblages are presented. In addition, existing streamflow data available for Bear-in-the-Lodge and Black Pipe Creeks are summarized.

Acknowledgments

Numerous individuals from various agencies provided their assistance and support to the study. Specifically, Dennis Unkenholz of GF&P provided considerable guidance and expertise for fish identifications. Dr. Charles Berry of USGS coordinated the activities of several students who served on the field teams—most notably, Nathan Morey, Vaugn Wassink, Jason Kral, and Bryan Able who collected, field-identified, and enumerated most of the aquatic vertebrate samples. Ryan Thompson, John Clark, Kathy Converse, and Richard Hudson of the USGS collected the physical habitat data. Gene Stueven and Pat Snyder of the DENR, and Michael Kuck of the U.S. Department of Agriculture, Natural Resources Conservation Service, provided valuable assistance with the selection of potential candidate reference sites. The efforts of Tina Laidlaw, Karl Hermann, and David Peck of the USEPA also are greatly appreciated.

Overview of the Environmental Monitoring and Assessment Program

Historically, most of the data collected for USEPA to evaluate the condition of our Nation's surface-water resources have consisted of physical and chemical data, which have been collected by States and Tribes using many different methods. These data have been compiled by USEPA and submitted to Congress in biennial reports called 305b reports (for section 305b of the Clean Water Act).

In the late 1980s, USEPA began to re-evaluate the methods previously used to determine the condition of the Nation's water resources. Several recommendations suggested that USEPA should collect data that could be used to evaluate environmental trends and identify potential problems in their infancy (U.S. Environmental Protection Agency, 1987a). This type of ecological "risk assessment" required development of a core set of indicators of ecological conditions that could be incorporated into the bioassessment process. A risk assessment can be defined as a process of assigning magnitudes and probabilities to the adverse effects of human activities (Suter, 1993).

During the 1990s, USEPA conducted research and monitoring demonstrations through several regional studies, including the Mid-Atlantic Highlands Streams Assessment study, that helped to develop and refine many of the bioassessment monitoring techniques and designs used by EMAP-West (U.S. Environmental Protection Agency, 2000). However, for EMAP-West, some novel tools still had to be developed, primarily to address the large environmental variability encountered throughout the western States (U.S. Environmental Protection Agency, 1998).

In 2000, USEPA initiated EMAP-West with the primary purpose of developing the tools needed to measure the status and trends in the condition of the surface-water resources of the western United States. Special emphasis was placed on developing a core set of biological measurements that would provide reliable bioassessment data for the diverse stream conditions found throughout the West.

Bioassessments largely consist of surveys involving the collection, identification, and enumeration of aquatic biota (algae, invertebrates, and vertebrates) inhabiting a water body and often include estimates of areal density and a categorization of riparian vegetation. Current (2005) thinking is that when bioassessment data are combined with chemical and physical data, the ability to estimate the overall condition of a water body is enhanced, thereby providing more validity and usefulness to water-resources assessments, and a more factual representation of aquatic conditions to our Federal and State decisionmakers.

Physical changes occurring in a water body, such as fluctuations in temperature and sediment concentrations, or chemical changes, such as fluctuations in concentrations of nutrients or trace metals, can serve as stressors and result from both natural and anthropogenic sources. Even subtle changes in physical or chemical conditions can stress more sensitive members of the aquatic community. This can cause a shift in biological integrity that favors the less sensitive and more tolerant aquatic organisms over those that are more sensitive and less tolerant, thus providing the potential for lowering species diversity. Generally speaking, a water body with good biological integrity has the capacity to support a diverse and balanced community of organisms that are representative of the composition found in the natural habitat of the area. Therefore, reliable bioassessment data are required to make meaningful assessments of biological integrity, which in turn, is essential for providing accurate evaluations of the condition of our Nation's surface-water resources.

The resource population of interest for EMAP-West was all perennial streams and rivers represented in USEPA's River Reach File (RF3), with the exception of the lower portions of the "Great Rivers" (the Columbia, Snake, Colorado, and Missouri Rivers). Because it was neither economically feasible nor practical to sample all perennial streams, USEPA developed a probability design to randomly select stream assessment sites that would be statistically representative of the surface waters in the West. The design ensures that streams of all orders are included and that sites will be located throughout the region of interest (Stevens and Olsen, 2004). Thus, the probability of a stream site being selected for assessment is proportional to its length times the weight assigned for its order. EMAP also incorporated a systematic sampling grid, designed to provide a uniform spatial coverage, to ensure that each ecological resource is sampled in proportion to its geographical presence. By incorporating these two site selection processes into EMAP, USEPA believes it provides a valid mechanism that will allow for the extrapolation of results for streams within each State, and for streams in all regions that share similar ecological characteristics (Larsen, 1997).

EMAP Implementation in South Dakota

In 2004, DENR estimated that there were 10,298 mi of major rivers and streams in South Dakota, of which about 7,360 mi or 71 percent have some sparse water-quality data available, largely as a result of compliance monitoring for 305(b) reporting (*http://www.state.sd.us/denr/document.htm*). The GF&P and other cooperating agencies also have collected data related to the distribution and diversity of the State's fish populations, especially in larger streams and rivers. However, for numerous other smaller order streams and tributaries, little or no water quality or fish data are known to exist. Previous monitoring and stream assessment activities likely did not provide detailed data sets collected using consistent methods. Furthermore, the high level of effort associated with conducting complex data-collection activities in remote locations coupled with the costs associated with sample analysis would make in-depth stream assessments impractical and cost prohibitive for the State without EMAP-West.

In South Dakota, data were collected for two different categories of sites: (1) randomly selected sites assigned for assessment by USEPA (fig. 1), and (2) candidate reference sites that were specifically selected for assessment (fig. 2). During 2000, USEPA completed sampling for 22 randomly selected sites (excluding repeat assessments) within South Dakota. During 2001–2003, the USGS and GF&P completed sampling for another 42 randomly selected sites assigned by USEPA, bringing the total to 64 sites. Eighteen repeat assessments were completed at 12 sites in accordance with the EMAP-West quality-assurance plan (U.S. Environmental Protection Agency, 1997b). During 2002–2004, the USGS and GF&P also completed stream assessments for 45 candidate reference sites. Thus, the total number of assessment sites in South Dakota during EMAP-West (2000–2004) was 109. Stream names and location information for assessment sites are summarized in table 1.

Relatively early in the EMAP-West stream assessment process, it became apparent that for some streams in south-central South Dakota, in-stream conditions varied considerably over relatively short distances of only a few miles. These changes appeared to be a result of geomorphologic changes associated with changes in the underlying geology. For these streams, moving a stream assessment site short distances upstream or downstream had the potential to provide substantially different bioassessment data. In order to obtain a better understanding of how geology influences stream conditions, two streams located in south-central South Dakota were chosen for multiple stream sampling at sites located along their longitudinal profile at points where notable changes in geomorphology were observed. Subsequently, three sites on Bear-in-the-Lodge Creek and three sites on Black Pipe Creek were selected for multiple stream sampling so that more could be learned about the geologic influences on stream conditions (fig. 3).

A complete set of core ecological indicators established by USEPA were measured at each stream site whenever possible. The ecological indicators measured included (1) physical habitat (channel and riparian characterization), (2) in-stream characteristics (vegetation and frequency of riffles and pools), (3) aquatic vertebrate assemblages (fish, amphibians, and crayfish), (4) periphyton assemblages (algae), (5) benthic macroinvertebrate assemblages (aquatic organisms without backbones that can be seen with the naked eye), (6) field properties (water temperature, pH, dissolved oxygen, specific conductance, and streamflow), (7) water chemistry (major ions and nutrients), and (8) fish tissue contaminants. However, periphyton and macroinvertebrate samples were not collected for two sites on Bear-in-the-Lodge Creek and for two sites on Black Pipe Creek.

USEPA established an "index" period for stream assessments in an attempt to reduce the effects of temporal variations at selected sites. The index period in South Dakota was between June 1 and August 31, and was when most of the field work was completed during a 5-year period from 2000 through 2004.

Field data were recorded on standardized data sheets (fig. 4) developed by the USEPA's Western Ecology Division (WED) in Corvallis, Oregon. The completed data sheets were returned to WED, where they were optically scanned to facilitate quick entry of the data into the USEPA's database and to minimize data entry errors. The WED also is responsible for tabulating, reviewing, and verifying the large volume of stream assessment data generated by field crews participating in EMAP-West.

Randomly Selected Sites

Once site location information for the randomly selected sites had been obtained from USEPA (coordinates for latitude and longitude in degrees, minutes, and seconds), the location of a site was plotted on a topographic map. The site was then field visited to confirm that the stream was representative of the target population (perennial and wadeable) and to determine the precise location of the site on the stream bank using maps and a Global Positioning System (GPS). Later, a field crew returned to the site to establish the length of the stream reach and to conduct the sampling. USEPA identified several alternate sites that could be substituted for assigned sites when reconnaissance visits indicated that they were unsafe (could not be waded), non-target, or dry, or because site access permission was denied. Sometimes alternate sites were substituted because errors in the sample selection process identified sample locations where no stream was present. These site selection errors were infrequent; however, they may represent a portion of the resource where no assessment data are available.

Samples were collected at 64 randomly selected sites during 2000–2003 (fig. 1; table 1). Twelve of these sites were selected for a total of 18 repeat assessments to provide estimates of important components of variability related to determining current status of the target population and trend detection.

Candidate Reference Sites

In order to provide a means for assessing the relative overall ecological condition of the randomly selected sites throughout South Dakota, it was necessary to establish some standard or benchmark for comparison purposes. Furthermore, estimates of reference condition are specifically included as part of objective 1 for the EMAP-West study design (U.S. Environmental Protection Agency, 1998). In South Dakota,

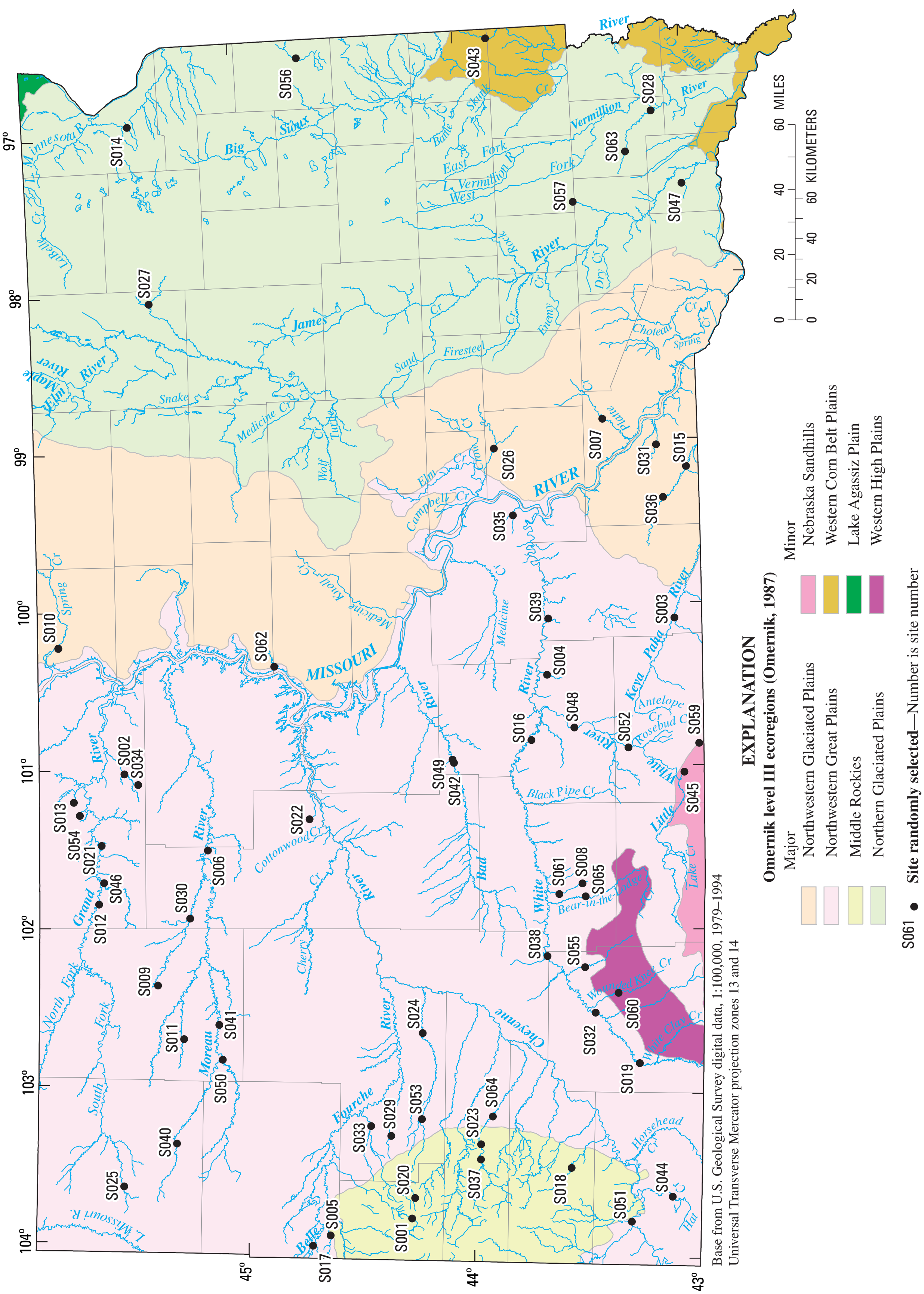

Figure 1. Location of South Dakota EMAP randomly selected wadeable stream sites visited during 2000–2003.

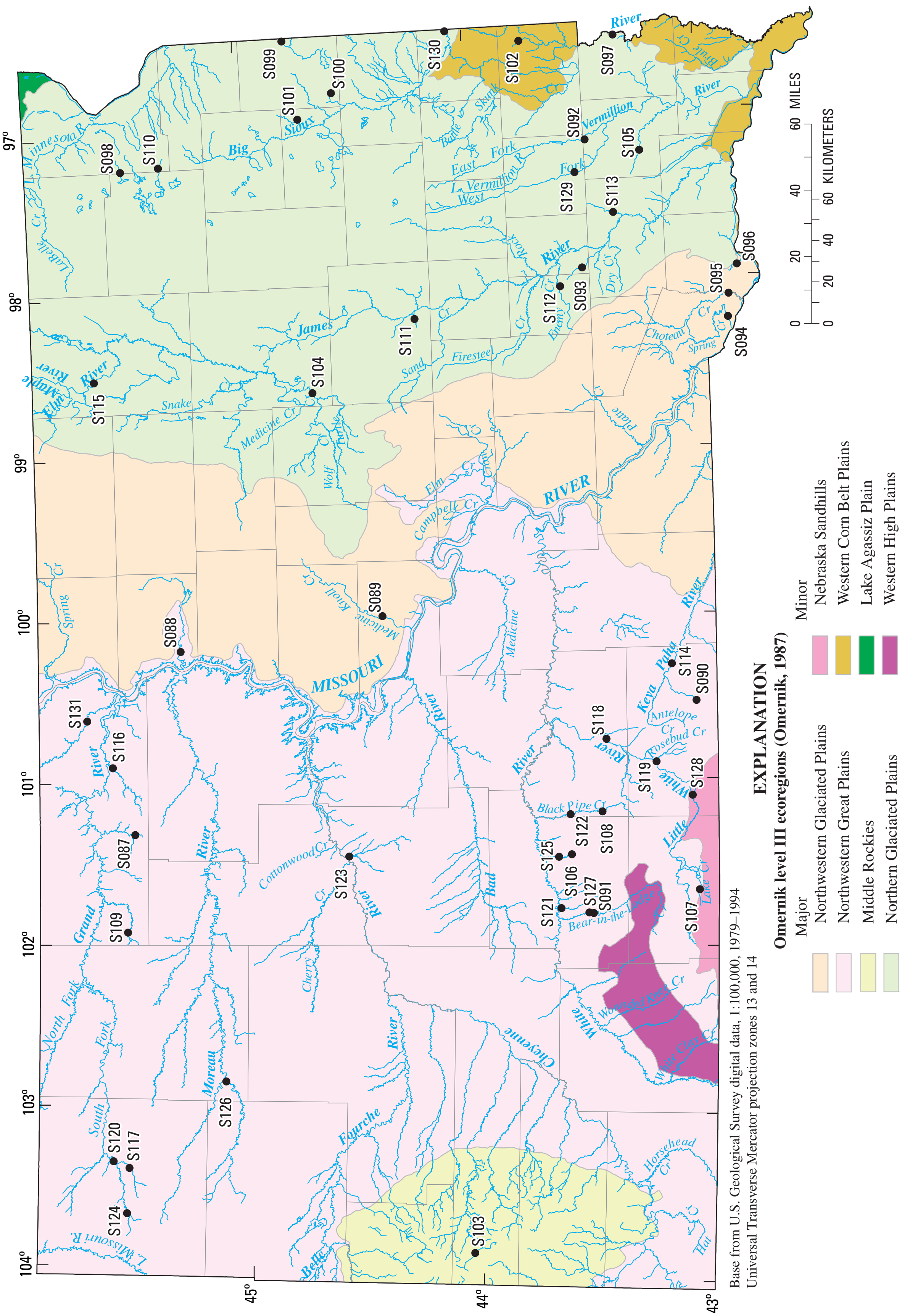

Figure 2. Location of South Dakota EMAP candidate reference sites visited during 2002–2004.

this objective was accomplished by establishing a network of candidate reference sites. These sites were selected for assessment after preliminary field reconnaissance, when it was determined that they appeared to meet an established set of selection criteria, and appeared to have reasonable potential for representing the best available physical, chemical, and biological conditions within each of the four major Omernik Level III Ecoregions (Omernik, 1987) within the State (the Northern Glaciated Plains, the Northwestern Glaciated Plains, the Northwestern Great Plains, and the Middle Rockies). Basically, ecoregions can be defined as areas that share similar types of ecosystems and have similar environmental resources. Locations of the various Level III Ecoregions and locations of the 45 candidate reference sites where assessments were completed are shown in figure 2. Additional candidate reference site information is provided in table 1.

During 2002–2003, USGS and GF&P primarily were responsible for selecting candidate reference sites for assessment. However, assistance with site selection was provided by personnel from various State and Federal agencies, Tribal representatives, various water-resource professionals, and other interested parties. Potential candidate candidate reference sites were screened using criteria developed and agreed upon by representatives from the various agencies listed above. The list of candidate reference site screening criteria is provided in table 3 in the Supplemental Information section at the end of the report.

Once a list of viable candidate reference sites was created using the screening criteria, sites were field visited by a team of hydrologists and further evaluated using a field questionnaire. Candidate reference sites that passed the field screening were ranked by score and the sites with the highest scores were added to the site list, and those sites with lower scores were added to the list of alternate sites.

In 2004, USEPA provided USGS and GF&P with a list of additional candidate reference sites for assessment. The USEPA's list of candidate reference sites was generated with a screening approach using Geographic Information System Technology, aerial photograph interpretation, and validation by field visits or best professional judgment. By the end of the 2004 field season, South Dakota's candidate reference site network totaled 45 sites and included sites selected by both methods. As assessment data are made available, USEPA, GF&P, DENR, and USGS will further evaluate the data to determine if a site remains a viable candidate for the candidate reference site network or if it should be removed.

Availability of Data Sets

During 2000–2004, 109 stream assessments were completed in South Dakota as part of EMAP-West. After field activities were finished, field data sheets were sent to USEPA. The data sheets were scanned and compiled in a database in preparation for analysis. However, as of the date of this report, some of the data sets had not been verified and were not available. Eventually, all the data sets will be archived in the USEPA's STOrage and RETrieval (STORET) database at *http://www.epa.gov/storet*. The EMAP Web site at *http://www.epa.gov/emap/html/dataI/index.html* also contains a list of individuals that should be consulted prior to attempting data retrieval and acquisition. The USEPA currently (2005) is finalizing a report containing statistical summaries of the data sets that include an initial assessment of ecological condition for the entire United States. Plans also are underway to provide a more focused report that describes the data collected specifically for streams in the States comprising USEPA Region VIII.

Table 1. Stream assessment site information for South Dakota EMAP sites visited during 2000–2004.

[EMAP, Environmental Monitoring and Assessment Program]

Site number (number refers to fig. 1 or fig. 2)	Sample ID	Site name	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	County	Date(s) visited Visit 1	Visit 2	Visit 3	Visit 4
		Randomly selected sites sampled 2000–2003							
S001	WSDP99-0502	Whitewood Creek EMAP site near Englewood, SD	441716	1034727	Lawrence	07-18-00	07-18-03		
S002	WSDP99-0503	High Bank Creek EMAP site near Timber Lake, SD	453416	1010059	Corson	07-20-00	07-30-00	06-14-01	07-19-01
S003	WSDP99-0507	Sand Creek EMAP site below Keyapaha, SD	430708	1000604	Tripp	07-30-00	07-02-03		
S004	WSDP99-0508	White Thunder Creek EMAP site near Bad Nation, SD	434118	1002612	Mellette	07-16-00			
S005	WSDP99-0509	Hay Creek EMAP site near Belle Fourche, SD	443856	1035414	Butte	07-09-00	06-11-03		
S006	WSDP99-0510	Moreau River EMAP site near Dewey County line in SD	451200	1013025	Ziebach	06-04-03			
S007	WSDP99-0512	Platte Creek EMAP site above Platte, SD	432449	0985239	Charles Mix	07-31-00	06-24-03		
S008	WSDP99-0514	Eagle Nest Creek EMAP site near Wanblee, SD	433231	1014305	Jackson	07-15-00	06-16-03		
S009	WSDP99-0515	Lone Tree Creek EMAP site near Bison, SD	452532	1022100	Perkins	07-06-00			
S010	WSDP99-0516	Spring Creek EMAP site near Pollock, SD	455120	1001251	Campbell	07-06-00	06-25-03		
S011	WSDP99-0525	Antelope Creek EMAP site near Date, SD	451836	1024113	Perkins	07-07-00	05-03-03		
S012	WSDP99-0526	Grand River EMAP site above Black Horse Butte Creek, SD	454114	1015021	Corson	06-27-02			
S013	WSDP99-0543	Stink Creek EMAP site near Bullhead, SD	454749	1011134	Corson	06-05-03			
S014	WSDP99-0544	No Name Creek EMAP site near Wilmot, SD	452745	0965621	Roberts	07-01-03			
S015	WSDP99-0546	Ponca Creek EMAP site near Herrick, SD	430258	0991052	Gregory	08-12-03			
S016	WSDP99-0547	White River EMAP site near Okaton, SD	434546	1005003	Mellette	07-16-00	08-12-03		
S017	WSDP99-0548	Belle Fourche River EMAP site above Belle Fourche, SD	444333	1035811	Butte	06-12-03			
S018	WSDP99-0561	Beaver Creek EMAP site near Norbeck Lake in SD	433504	1032747	Custer	06-29-00	07-17-03		
S019	WSDP99-0579	White River EMAP site near Redshirt, SD	431714	1024903	Shannon	09-04-01			
S020	WSDP99-0580	Elk Creek EMAP site near Nemo, SD	441636	1033944	Lawrence	06-08-01			
S021	WSDP99-0581	Louse Creek EMAP site near Timber Lake, SD	454033	1012757	Corson	07-18-01			
S022	WSDP99-0582	Dupree Creek EMAP site near Carlin Flat, SD	444458	1011834	Ziebach	06-26-01			

Table 1. Stream assessment site information for South Dakota EMAP sites visited during 2000–2004.—Continued

Site number (number refers to fig. 1 or fig. 2)	Sample ID	Site name	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	County	Date(s) visited: Visit 1	Visit 2	Visit 3	Visit 4
Randomly selected sites sampled 2000–2003—Continued									
S023	WSDP99-0585	Spring Creek EMAP site near Rapid City, SD	435915	1031931	Pennington	06-19-01			
S024	WSDP99-0586	Elk Creek EMAP site above Elm Springs, SD	441459	1023830	Meade	06-21-01			
S025	WSDP99-0587	South Fork of Grand River EMAP site near Buffalo, SD	453412	1033702	Harding	06-12-01			
S026	WSDP99-0588	Smith Creek EMAP site near Kimball, SD	435353	0990210	Brule	07-13-01			
S027	WSDP99-0589	Mud Creek EMAP site near Groton, SD	452419	0980332	Brown	07-12-01			
S028	WSDP99-0590	Turkey Ridge Creek EMAP site near Centerville, SD	430820	0970034	Turner	07-11-01	07-26-01	07-11-02	07-25-02
S029	WSDP99-0593	Alkali Creek EMAP site near Sturgis, SD	442309	1031643	Meade	06-07-01			
S030	WSDP99-0594	Thunder Butte Creek EMAP site near Thunder Butte, SD	451656	1015542	Ziebach	06-26-01			
S031	WSDP99-0596	Whetstone Creek EMAP site near Bonesteel, SD	431047	0990235	Gregory	08-03-01			
S032	WSDP99-0599	White River EMAP site near Rockyford, SD	432903	1023039	Shannon	06-19-02			
S033	WSDP99-0602	Bear Butte Creek EMAP site near Sturgis, SD	442829	1031312	Meade	06-11-01			
S034	WSDP99-0603	Unnamed Creek EMAP site near Timber Lake, SD	453033	1010505	Corson	07-17-01			
S035	WSDP99-0604	Big Creek EMAP site near Oacoma, SD	434920	0992704	Lyman	07-10-01			
S036	WSDP99-0605	Ponca Creek EMAP site near Burke, SD	430919	0992156	Gregory	07-25-01			
S037	WSDP99-0657	Spring Creek EMAP site below Sheridan Lake in SD	435914	1032505	Pennington	06-05-02			
S038	WSDP99-0658	White River EMAP site near Jackson County line in SD	434148	1020949	Shannon	06-17-03			
S039	WSDP99-0660	Cottonwood Creek EMAP site near Presho, SD	434038	1000530	Tripp	07-10-02			
S040	WSDP99-0664	North Fork of Moreau River EMAP site, SD	452012	1032039	Harding	06-26-02			
S041	WSDP99-0665	Moreau River EMAP site, SD	450914	1023548	Perkins	06-25-02			
S042	WSDP99-0666	Bad River EMAP site near Capa, SD	440646	1005702	Jones	07-09-02			
S043	WSDP99-0667	Pipestone Creek EMAP site near Minnesota border in SD	435110	0963041	Moody	07-23-02			
S044	WSDP99-0669	Hat Creek EMAP site near Rumford, SD	430803	1033752	Fall River	06-06-02	06-18-02	06-10-03	08-13-03
S045	WSDP99-0670	Spring Creek EMAP site above Little White River in SD	430509	1010225	Todd	07-12-02			

Table 1. Stream assessment site information for South Dakota EMAP sites visited during 2000–2004.—Continued

Site number (number refers to fig. 1 or fig. 2)	Sample ID	Site name	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	County	Date(s) visited: Visit 1	Visit 2	Visit 3	Visit 4
Randomly selected sites sampled 2000–2003—Continued									
S046	WSDP99-0672	Grand River EMAP site below Black Horse Butte Creek, SD	453957	1014214	Corson	06-12-02			
S047	WSDP99-0674	Beaver Creek EMAP site above Beaver Lake in SD	430110	0972730	Yankton	07-24-02			
S048	WSDP99-0678	Little White River EMAP site at White River, SD	433415	1004545	Mellette	07-18-02			
S049	WSDP99-0679	Bad River EMAP site at Capa, SD	440624	1005814	Jones	07-09-02			
S050	WSDP99-0681	Moreau River EMAP site near Imogene, SD	450812	1024848	Perkins	06-13-02			
S051	WSDP99-0695	Cheyenne River EMAP site, 1.5 mile east of Edgemont, SD	431849	1034712	Fall River	06-18-02			
S052	WSDP99-0696	Little White River EMAP site near Soldier Creek, SD	432000	1005323	Todd	07-17-02			
S053	WSDP99-0697	Elk Creek EMAP site near Bend, SD	441459	1031022	Meade	06-04-02			
S054	WSDP99-0698	White Shirt Creek EMAP site near McIntosh, SD	454615	1011636	Corson	06-11-02			
S055	WSDP99-0501	Medicine Root Creek EMAP site below Kyle, SD	433149	1021355	Shannon	07-11-00			
S056	WSDP99-0505	Cobb Creek EMAP site near Brandt, SD	444148	0963351	Deuel	06-28-00			
S057	WSDP99-0506	Wolf Creek EMAP site near Bridgewater, SD	433015	0973229	McCook	06-30-00			
S059	WSDP99-0521	Bull Creek EMAP site above SD-NE State line in SD	430110	1005205	Todd	07-25-00			
S060	WSDP99-0522	Porcupine Creek EMAP site at Sharps Corner, SD	432256	1022320	Shannon	07-11-00			
S061	WSDP99-0523	Eagle Nest Creek EMAP site near Wanblee, SD	433837	1014659	Jackson	07-13-00			
S062	WSDP99-0527	Artichoke Creek EMAP site at Missouri River near Agar, SD	445353	1002118	Sully	07-22-00			
S063	WSDP99-0533	Turkey Ridge Creek EMAP site near Turkey Ridge, SD	431540	0971503	Turner	06-28-00			
S064	WSDP99-0540	Spring Creek EMAP site below Rockerville, SD	435611	1030914	Pennington	07-06-00			
S065	WSDP99-0541	Bear-in-the-Lodge Creek EMAP site near Potato Creek, SD	433140	1014749	Jackson	07-14-00			
Candidate reference sites sampled 2002–2004									
S087	WSDP02-R001	Firesteel Creek EMAP reference site near Firesteel, SD	453147	1011921	Corson	07-23-02			
S088	WSDP02-R002	Swan Creek EMAP reference site near Akasaka, SD	451923	1001137	Walworth	07-24-02			

Table 1. Stream assessment site information for South Dakota EMAP sites visited during 2000–2004.—Continued

Site number (number refers to fig. 1 or fig. 2)	Sample ID	Site name	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	County	Date(s) visited: Visit 1	Visit 2	Visit 3	Visit 4
Candidate reference sites sampled 2002–2004—Continued									
S089	WSDP02-R003	Medicine Knoll Creek EMAP reference site near Canning, SD	442632	1000001	Hughes	07-25-02			
S090	WSDP02-R004	Rock Creek EMAP reference site near Valentine, NE	430516	1003214	Todd	07-31-02			
S091	WSDP02-R005	Bear-in-the-Lodge Creek EMAP reference site near Wanblee, SD	433226	1014832	Jackson	07-30-02			
S092	WSDP02-R006	East Fork Vermillion River EMAP reference site near Monroe, SD	432932	0970938	Turner	08-01-02			
S093	WSDP02-R007	Twelvemile Creek EMAP reference site near Ethan, SD	433148	0975546	Hanson	08-02-02			
S094	WSDP02-R008	Spring Creek EMAP reference site near Greenwood, SD	425421	0981520	Charles Mix	08-06-02			
S095	WSDP02-R009	Choteau Creek EMAP reference site near Avon, SD	425402	0980702	Charles Mix	08-06-02			
S096	WSDP02-R010	Emanuel Creek EMAP reference site near Springfield, SD	425133	0975638	Bon Homme	08-07-02			
S097	WSDP02-R011	Peterson Creek EMAP reference site near Canton, SD	432053	0963236	Lincoln	08-08-02			
S098	WSDP02-R012	Chekapa Creek EMAP reference site near Grenville, SD	453051	0971329	Roberts	08-13-02			
S099	WSDP02-R013	West Fork Lac qui Parle River EMAP reference site near Gary, SD	444700	0962813	Deuel	08-14-02			
S100	WSDP02-R014	Peg Munky Run EMAP reference site near Estelline, SD	443455	0964812	Deuel	08-14-02			
S101	WSDP02-R015	Stray Horse Creek EMAP reference site near Castlewood, SD	444402	0965709	Hamlin	08-14-02			
S102	WSDP02-R016	West Pipestone Creek EMAP reference site near Sherman, SD	434522	0963256	Minnehaha	08-16-02			
S103	WSDP03-R017	Castle Creek EMAP reference site near Deerfield Lake in SD	440230	1035156	Pennington	07-07-03			
S104	WSDP03-R018	Turtle Creek EMAP reference site near confluence at Wolf Creek in SD	444313	0983743	Spink	07-16-03			
S105	WSDP03-R019	Turkey Ridge Creek EMAP reference site near Turkey Ridge, SD	431530	0971428	Turner	07-31-03			

Table 1. Stream assessment site information for South Dakota EMAP sites visited during 2000–2004.—Continued

Site number (number refers to fig. 1 or fig. 2)	Sample ID	Site name	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	County	Date(s) visited Visit 1	Visit 2	Visit 3	Visit 4
		Candidate reference sites sampled 2002–2004—Continued							
S106	WSDP03-R020	Pass Creek EMAP reference site near Hwy 44 in SD	433801	1012723	Jackson	07-08-03			
S107	WSDP03-R021	Lake Creek EMAP reference site near Lacreek National Wildlife Refuge in SD	430448	1014004	Bennett	08-05-03			
S108	WSDP03-R022	Blackpipe Creek EMAP reference site near Hwy 63 in SD	433005	1011200	Mellette	07-10-03			
S109	WSDP03-R023	Blackhorse Butte Creek EMAP reference site near Meadow, SD	453350	1015527	Corson	07-22-03			
S110	WSDP03-R025	Owens Creek EMAP reference site near Ortley, SD	452055	0971232	Roberts	07-24-03			
S111	WSDP03-R026	Cain Creek EMAP reference site near confluence at James River in SD	441552	0981155	Beadle	07-15-03			
S112	WSDP03-R027	Enemy Creek EMAP reference site below Mitchell, SD	433743	0980217	Davison	07-17-03			
S113	WSDP03-R028	Wolf Creek EMAP reference site near Wolf Creek Colony, SD	432305	0973620	Hutchin-son	07-30-03			
S114	WSDP03-R029	Keya Paha River EMAP reference site near Hidden Timber, SD	431130	1001859	Todd	08-06-03			
S115	WSDP03-R032	Elm Creek EMAP reference site near Westport, SD	454002	0983111	Brown	07-29-03			
S116	WSDP04-R033	High Bank Creek EMAP reference site near Little Eagle, SD	453733	1005426	Corson	06-22-04			
S117	WSDP04-R034	Clarks Fork Creek EMAP reference site near Buffalo, SD	453256	1032255	Harding	06-03-04			
S118	WSDP04-R035	Little White River EMAP reference site south Hwy 44 near White River, SD	432851	1004548	Mellette	07-08-04			
S119	WSDP04-R036	Little White River EMAP reference site at Ghost Hawk Park, near Rosebud, SD	431554	1005402	Todd	07-06-04			
S120	WSDP04-R038	South Fork Grand River EMAP reference site near Buffalo, SD	453707	1032031	Harding	06-02-04			
S121	WSDP04-R040	Eagle Nest Creek EMAP reference site near Interior, SD	434049	1014644	Jackson	06-14-04			
S122	WSDP04-R041	Black Pipe Creek EMAP reference site north Hwy 44 near Norris, SD	433822	1011255	Mellette	06-09-04			
S123	WSDP04-R044	Plum Creek EMAP reference site near Cherry Creek, SD	443559	1012744	Haakon	06-21-04			

Table 1. Stream assessment site information for South Dakota EMAP sites visited during 2000–2004.—Continued

Site number (number refers to fig. 1 or fig. 2)	Sample ID	Site name	Latitude (degrees, minutes, seconds)	Longitude (degrees, minutes, seconds)	County	Date(s) visited: Visit 1	Visit 2	Visit 3	Visit 4
Candidate reference sites sampled 2002–2004—Continued									
S124	WSDP04-R045	South Fork Grand River EMAP reference site above Buffalo, SD	453324	1033944	Harding	06-04-04			
S125	WSDP04-R046	Pass Creek EMAP reference site near Kadoka, SD	434126	1012807	Jackson	06-07-04			
S126	WSDP04-R047	South Fork Moreau River EMAP reference site below Zeona, SD	450801	1025030	Perkins	06-01-04			
S127	WSDP04-R048	Bear-in-the-Lodge Creek EMAP reference site below Wanblee, SD	433338	1014821	Jackson	06-05-04			
S128	WSDP04-R049	Little White River EMAP reference site near Spring Creek, SD	430631	1010613	Todd	07-07-04			
S129	WSDP04-R050	West Fork Vermillion River EMAP reference site near Stanley Corner, SD	433240	0972115	McCook	07-09-04			
S130	WSDP04-R051	Flandreau Creek EMAP reference site near Flandreau, SD	440428	0962754	Moody	07-01-04			
S131	WSDP04-R052	Oak Creek EMAP reference site near Mahto, SD	454406	1003654	Corson	06-23-04			

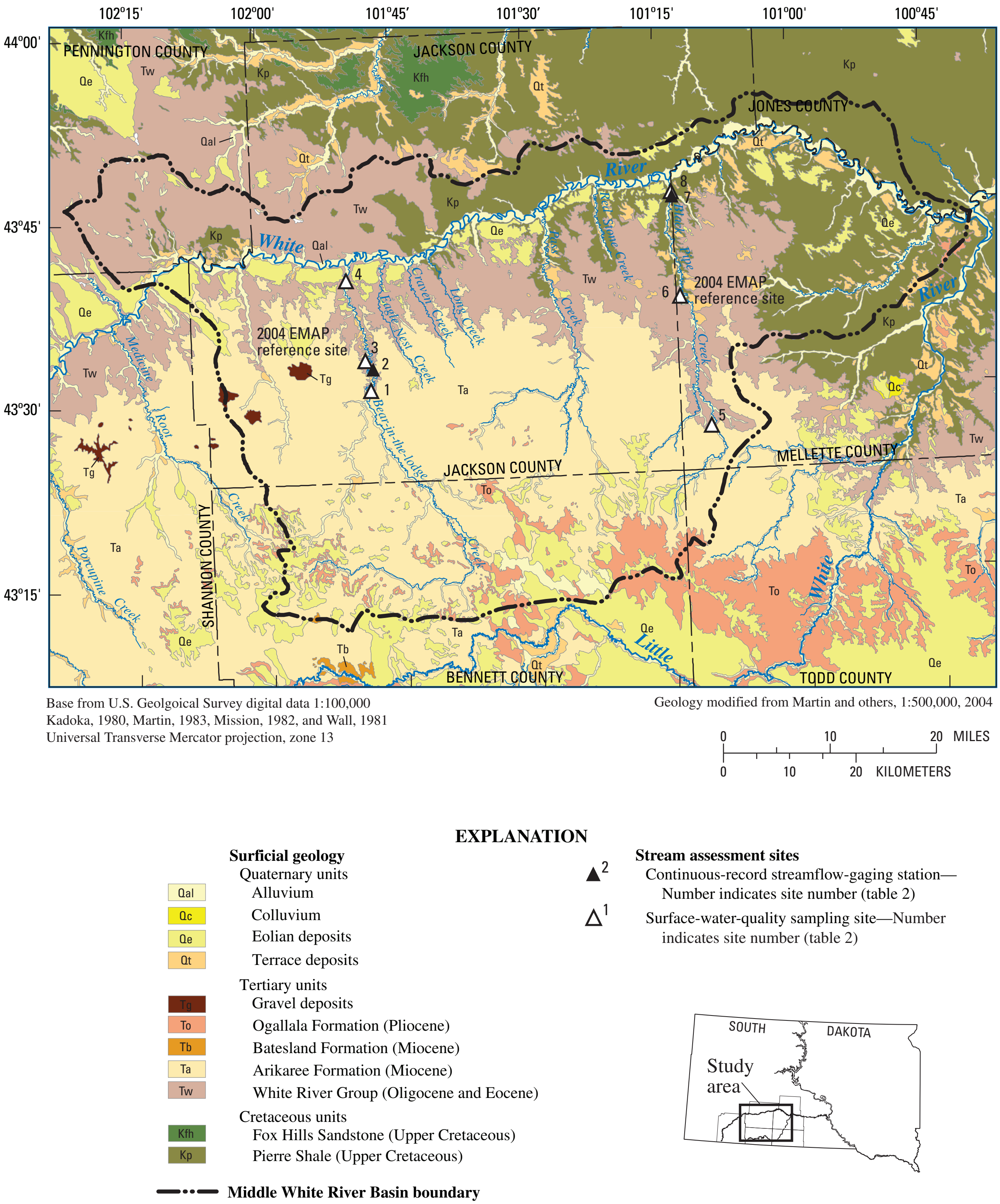

Figure 3. Generalized geologic map showing surficial geology of a part of the White River Basin and location of multiple assessment sites in the study area.

Figure 4. Field data were recorded on standardized field data sheets during field activities.

Methods and Activities

This section of the report contains an overview of EMAP methods for data collection and a description of the types of data collected during stream assessments. Methods are described for characterizing physical stream attributes, collecting vertebrate and invertebrate data, and assessing water quality. Methods used to characterize geologic influences on stream conditions also are described.

Methods for Characterization of Physical Stream Attributes

Most of the methods used for assessing stream condition during EMAP-West were developed during previous EMAP studies conducted by USEPA. The methods were developed jointly by investigators working at the USEPA's National Exposure Research Laboratory (NERL) in Cincinnati, Ohio, and by the National Health and Environmental Effects Research Laboratory (NHEERL) in Corvallis, Oregon.

The methods described in this section of the report are taken from Peck and others (2003). A more thorough discussion of the following methods can be found in that document.

Reach Layout

One of the first tasks for characterization of physical stream attributes was for the field crew to establish the sampling reach. To ensure that an accurate representation of environmental conditions and biota are obtained, a sufficient stream length needs to be sampled. Previous studies conducted by USEPA have shown that assessing a stream reach that is equivalent to 40 channel widths in length will generally yield about 90 percent of the fish species present (Reynolds and others, 2003). Similar considerations for other factors led to development of EMAP protocol that stream reaches should be at least 40 channel-widths long or a minimum of 150 meters (m), whichever is longer.

The randomly selected site location coordinates (latitude and longitude) provided by USEPA were designated as the "X-site." For each stream site, the mean wetted width at the X-site was determined and then multiplied by 40 to get the total length of the stream reach to be assessed (fig. 5). The stream reach was then divided into 11 equally spaced transects, five upstream and five downstream from the X-site, creating 10 segments that were each four stream-widths long (fig. 6). In cases where the wetted width of the stream at the X-site was fairly narrow (less than 3.75 m), each of the 10 segments was assigned a length of 15 m. Therefore, either process produced 10 equally spaced segments separated by 11 transects that were subsequently labeled from A to K. Typically, the A transect represented the most downstream transect and K represented the most upstream transect. The middle or F transect typically represented the location of the X-site.

Channel Dimensions and Bank Characteristics

At each of the 11 stream transects (labeled A to K; fig. 5) the wetted width of the stream was measured and recorded on field forms in order to determine channel dimensions present throughout the designated stream assessment reach (fig. 7). Measurements of channel width allow for the determination of the stream's structural complexity and when coupled with depth measurements, provide a mechanism for estimating stream volume throughout the reach.

Bank characteristics include several measurements such as estimates of bank angle, undercutting, and bankfull flow during base-flow conditions. Bank angle is determined for both banks at each of the 11 transects. To accomplish this, a rod was laid on the bank with one end at the water's edge, then a clinometer was placed on the rod to obtain the bank angle.

Measurements of bank characteristics also include estimates of the extent of bank undercutting, channel incision, and height of bankfull flow above the present water-surface elevation. The extent of bank undercutting was determined by measuring the horizontal distance from the deepest point of the undercut to a point on the end of the protruding overhang of the bank to where a vertical plumb line would hit the water's surface. The length of the measured section provides an estimate of the extent of bank undercutting.

An estimate of channel incision was obtained when a surveyor's rod was held perpendicular to the water surface just at the edge of the water. Channel incision was determined to be the height up from the water's surface to the first terrace of the valley floodplain. Height estimates generally were determined only by sighting.

Estimates for the height of bankfull flow above the present base-flow water level were made by placing a surveyor's rod at the water's edge while observing the physical evidence

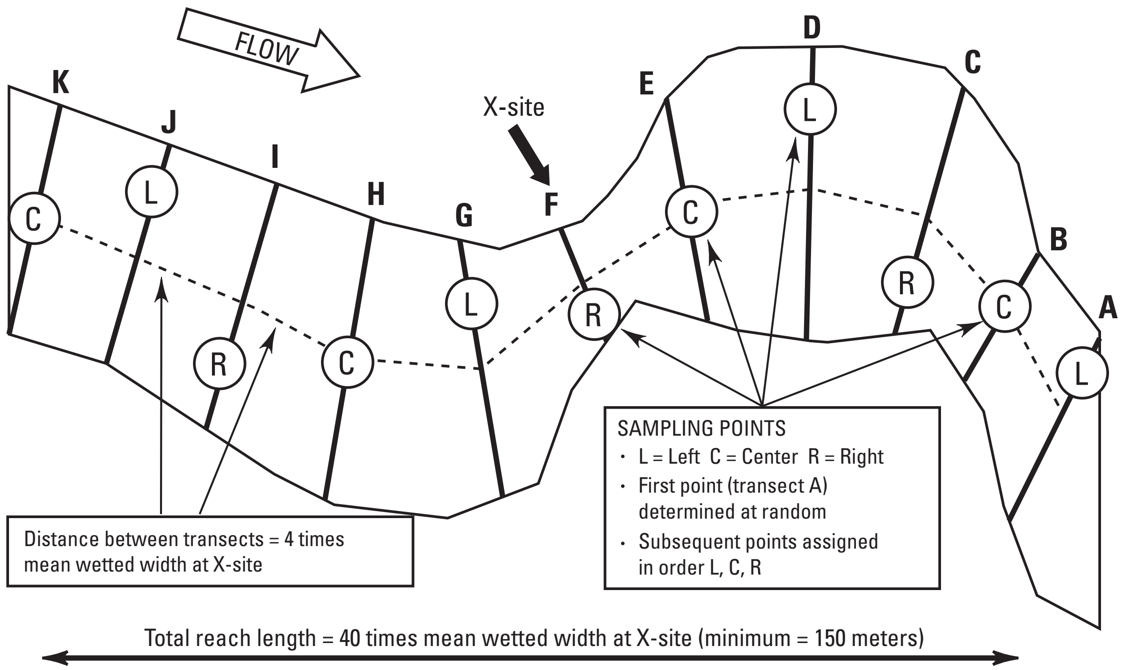

Figure 5. Depiction of a stream reach layout (reproduced from Environmental Monitoring and Assessment Program-Western Pilot field manual courtesy of U.S. Environmental Protection Agency).

on the stream banks, then estimating their elevation using the rod. Physical evidence consisted of locating areas where stream sediments transitioned to terrestrial vegetation. Other examples of physical evidence include the presence of moss on rocks along the bank and the presence of drift material deposited along the bank and on the overhanging vegetation. After identifying areas of bankfull flow on each bank, the width of the stream was measured between the two points and recorded. This allowed for calculation of stream volume at bankfull flow.

Figure 6. Field crew members laying out a transect.

Thalweg Measurements

The term "thalweg" refers to the deepest portion of the stream channel. Typically, depth measurements were collected at 100 to 150 equally spaced points throughout the reach, and the resulting data can be used to construct a thalweg profile, which provides a longitudinal representation of channel depth. The depth measurements also can provide valuable information about stream size and channel complexity as well as the location and relative size of riffles and pools. During thalweg measurements, the location and width of sand or gravel bars also were noted and recorded.

The number of depth measurements and spacing between them was based on the wetted width of the stream at each transect. At places where the pools were too deep to be waded, a calibrated surveyor's rod was rested on the bottom of the pool, and a clinometer was laid on the rod to measure the angle of insertion. The depth reading from the rod also was recorded. Using those two values, a pool depth was calculated.

Substrate Size and Type

Characterization of the substrate is a critical component of any bioassessment because the substrate size and type (silt, sand, gravel, and cobbles) have a large influence on the composition and diversity of aquatic invertebrates and vertebrates inhabiting a stream. Substrate size also has a direct influence on both hydraulic roughness and stream velocity. Furthermore, a large percentage of fine sediments can provide an indication

Figure 7. Field crew members measured the wetted stream width to determine channel dimensions throughout the designated stream assessment reach.

of the extent that erosional processes are occurring upstream, and sometimes can be linked to anthropogenic activities such as logging, mining, and farming within the drainage basin.

To provide an accurate determination of substrate size and type, bed materials were categorized into various classes and sizes according to classifications provided by the U.S. Environmental Protection Agency (2001). Determinations of substrate size and type were made at five locations along each transect (5-point pebble-counts), at points equal to 100 (right stream bank), 75, 50, 25, and 0 percent (left stream bank) of the wetted width of the individual transect. Five-point pebble-counts also were made at locations midway between established transects so that data were collected from 21 transects at a total of 105 points along the stream reach.

The extent (average percent) of embeddedness also was estimated at points where substrate size and type were measured, but only at transects A through K. At these points, embeddedness was estimated within the area of a circle approximately 10 centimeters (cm) in diameter. Embeddedness is an estimate of the extent that bed materials are buried in bottom sediments that are the size of sand grains (0.06–2 millimeters (mm) in diameter) or smaller; thus, sands and silts were considered to be 100-percent embedded, whereas bedrock and hardpan were considered to be 0-percent embedded.

Riparian Vegetation Cover and Structure

Riparian vegetation has important influences on stream condition. Tall trees provide a canopy over the stream that provides shade and lowers water temperature. Leaves from overhanging trees fall into the stream and become food for aquatic insects and provide a source of particulate organic material for other organisms. Limbs from these trees also fall into the stream and provide additional organic material and habitat for insects, algae, and fish. Terrestrial vegetation provides bank stability that can reduce sediment loading. The presence of non-native or invasive species of plants or agricultural crops within the riparian corridor also provides a means of assessing potential effects of anthropogenic activities.

Stream canopy cover was measured using a spherical convex canopy densiometer. Measurements were made at mid-channel, right edge of water, and left edge of water on all 11 transects (A–K). Readings were made holding the densiometer 0.3 m above the water surface while facing upstream, right bank, downstream, and left bank.

Terrestrial vegetation and structure were estimated for three conceptual layers near or above the stream—the canopy layer consisting of vegetation greater than 5 m in height, the understory layer consisting of vegetation from 0.5 to 5 m in height, and the ground cover layer consisting of vegetation less than 0.5 m in height. At the mid-channel point of each transect, an area was visualized that extended 5 m upstream and 5 m downstream and 10 m out from both stream banks. Within these two areas, visual estimates were made to determine the dominant vegetation type and areal extent for each of the three layers. Various keys were used to assist with the identification of trees and non-native or invasive plants.

Streamflow

The EMAP study design established an index period for conducting stream assessments that roughly runs from the beginning of June through the end of August. The intent of establishing this index period was to conduct assessments under steady or base-flow conditions. Sampling during high-flow conditions likely would produce different chemical and biological data than those obtained during stable base-flow conditions. Furthermore, it is difficult and potentially dangerous to conduct assessments when the water is high and turbid. No assessments were made when streams appeared to be approaching bankfull levels, or when streams where located in very remote areas where recent rainfall made access difficult. Visits to sites were rescheduled when unfavorable conditions were encountered.

Streamflow was determined at most assessment sites (fig. 8) at the Xsite coordinates provided by USEPA using methods established by USGS (Rantz and others, 1982). Streamflow at some sites could not be measured because the water level was too low to measure. For those sites, only visual estimates of streamflow were provided. Some sites consisted of only a series of intermittent pools of varying sizes and subsequently only estimates, or no streamflow data, were reported for those sites.

Stream Gradient

The velocity of a stream is greatly influenced by stream gradient. Increases in stream gradient increase velocity, thereby increasing the stream's ability to erode and transport

Figure 8. A field crew member making a stream discharge measurement at the “X-site.”

sediments. Changes in gradient along the longitudinal profile of a stream also enhances the diversity and complexity of the aquatic habitat. As velocity increases, streamflow changes from laminar to turbulent flow. The resulting turbulent flow helps facilitate the exchange of gases between the stream and the atmosphere.

Measurement of stream gradient was completed by a two-person team with each person having a surveyor’s pole flagged at exactly the same height. Measurements were made starting at the downstream end of the reach and were accomplished by backsiting. For example, one person would stand at the water’s edge at transect A while the other person would stand at the water’s edge at transect B. Team members used a clinometer to measure the percent slope between the two transects. One person would stand at the upstream transect and hold the clinometer at the previously flagged level on their pole and backsite to the flagged level on the downstream pole and record the percent slope between the two points. This process would be repeated by moving upstream until the gradient between each successive transect was measured. At points where there was no direct line of site between transects, intermediate measurements were made and recorded at points between transects.

Methods for Collecting Vertebrate Data

The purpose of collecting vertebrate data was to determine their relative abundance throughout the assessment reach and to identify any obvious external abnormalities present on the specimens (fig. 9). Trained biologists from GF&P or from South Dakota State University conducted the sampling and identification activities. Following identification, fish were measured, inspected, and returned to the stream as soon as possible (fig. 10). State or Federally listed species were photographed on a measuring board next to a card containing the stream name and date of collection, then were immediately returned to the water. Overall, mortality rates generally were very low. Some specimens that proved difficult to identify in the field were sent to the Smithsonian Institution in Washington, D.C., for identification. Only amphibians and fish were counted; reptiles were not included in the tallies. Crayfish also were tallied when collected to provide information related to potentially introduced species.

Voucher specimens were collected whenever possible. These specimens will provide a permanent, archived, historical record of fish collections. After the required data were recorded, selected specimens were anesthetized, placed in nylon mesh bags, then put into a labeled jar containing a formalin preservation solution. Some vouchered samples were used for analysis of fish tissue contaminants. All vouchered samples were shipped to the National Museum of Natural History in Washington, D.C., for confirmation of identification and for permanent cataloging.

All areas between established transects were sampled unless they were too deep to wade or the pools were to small and shallow to hold any targeted organisms. Vertebrate samples were collected using either seining or electrofishing

Figure 9. Field crew biologists documented abnormalities visible on vertebrate specimens.

Figure 10. Vertebrate specimens, such as this Shorthead Redhorse, were measured following the collection and identification process.

Figure 11. Field crew members identified vertebrate species while electrofishing.

methods. Seining was used when streams appeared turbid, when field measurements indicated that stream conductivity was too high for electrofishing, or when the presence of Topeka Shiners (an endangered species) was possible.

Seining

A two-person seine with a mesh size of 0.6 cm was used when stream conditions dictated. Seining began at the downstream end of the reach (A transect) and proceeded upstream. Riffle, pool, and snag habitats were sampled when present. As seining progressed to the next transect upstream, the contents of the seine were dumped into buckets and the biologists began tallying and recording the data. This procedure was repeated until the crew reached the final upstream (K) transect.

Electrofishing

Most of the vertebrate samples were collected by seining. However, a Smith-Root model 12-B, P.O.W. backpack electrofishing unit (DC pulsed; volts 100 to 600; pulse rate of 60 hertz and a pulse width of 2-6 milliseconds) was used at several stream assessment sites where conductivities generally were low and the water was clear (fig. 11). Electrofishing in large streams typically required the efforts of all four team members. Team members in the stream wore waders and rubber gloves to prevent being shocked. Netters were careful not to touch the water or the anode while the shocking unit was operating. The person operating the backpack shocker often held the anode in one hand and a dip net in the other hand (fig. 11) and typically worked a net from the middle of the stream over to the right bank, while a second person worked a net from the middle of the stream to the left bank. A third person followed behind the operator with yet another net. Netted vertebrates were placed in buckets carried along by the netters in the stream and were later emptied into larger buckets positioned on shore at the next upstream transect. The fourth team member stayed on the bank and initiated the identification and enumeration process. Shocking proceeded in a similar manner as seining, from downstream to upstream. Two people could complete the electrofishing on small creeks and streams.

Methods for Collecting Invertebrate Data

Aquatic invertebrate samples collected during EMAP-West consisted of both benthic and periphyton macroinvertebrates. Both of these macroinvertebrates serve as very useful indicators of aquatic condition because they tend to respond rapidly to changing environmental conditions, often in very different ways (Fore and others, 1996). The type of response can sometimes be linked to a particular type of stressor such as nutrient enrichment or exposure to toxic metals, herbicides, or other forms of aquatic contamination.

Because benthic macroinvertebrates are not very mobile, are relatively easy to catch, and often live in the aquatic environment for a year or more, they provide a convenient method for assessing the biological integrity of a stream. Therefore, much can be learned about the short-term history of in-stream conditions by looking at benthic macroinvertebrate species diversity and community composition.

Benthic Macroinvertebrates

The term "benthic macroinvertebrate" generally is used to describe organisms that live in the bottom substrate of freshwater environments during part of their life cycle. For many years, the usefulness of benthic macroinvertebrate data for assessing stream conditions was not fully appreciated. However, recent advances associated with quantitative sampling methods, analytical processes, taxonomy, and identification methodology, followed by the compilation of toxicological data related to species' response to pollution, have all served to strengthen the case for making benthic macroinvertebrate data an integral part of biomonitoring programs. Although the costs of collecting benthic macroinvertebrate samples are relatively low, large numbers of organisms are needed in order to provide more precise estimates of population abundance, and substantial costs can be incurred as a result of sample processing and identification (Rosenberg and Resh, 2001). The USEPA has recognized the importance of benthic macroinvertebrate data for assessing stream condition and biological integrity and has incorporated data-collection and analysis activities into the EMAP stream assessment process (Klemm and others, 1990).

Two types of benthic macroinvertebrate samples were collected—reach-wide and targeted riffle. The reach-wide samples were collected at the same time and from the same locations where periphyton samples were collected. Samples were collected using a 500-micron (µm) mesh D-frame kick net that had an opening width of 12 in. The opening of the net was placed facing upstream so that the current swept dislodged organisms into the net. A 1-ft^2 area directly in front of the net was visualized, and all loose rocks and substrate particles (larger than a golf ball) that were more than halfway inside the 1-ft^2 area were picked up and scrubbed with a brush so that any dislodged organisms were carried into the net by the current. Cleaned rocks were then returned to the stream bed outside the 1-ft^2 area in front of the net. The substrate area in front of the net was then vigorously disturbed for 30 seconds by kicking. Samples were rinsed into a bucket and composited with reach-wide samples obtained from the other transects.

Targeted riffle samples were collected using methods described for reach-wide samples. However, a minimum of eight 1-ft^2 areas were required for a sample to be collected. Multiple areas on a single riffle could be sampled to obtain the eight samples necessary in the event that the reach consisted largely of pool-glide type habitat. All eight targeted riffle samples were combined into a single composite sample prior to processing.

Sample processing for reach-wide and targeted riffle samples consisted of screening samples of each type through a 500-µm mesh sieve (fig. 12) to remove as much debris and sediment as possible. Rinse bottles filled with stream water were used to facilitate this process. Samples were then rinsed into containers labeled as reach-wide or targeted riffle and preserved with 95-percent ethanol.

Figure 12. Field crew members processing benthic macroinvertebrates.

Periphyton

Periphyton encompasses several types of aquatic organisms including algae, fungi, bacteria, protozoans, and other organic matter. For EMAP, periphyton samples were collected from both erosional and depositional habitats and then composited into a single reach-wide sample for processing. Erosional habitats consisted of rapidly flowing areas of the stream such as riffles where submerged rocks or woody debris were present. Depositional habitats consisted mostly of pools where flows were diminished.

Sampling started at the most downstream (A) transect and proceeded upstream. The starting position on the A transect was randomly selected from one of three positions (right bank, left bank, center channel) and alternated as sampling progressed upstream. Thus, if the right bank was randomly selected for the A transect, periphyton would be collected from the B transect at the left bank position and from the C transect at the center channel position alternating until all 11 transects were sampled (fig. 5).

For riffle habitats, a delimeter with an inside area of 12 square centimeters (cm^2) was placed on the upper surface of a rock that was completely submerged, and the area was brushed with a toothbrush for about 30 seconds and then the scrubbed area was rinsed through a funnel into a 500-milliliter (mL) bottle and composited. For depositional areas, the delimeter was placed on the stream bed, and the top 1 cm of bottom material within the delimited area was sucked into a 60-mL syringe and composited.

After sampling, a 50-mL aliquot of the composite was put into a small sealable container and preserved with a 10-percent formalin solution and labeled "identification and enumeration" sample. Another 50-mL aliquot of the composite was placed in another small sealable container and labeled "acid/alkaline phosphatase activity," and the sample was placed on ice. A third aliquot consisting of 25 mL of the composite sample was filtered through a glass fiber filter, and the filter and filtrate were placed into a small sealable container and labeled "biomass sample" then placed on ice. A fourth aliquot consisting of 25 mL of the composite sample was filtered through a glass-fiber filter, and the filter and the filtrate were placed in another small resealable container and labeled "chlorophyll sample," then put in a resealable bag and placed on ice.

Methods for Assessing Water Quality

Two methods were used to assess stream-water quality for EMAP-West. Field measurements were made using submersible multi-probe instrumentation that provided instantaneous *in situ* measurements of stream-water quality for four properties: (1) dissolved oxygen, (2) pH, (3) specific conductance, and (4) water temperature. Field measurements were made at the approximate location of the centroid of flow at the X-site (F transect; fig. 5).

Aliquots of stream water also were collected and sent to WED for analysis. Water samples were collected by team members wearing latex surgical gloves to prevent sample contamination. Samples were collected from the centroid of flow and put into a 4-liter (L) acid rinsed container that was completely filled to remove any trapped air. The container was tightly sealed, labeled, and placed immediately on ice. Samples were shipped in a cooler filled with ice to USEPA by an express service. Following receipt, the chilled water sample was filtered and preserved by USEPA, generally within 72 hours of sample collection. Concentrations of trace elements, major ions, nutrients, and turbidity were measured from aliquots taken from this sample.

Additional water samples were collected in two 50-mL sterile syringes that were held underwater and filled, and then held upright while the air was ejected from the syringe. Syringe water was used largely for the analysis of pH and dissolved inorganic carbon. Specially designed teflon syringe locks were used to protect samples from exchanging carbon dioxide with the atmosphere. Filled and locked syringes were labeled, sealed into special shipping containers, placed in the ice chest, and sent with the other time-dependant samples to USEPA.

Quality Assurance and Quality Control

Quality assurance is a required element of all USEPA-sponsored studies that involve the collection and analysis of environmental samples (U.S. Environmental Protection Agency, 2003). This meant that all participants of the field teams received in-depth training on methods and procedures from USEPA or from experienced USGS personnel that had successfully completed the training and had previously served as field crew members. All field crew members also were provided with copies of the EMAP-West field manual and the quality-assurance plan (U.S. Environmental Protection Agency, 1997). Field team leaders also were provided with phone numbers of USEPA contacts that could provide additional guidance and information.

Twelve sites (approximately 15–20 percent) were revisited for repeat assessments, either during the same field season or during successive field seasons, to assess the variability and precision of the various methods used to measure ecological indicators (Larsen, 1997). Furthermore, annual field audits were conducted by USEPA personnel during actual stream visits, and the entire stream assessment process was evaluated for compliance with EMAP methods and protocols.

Field Measurements

Field measurements were completed using submersible multi-probe water-quality instruments that were calibrated each time they were used (fig. 13). Instrument calibration followed guidelines established by the manufacturer and guidelines for field measurements outlined in the USGS National Field Manual for the Collection of Water-Quality Data (U.S. Geological Survey, 1997–2004). All calibration data were recorded in logbooks that accompanied each instrument into the field and included the operator's observations about instrument performance and maintenance. USGS employees with the responsibility of collecting water-quality data generally receive 2 weeks of intensive training at the USGS National Training Center in Denver, Colorado, where they learn the theories and methods used for the collection of ground-water and surface-water samples. USGS field personnel that routinely collect field measurement data that are entered into the national database also are required to participate in the National Field Quality Assurance Program that audits the performance of instruments and operators on at least an annual basis (Stanley, 1996).

Figure 13. Crew members calibrated water-quality instruments prior to collecting field measurements.

Calibration standards were purchased from the USGS Quality of Water Service Unit in Ocala, Florida, or from the National Water Quality Laboratory in Denver, Colorado. Prior to calibration, an aliquot of stream water was analyzed, and then calibration standards were selected that bracketed the expected value for the stream water. The instrument was then calibrated using the appropriate standard(s). Only valid standards were used for instrument calibration; standards that exceeded expiration dates were discarded. Standards for pH and specific conductance were immersed in the stream for about 20 minutes prior to instrument calibration so that the temperature of the stream and the standards were similar. Generally, two-point calibrations were used for pH and specific conductance. Measurements generally were recorded on field sheets when the instrument stabilized and when two consecutive readings varied by less than 0.3 milligram per liter for dissolved oxygen, 0.1 pH unit, 5 percent for specific conductance, and 0.2°C for water temperature.

Chemical Analysis

The chemical analysis of stream water samples was completed by the USEPA or their contract laboratories. A list of associated data reporting criteria and methods used for the chemical analysis of water samples are presented in tables 4 and 5, respectively, in the Supplemental Information section (U.S. Environmental Protection Agency, written commun., 2005). That communication also summarizes the methods for the collection, handling, processing, analysis, and management of EMAP data.

Methods for Characterizing Geologic Influences on Stream Condition

Geology can have a substantial influence on the natural conditions of a stream and further complicates the evaluation of human influences on stream condition. One obvious example of this occurs when streams transition from mountainous reaches with steep gradients to plains reaches with lesser gradients. More subtle changes can occur in other settings as well. A series of field surveys, incorporating many of the methods previously described for conducting stream assessments for the EMAP-West, were conducted at several predetermined points along the longitudinal profile of two streams—Bear-in-the-Lodge and Black Pipe Creeks—in order to demonstrate the geologic influences on stream condition.

Physical habitat and vertebrate data were collected at three sites along the longitudinal profiles of Bear-in-the-Lodge Creek and Black Pipe Creek (fig. 3) during a one-time assessment in 2004, in order to document differences between upstream sites and downstream sites with respect to in-stream and near-stream conditions. Along with physical habitat and vertebrate data, water chemistry data were collected only at the middle site on each stream. Site number and site type are provided in table 2.

The middle site on each stream was selected by USEPA as an assessment site for EMAP-West. Data-collection activities at these two sites (table 2, sites 3 and 6) included assessments of physical, chemical, and biological conditions. Samples for the analysis of water chemistry and benthic macroinvertebrate assemblages were collected by the USGS at these two sites and sent to USEPA for analysis. Data-collection activities at the other four stream assessment sites (table 2, sites 1, 4, 5, and 8) included similar assessments of physical habitat and vertebrate identification and enumeration; however, only field properties were measured to determine basic water quality, and no samples were submitted to the USEPA for the analysis of water chemistry.

Geologic Influences on Stream Condition

This section describes the results of assessments conducted on two streams in south-central South Dakota—Bear-in-the-Lodge and Black Pipe Creeks. These assessments were conducted in order to demonstrate the geologic influences on stream conditions. Basin characteristics, streamflow, water quality, vertebrate richness, and physical habitat are described.

Basin Characteristics and Streamflow

The drainage basins for Bear-in-the-Lodge Creek includes portions of the Western High Plains and the Northern Great Plains ecoregions, while the drainage basin for Black Pipe Creek lies entirely within the Northern Great Plains ecoregion (fig. 2). A series of benches and buttes, underlain by Tertiary sandstones, siltstones, and shale is present in the southern portion of the study area (Malo, 1997). Silts and clays of the White River Group of Tertiary-age (Oligocene and Eocene) are present in the northern part of the study area (fig. 3).

The drainage basin of Bear-in-the-Lodge Creek encompasses approximately 365 mi^2. The elevation at the assessment site on upper Bear-in-the-Lodge (site 1) is about 2,570 ft above NGVD 29, and the elevation at the lower site (site 4) is about 2,280 ft above NGVD 29. The drainage basins of both streams are entirely within a single hydrologic unit (fig. 3) as designated by the hydrologic unit map for the State of South Dakota (U.S. Geological Survey, 1978). The headwaters of Bear-in-the-Lodge Creek are located in northwestern Bennett County in an area where intermittent eolian deposits and remnants of the Pliocene-age Ogallala Formation overlie the Miocene-age Arikaree Formation (fig. 3). The Ogallala Formation is a fine- to medium-grained sandstone containing some silty clay; the Arikaree Formation is an interbedded calcareous sand, silt, and clay (Ellis and Adolphson, 1971). The stream flows to the southeast and then abruptly turns north and flows northwest through Jackson County where it crosses

Table 2. Information for sites used to characterize geologic influences.

[USGS, U.S. Geological Survey; USEPA, U.S. Environmental Protection Agency; EMAP, Environmental Monitoring and Assessment Program]

Site number (fig. 3)	USGS station number	Site name	Site type
1	433151101480700	Upper Bear-in-the-Lodge Creek	USGS stream assessment site
2	06446700	Bear-in-the-Lodge Creek near Wanblee, SD	USGS streamflow gaging station (not a stream assessment site)
3	433338101482100	Bear-in-the-Lodge Creek	USEPA/EMAP reference site
4	434027101502600	Lower Bear-in-the-Lodge Creek	USGS stream assessment site
5	432735101100300	Upper Black Pipe Creek	USGS stream assessment site
6	433822101125500	Black Pipe Creek	USEPA/EMAP reference site
7	06447230	Black Pipe Creek near Belvidere, SD	USGS streamflow gaging station (not a stream assessment site)
8	434633101134000	Lower Black Pipe Creek	USGS stream assessment site

the White River Group just prior to joining the White River. The White River Group is a poorly consolidated siltstone and claystone containing some beds of fine-grained sand (Ellis and Adolphson, 1971).

The drainage basin of Black Pipe Creek encompasses approximately 250 mi^2. Elevations range from about 2,530 ft above NGVD 29 (site 5) at upper Black Pipe Creek to about 2,020 ft above NGVD 29 at the lower site (site 8). The headwaters of Black Pipe Creek are located in northeast Bennett County, in an area where intermittent eolian deposits overlie the Arikaree Formation. Some remnants of the Ogallala Formation also are present in the area. The stream flows to the northeast into Mellette County where it flows across the outcrop of the White River Group. The stream turns north and then makes contact with isolated outcrops of terrace deposits of Quaternary age. The stream turns and flows to the northwest across outcrops of the Late Cretaceous-age Pierre Shale. The Pierre Shale is a dark gray marine shale and mudstone containing some layers of bentonite (Ellis and Adolphson, 1971). The stream then flows across various isolated outcrops consisting of alluvium or eolian deposits just prior to joining the White River near the Jackson and Mellette County line.

The climate, which is characteristic of the northern Great Plains, is semi-arid with cold winters and hot summers. The following climate data was obtained from the South Dakota State University (2005). Most of the precipitation falls during the growing season between April and September. Climatological data available for Martin, South Dakota (located about 20 miles south of the study area), for the period 1971–2000 indicate that May is typically the wettest month with an average of 3.36 in. of precipitation, and December typically is the driest month with an average of 0.3 in. of precipitation. The average annual air temperature for the period 1971–2000 is about 47.3°F, with an average of 72.8°F for July and an average of 22.0°F for January.

Much of western South Dakota has been in a persistent drought since the latter part of the 1990s. Hydrologic conditions for water year 2004 (October 1, 2003, through September 30, 2004) were much different than the wetter conditions experienced during the mid- to early 1990s, and generally resulted in precipitation and streamflow levels that were well below normal throughout much of western South Dakota. The 2004 U.S. drought monitor map (National Oceanographic and Atmospheric Administration, 2004) showed that the lower one-third of South Dakota, which includes the study area, was under severe to extreme drought conditions at the time the stream assessments were conducted during June 2004. As a result, most perennial streams probably experienced reduced streamflow due to extended period of intense drought conditions.

The USGS has operated streamflow gaging stations on Bear-in-the-Lodge and Black Pipe Creeks (fig. 3) for several years. Streamflow data have been collected at continuous gaging station 06446700, Bear-in-the-Lodge Creek near Wanblee, SD (table 2, site 2), for water years 1995 through 2003 and are presented graphically in figure 14. Streamflow data also have been collected at continuous gaging station 06447230, Black Pipe Creek near Belvidere, SD (table 2, site 7), from 1993 to 2003 and are presented graphically in figure 15. The annual mean streamflow is 24.3 ft^3/s at site 2 and 32.1 ft^3/s at site 7 (Burr and others, 2004).

Stream assessment sites on Bear-in-the-Lodge Creek were visited during June 15–16, 2004, and at that time, streamflow at the upper site (site 1 in fig. 3) measured

6.83 ft^3/s. Streamflow at site 3, the candidate reference site selected by USEPA, measured 7.13 ft^3/s, and streamflow at site 4 measured 5.92 ft^3/s. Streamflow data presented in graph B of figure 14 indicate that the monthly mean streamflow for June at the streamflow gaging station (site 2) for the period of record is about 50 ft^3/s. Measured streamflow at all three sites on Bear-in-the-Lodge Creek was less than the 10th percentile of values recorded for June at site 2 for the period of record.

Sites on Black Pipe Creek were visited during June 8–9, 2004, and at that time, streamflow at the upper site (site 5 in fig. 3) measured 1.45 ft^3/s. Streamflow at site 6, the candidate reference site selected by USEPA, measured 0.38 ft^3/s, and streamflow at site 8 was estimated visually as 0.01 ft^3/s. Streamflow data presented in graph B of figure 15 indicate that the monthly mean streamflow for June at site 7 for the period of record is about 68 ft^3/s. The streamflow measurement for site 5 fell between the 10th and 25th percentiles of the June values; however, streamflow measurement for sites 6 and 8 were less than the 10th percentile of values recorded at the streamflow gaging station site on Black Pipe Creek during the period of record.

Water Quality

Full sets of samples for the characterization of stream-water chemistry were collected only at site 3 on Bear-in-the-Lodge Creek and at site 6 on Black Pipe Creek. These two sites were selected by USEPA because they met their preliminary candidate reference site screening criteria. Results of the water-quality analyses are provided in table 6 in the Supplemental Information section. A summary of the analytical methodologies used for determination of stream-water chemistry are provided in table 5. Field measurements were completed for all six sites and also are included in table 6.

Values for dissolved oxygen and specific conductance generally increased from upstream to downstream locations on Bear-in-the-Lodge Creek. Values for pH and water temperature generally decreased from upstream to downstream locations. Decreasing water temperatures could be an indication of ground-water inflows.

Values for dissolved oxygen, pH, and water temperature generally increased from upstream to downstream locations on Black Pipe Creek. Most notably, values for specific conductance increased from 434 microsiemens per centimeter at 25 degrees Celsius (µS/cm) at site 5 to 1,342 µS/cm at site 8, probably as a result of contact with the underlying Pierre Shale.

Vertebrate Richness

Vertebrate data collected from three reaches on Bear-in-the-Lodge Creek and three reaches on Black Pipe Creek during June 2004 are provided in tables 7 and 8, respectively, in the Supplemental Information section. Overall, Bear-in-the-Lodge Creek had a slightly larger richness of vertebrate species than Black Pipe Creek. The total number of fish (excluding crayfish) caught from all three reaches also was much higher at Bear-in-the-Lodge Creek (547) than at Black Pipe Creek (147). More fish were found at the lower site (site 4) on Bear-in-the-Lodge Creek than at sites farther upstream. Proximity of site 4 to the confluence with the White River might help to explain the high number of fish caught. Relatively large fish ranging from 183 mm at the upper site to 532 mm at the lower site were found in Bear-in-the-Lodge Creek.

Black Pipe Creek had slightly lower species richness overall than Bear-in-the-Lodge Creek. A slightly larger richness of vertebrate species was found at the lower site (site 8) on Black Pipe Creek than at the two upstream sites. Proximity of site 8 to the confluence with the White River might help to explain the higher richness. Fish such as channel catfish (310 mm) and river carpsucker (152 mm) were found only at the lower site. These fish are common to the main stem White River (Fryda, 2001) and tended to be some of the larger fish caught in Black Pipe Creek. Examples of fish caught, identified, and measured at Bear-in-the-Lodge Creek or Black Pipe Creek are shown in figure 16.

Physical Habitat

Physical habitat data collected from three reaches on Bear-in-the-Lodge Creek (fig. 17) and three reaches on Black Pipe Creek (fig. 18) during June 2004 are provided in tables 9 and 10, respectively, in the Supplemental Information section. In addition to the physical measurements and determinations, rapid habitat assessments also were used to characterize the habitat of both streams. Table 11 contains the responses of the field crews to their visual assessment of stream habitat and the area immediately adjacent to the stream. The procedures used for the rapid habitat assessment follow those originally described by Barbour and others (1999).

Substrate particle size for each site was characterized by averaging the 5-point pebble counts collected at 11 transects. Similar measurements also were made at points midway between established transects so that data were collected from 21 transects at a total of 105 points along the stream reach. Average substrate particle size for each site was the mean of size class for the 105 total pebble counts. Upper Bear-in-the-Lodge Creek (site 1, table 2 and fig. 17*A*) has an average substrate composition generally consisting of coarse to fine gravels that gradually transitions to silt and clays at site 3. The substrate largely is composed of hardpan and silt and clay at site 4. Thus, average substrate sizes decreased in a downstream direction.

Fish cover at the upper site largely is composed of overhanging vegetation and woody debris. The predominant fish cover at site 3 (fig. 17*B*) is composed of woody debris and macrophytes and then transitions to macrophytes at site 4 (fig. 17*C*).

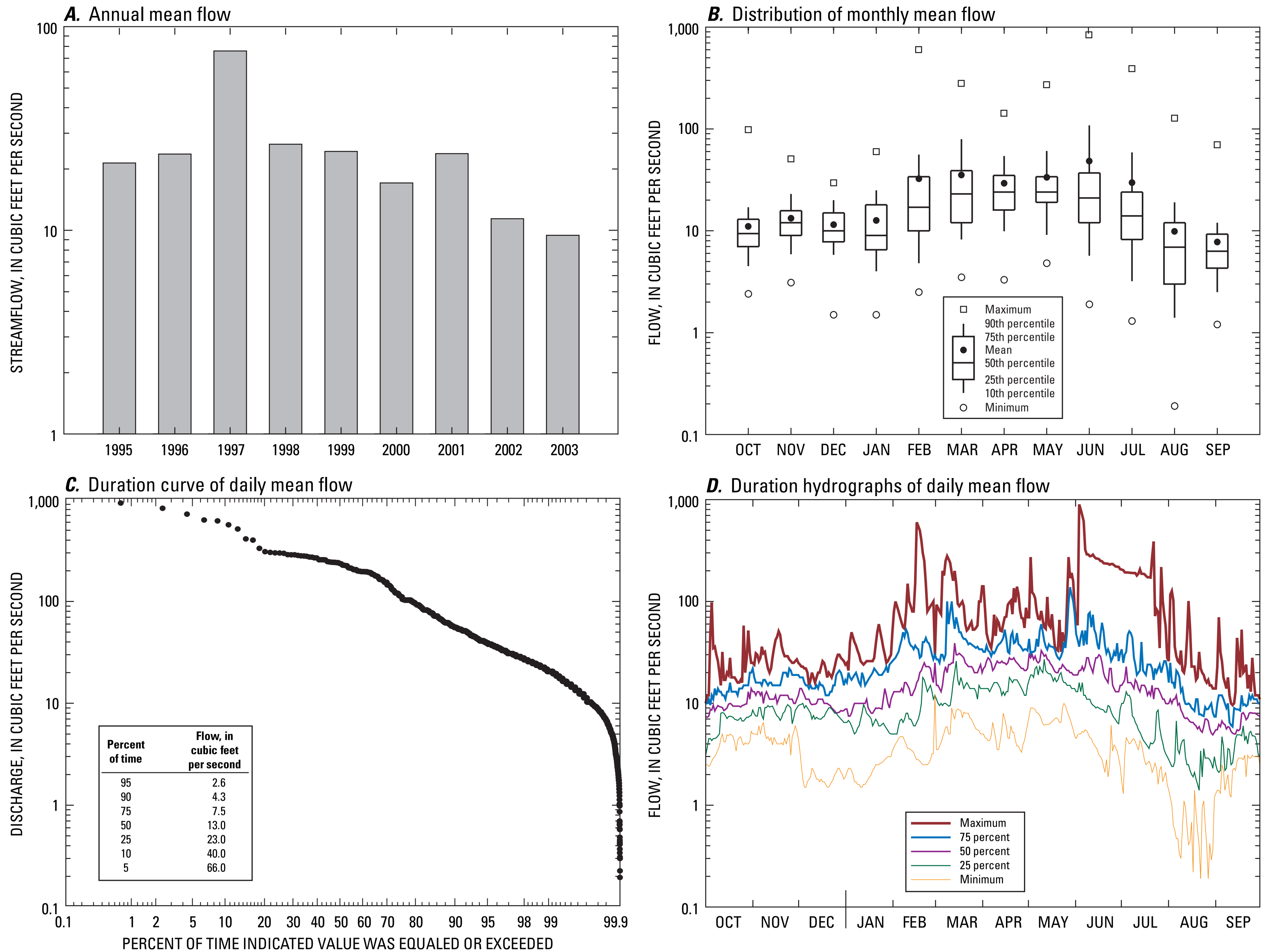

Figure 14. Variations in annual, monthly, and daily mean streamflow for station 06446700, Bear-in-the-Lodge Creek near Wanblee, SD, water years 1995–2003.

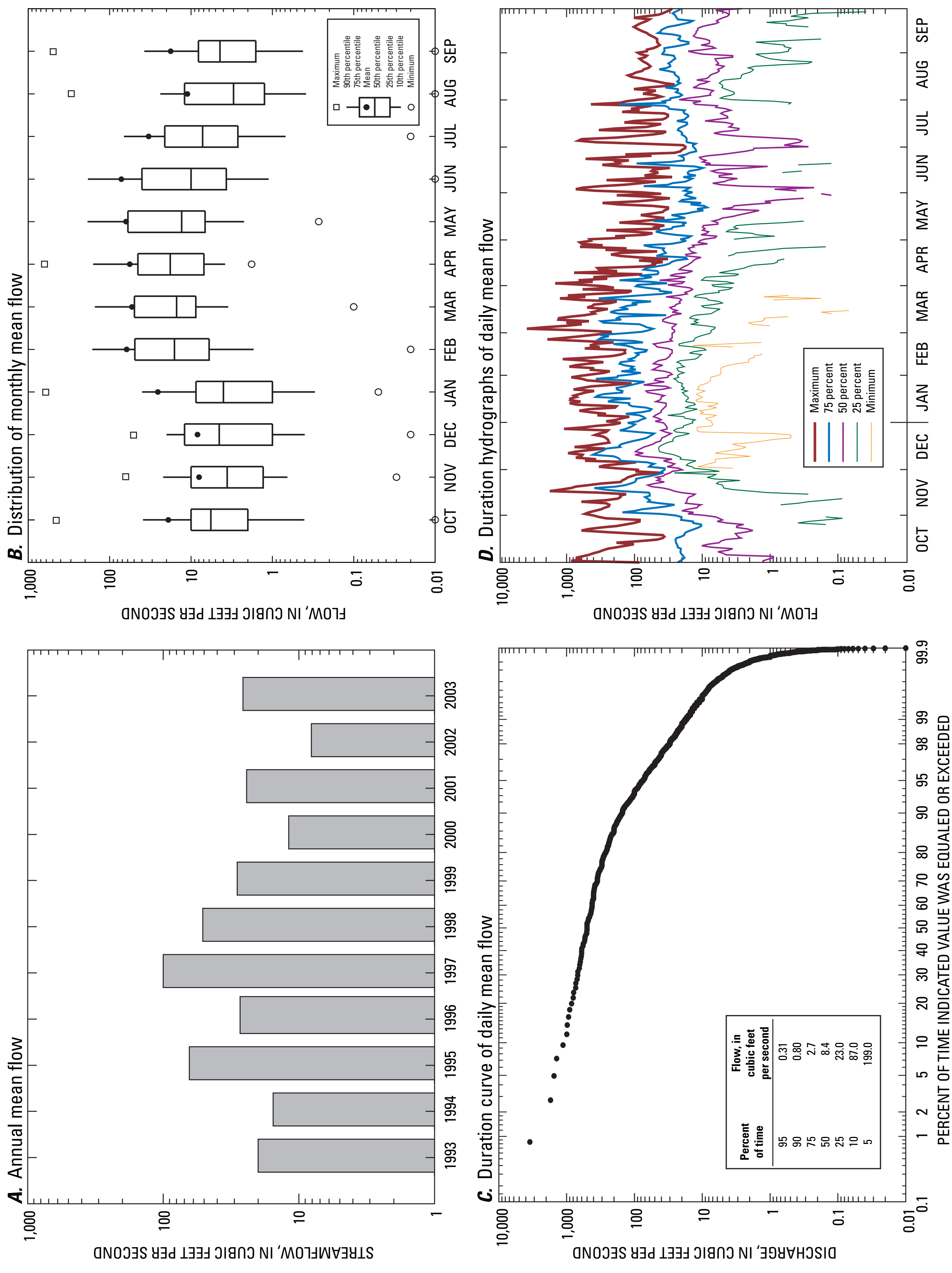

Figure 15. Variations in annual, monthly, and daily mean streamflow for station 06447230, Black Pipe Creek near Belvidere, SD, water years 1993–2003.

A *B*

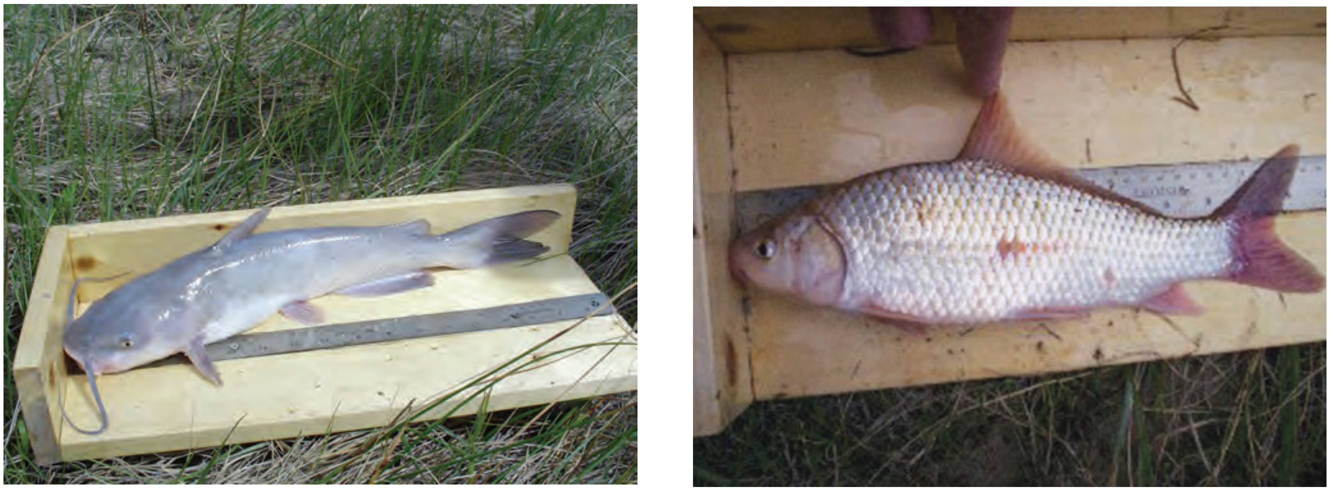

Figure 16. Examples of fish caught, identified, and measured at Bear-in-the-Lodge or Black Pipe Creeks include (A) channel catfish and (B) river carp sucker.

Riparian cover consisted of sparse to moderate densities of big and small trees and grasses at the upper site on Bear-in-the-Lodge Creek. The predominate riparian cover transitioned to grasses at site 3 and was largely composed of barren dirt at the lower site (table 9).

Thalweg depths and wetted widths varied among sites on Bear-in-the-Lodge Creek and showed no trend in relation to stream size. The average maximum thalweg depth for all transects at the upper site (site 1) was 42.8 cm. The largest maximum thalweg depth measurement at this site was 62 cm at transect J, and the smallest maximum thalweg depth measurement at this site was 23 cm at transect H. The average wetted width of the reach was 3.9 m, with a minimum width of 2.6 m at transect D and a maximum width of 5.3 m at transect I.

The average maximum thalweg depth for all transects at the middle site (site 3) was 79.7 cm. The largest maximum thalweg depth measurement at this site was 120 cm at transect I, and the smallest maximum thalweg depth measurement at this site was 38 cm at transect J. The average wetted width of site 3 was 4.0 m, with a minimum width of 2.9 m at transect H and a maximum width of 5.5 m at transect I.

The average maximum thalweg depth for all transects at the lower site (site 4) was 51.4 cm. The largest maximum thalweg depth measurement recorded at this site was 90 cm at transect I, and the smallest maximum thalweg depth measurement at this site was 30 cm at transects A, B, and C. The average wetted width of site 4 was 5.7 m, with a minimum width of 4.4 m at transect C and a maximum width of 7.2 m at transect J.

The stream channel was characterized as largely consisting of riffles at site 1, and transitioned into a glide throughout most of the transects at site 3. Site 4 was characterized as either a glide or glide/riffle combination throughout the reach.

Rapid habitat assessments for Bear-in-the-Lodge Creek tended (table 11) to rate this stream between optimal and sub-optimal for most categories. Bank stability and vegetative protection tended to decline somewhat at the middle and lower sites.

Upper Black Pipe Creek (site 5) generally had a substrate composition of silt and sand. Substrate composition was largely silt and clay at the middle site (site 6), and consisted of sand and fine gravel at the lower site (site 8). Thus, average substrate size increased from silt to fine gravel in a downstream direction (table 10).

Fish cover at site 5 on Black Pipe Creek primarily was composed of overhanging vegetation and filamentous algae (fig. 18*A*). Overhanging vegetation was the predominant fish cover at site 6 (fig. 18*B*), whereas macrophytes provided the dominant fish cover at site 8 (fig. 18*C*). Fish cover was largely categorized as sparse throughout the three reaches on Black Pipe Creek.

Riparian cover at the upper and middle sites on Black Pipe Creek was a mixture of grasses and woody shrubs. Riparian cover was largely absent at the lower site and consisted of grasses and bare dirt.

The average maximum thalweg depth for all transects at upper Black Pipe Creek (site 5) was 30.8 cm. The largest maximum thalweg depth measurement at this site was 41 cm at transect I, and the smallest maximum thalweg depth measurement at this site was 22 cm at transect D. The average wetted width of the reach was 2.4 m, with a minimum width of 1.6 m at transect A and a maximum width of 3.9 m at transect F.

The average maximum thalweg depth for all transects at the middle site on Black Pipe Creek (site 6) was 54.8 cm. The largest maximum thalweg depth measurement at this site was 87 cm at transect E, and the smallest maximum thalweg

A

B

C

Figure 17. Bear-in-the-Lodge Creek, assessment sites: (A) upper site (site 1), (B) middle site (site 3), and (C) lower site (site 4).

A

B

C

Figure 18. Upper Black Pipe Creek, assessment sites: (A) upper site (site 5), (B) middle site (site 6), and (C) lower site (site 8).

depth measurement at this site was 16 cm at transect J. The average wetted width of the reach was 2.0 m, with a minimum width of 1.2 m at transect J and a maximum width of 2.8 m at transect C.

The average maximum thalweg depth for all transects at lower Black Pipe Creek (site 8) was 14.1 cm. The largest maximum thalweg depth measurement at this site was 26 cm at transect D, and the smallest maximum thalweg depth measurement at this site was 6 cm at transect G. The average wetted width of the reach was 2.2 m, with a minimum width of 0.7 m at transect H and a maximum width of 4.2 m at transect A.

The stream channel at site 5 on upper Black Pipe Creek was categorized as a glide that transitioned into a glide/riffle throughout the reach at site 6. The stream channel at the lower site (site 8) consisted largely of a series of interconnected pools throughout the reach.

No rapid habitat assessment rating was completed for upper Black Pipe Creek (site 5, table 11 in the Supplemental Information section). Sites 6 and 8 generally received ratings that ranged from suboptimal to poor for most categories that evaluated in-stream and near-stream conditions.

Vertebrate /Physical Habitat Associations

Differences in thalweg depth and wetted width between Bear-in-the-Lodge and Black Pipe Creeks may explain patterns in vertebrate diversity and abundance. On average, Bear-in-the-Lodge Creek had a deeper thalweg and wider wetted width than Black Pipe Creek. Therefore, habitat volume for aquatic vertebrates (that is, fish) was greater in Bear-in-the-Lodge Creek than Black Pipe Creek. A longitudinal thalweg profile was plotted in relation to transect location for each site. Because vertebrate location to nearest transect was recorded during sampling, vertebrate location to thalweg depth could be determined. Accordingly, most vertebrates were collected nearest transects that represented the deepest pools in the sample reach for all sites. Given the intermittent nature of streams in the White River drainage basin, pools provide critical refuge for fish during low-flow periods. The continuing drought during this study period likely strengthened the importance of pool habitat for fish. The greater availability of pool habitat, and thus refuge area, in Bear-in-the-Lodge Creek would allow this stream to support a greater diversity and abundance of fish than Black Pipe Creek.

Summary

During 2000, the U.S. Environmental Protection Agency (USEPA) initiated a 5-year study called the Environmental Monitoring and Assessment Program-West (EMAP-West). The two primary objectives of the surface-water component of the EMAP-West were to (1) develop the monitoring tools (biological indicators, stream survey design, and estimates of reference condition) necessary to produce unbiased estimates of the ecological condition of surface waters across a large geographic area of the West; and (2) demonstrate the effectiveness of those tools in a large-scale assessment.

The resource population of interest for EMAP-West was all perennial streams and rivers represented in USEPA's River Reach File (RF3), with the exception of the lower portions of the "Great Rivers" (the Columbia, Snake, Colorado, and Missouri Rivers). Assessments sites were selected randomly using a probability design where each site had a known probability for selection.

This was done to ensure that all types of streams are included in the final list of sites and to allow for adequate spacial representation.

During 2000, USEPA completed assessments at 22 randomly selected wadeable stream sites in South Dakota. In 2001, the South Dakota Department of Game, Fish and Parks (GF&P) and the U.S. Geological Survey (USGS) entered into a cooperative agreement to complete the remaining stream assessments in South Dakota for the duration of the EMAP-West study. During 2001–2003, USGS and GF&P completed another 42 stream assessments bringing the total number of randomly selected stream assessments to 64. USGS personnel used several monitoring techniques developed by the USEPA for conducting the ecological assessments. Many chemical, physical, and biological indicators were assessed at selected sites that included water chemistry, physical habitat, periphyton assemblages, benthic macroinvertebrate assemblages, aquatic vertebrate communities, and fish tissue contaminants.

EMAP-West was expanded beginning in 2002 to include the selection and sampling of candidate reference sites throughout South Dakota. Candidate reference sites were not selected randomly but were specifically selected because it was generally believed that they possessed the best attainable aquatic conditions within the major Level III Ecoregions present in South Dakota. Inclusion of candidate reference sites into EMAP-West provided a valuable mechanism for assessing the overall health of sites randomly selected by USEPA throughout the State by providing standards or benchmarks that could be compared against existing aquatic conditions at randomly selected sites. Guidelines for selecting candidate reference sites were developed jointly by several State and Federal agencies to ensure that sites were representative of a variety of hydrogeological, ecological, and land-use settings found throughout South Dakota. During 2002–2004, USGS and GF&P completed stream assessments for 45 candidate reference sites. Thus, for the 5-year duration of EMAP-West (2000–2004), assessments were completed at 109 sites. Eighteen repeat assessments were completed at 12 of the 64 randomly selected assessment sites to provide estimates of important components of variability and for quality-assurance purposes. Repeat assessments were not included in the 109 site assessment total.

This report provides an overview of EMAP-West activities in South Dakota during 2000–2004. It presents stream assessment site locations and describes the methods used to collect the chemical, physical, and biological data that will be

used by USEPA to estimate the ecological conditions of our Nation’s stream and river resources in the 12 western States included in EMAP-West.

Relatively early in the EMAP-West stream-assessment process, it became apparent that for some streams in south-central South Dakota, in-stream conditions varied considerably over relatively short distances of only a few miles. These changes appeared to be a result of geomorphic changes associated with changes in the underlying geology. For these streams, moving stream assessment sites short distances upstream or downstream had the potential to provide substantially different bioassessment data. In order to obtain a better understanding of how geology influences stream conditions, two streams located in south-central South Dakota were chosen for multiple stream sampling at sites located along their longitudinal profile at points where notable changes in geomorphology were observed. Subsequently, three sites on Bear-in-the-Lodge Creek and three sites on Black Pipe Creek were selected for multiple stream sampling using EMAP-West protocols so that more could be learned about the geologic influences on stream conditions.

Values for dissolved oxygen and specific conductance generally increased from upstream to downstream locations on Bear-in-the-Lodge Creek. Values for pH and water temperature generally decreased from upstream to downstream locations. Decreasing water temperature could be indicative of ground-water inflows.

Values for dissolved oxygen, pH, and water temperature generally increased from upstream to downstream locations on Black Pipe Creek. The increase in temperature at the lower sites is a result of less dense riparian cover, and the warmer water also could account for the lower concentrations of dissolved oxygen found in the lower reaches of Black Pipe Creek. Values for specific conductance were more than three times greater at the lower site (1,342 microsiemens per centimeter (μS/cm)) than at the upper site (434 μS/cm). The increase probably occurs when the stream transitions from contacting the underlying Arikaree Formation to contacting the underlying Pierre Shale.

Vertebrate richness was found to be slightly higher for Bear-in-the-Lodge Creek (547 total number of fish) than for Black Pipe Creek (147 total number of fish). On average, reaches on Bear-in-the-Lodge Creek had a deeper thalweg and wider wetted stream width than Black Pipe Creek. This resulted in a larger habitat volume of aquatic vertebrates in Bear-in-the-Lodge Creek than in Black Pipe Creek and probably is the reason for the higher vertebrate richness found in Bear-in-the-Lodge Creek.

Average substrate size decreased in a downstream direction for Bear-in-the-Lodge Creek. In-stream fish cover also transitioned from woody debris to macrophytes in a downstream direction for Bear-in-the-Lodge Creek, whereas the predominate riparian cover transitioned from trees to barren dirt in the lower reaches. The stream channel for Bear-in-the-Lodge Creek largely consisted of riffles in the upper stream reaches and transitioned into glide or glide/riffle combinations in the lower reaches. Rapid habitat assessments metrics generally were scored as good except for sediment deposition and riffle frequency.

Average substrate size for Black Pipe Creek increased from silt to fine gravel in a downstream direction. In-stream fish cover was composed of overhanging vegetation and algae in the upper reaches and transitioned to macrophytes in the lower reaches. However, fish cover was sparse throughout all reaches. Riparian cover largely consisted of grasses and woody shrubs in the upper reaches of Black Pipe Creek and transitioned to grasses and bare dirt in the lower reaches. The stream channel was largely a glide in the upper reaches and transitioned to a glide/riffle in the middle reaches and to a series of interconnected pools in the lower reach. No rapid habitat assessments were completed for the upper reach, but the lower reaches were categorized as poor for most in-stream and near-stream conditions.

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Supplemental Information

Table 3. General guidelines for consideration in selection of candidate reference sites.

1. **General flow characteristics**—Two specific criteria: (A) Sufficiently perennial to maintain viable aquatic communities during most years; and (B) can be waded in all but deepest of holes. Also a general guideline that tributaries near confluence with larger stream may make ideal candidates.
2. **Geographic distribution and representative characteristics**—Reference sites need to have a wide geographic distribution within the State and represent the best attainable aquatic conditions within the designated area. In addition to having good representation for the four major Omernik level III ecoregions (Omernik, 1987) within the State, a variety of different hydrogeologic/land-use/landscape settings need to be addressed. Target areas might include:
    - Black Hills
    - Badlands (parts of White River and some of its tributaries)
    - Sand Hills (Little White/Keya Paha Rivers)
    - Western South Dakota shales (Cheyenne/Bad Rivers)
    - Western South Dakota sandstones/siltstones (Grand/Moreau Rivers)
    - Missouri River breaks
    - Upper James River
    - Lower James/Lower Big Sioux/Vermillion Rivers
    - Coteau des Prairies
    - Upper Big Sioux River
3. **Consideration of core factors listed in U.S. Environmental Protection Agency Region 7 document**—The 11 core factors listed should be an excellent starting point for evaluating candidate sites—wastewater treatment plants (and other point sources of pollution), combined animal feeding operations (CAFOs), instream habitat, raparian habitat, land use/land cover (broad scale), land use/land cover (site specific), physical and chemical properties, altered hydrologic regime, biological metrics, faunal assemblages, and representativeness.
4. **Geographic information system (GIS) analysis using selected coverages (land use, conservation easements, CAFOs, wastewater discharges, and others)**—Again, no specific approach envisioned; however, numerous insights probably can be obtained by consideration of available GIS coverages.
5. **Long-term viability/security/accessibility**—Long-term potential for maintenance in a minimal-influence condition would be beneficial. Best prospects might include public ownership and permanent conservation easements, which also could be conducive to future site accessibility. Physical accessibility of sites also could be a consideration.
6. **Parallelism with other programs**—Another desirable quality would be parallelism with other environmental programs such as various Nataural Resource Conservation Service programs, availability of long-term water-quality data (305B monitoring sites, U.S. Geological Survey or Tribal data), and biological data from previous surveys. Expressed interest from land-management agencies (see item 7) would be beneficial.
7. **Multiple recommendations**—Recommendations from multiple sources (District Conservationists in overlapping areas, interested agencies, collaborating agencies) would be indicative of high potential for candidate sites.
8. **Professional judgment**—It is envisioned that no rigid method can be established to identify or score potential sites. Professional judgment and discussions leading to consensus among collaborating agencies may be an important factor in finalizing selections.

Table 4. Data reporting criteria for water chemistry analyses.

[From U.S. Environmental Protection Agency, written commun., 2005. mg/L, milligrams per liter; °C, degrees Celsius; μeq/L, microequivalents per liter; μS/cm, microsiemens per centimeter at 25 degrees Celsius; μg/L, micrograms per liter; NTU, nephelometric turbidity units; PCU, platinum cobalt units]

Measurement	Units	Number of significant figures	Maximum number of decimal places
Dissolved oxygen	mg/L	2	1
Temperature	°C	2	1
pH	pH units	3	2
Carbon, dissolved inorganic	mg/L	3	2
Carbon, dissolved organic	mg/L	3	1
Acid neutralizing capacity	μeq/L	3	1
Aluminum (total dissolved, total monomeric, and organic monomeric)	μeq/L	3	1
Specific conductance	μS/cm	3	1
Calcium, magnesium, sodium, and potassium	μeq/L	3	2
Ammonium, chloride, nitrate, and sulfate	μeq/L	3	2
Silica	mg/L	3	2
Total phosphorus and total nitrogen	μg/L	3	2
Turbidity	NTU	3	2
True color	PCU	2	0
Total suspended solids	mg/L	3	1

Table 5. Analytical methodologies for water chemistry.

[Quality-assurance classification: C, critical; N, non-critical. µeq/L, microequivelents per liter; CO_2, carbon dioxide; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; µg/L, micrograms per liter; ppm, parts per million; UV, ultraviolet; PCU, platinum cobalt units; NTU, nephelometric turbidity units; USEPA, U.S. Environmental Protection Agency; APHA, American Public Health Association; EDTA, ethylenediamine-tetraacetic acid]

Property or constituent	Quality-assurance classification	Expected range	Summary of method	References
pH, closed system	C	3 to 9 pH units	Sample collected and analyzed without exposure to atmosphere; electrometric determination (pH meter and glass combination electrode)	USEPA 150.6 (modified); USEPA (1987)
pH, equilibrated	N	3 to 9 pH units	Equilibration with 300 ppm CO_2 for 1 hour prior to analysis; electrometric determination (pH meter and glass combination electrode)	USEPA 150.6 (modified); USEPA (1987)
Acid neutralizing capacity (ANC)	C	-100 to 5,000 µeq/L	Acidimetric titration to pH 3.5, with modified Gran plot analysis	USEPA 310.1 (modified); USEPA (1987)
Carbon, dissolved inorganic (DIC)[1]	N	0.1 to 50 mg C/L	Sample collected and analyzed without exposure to atmosphere; acid-promoted oxidation to CO_2, with detection by infrared spectrophotometry	USEPA (1987)
Carbon, dissolved organic (DOC)	C	0.1 to 30 mg C/L	UV-promoted persulfate oxidation, detection by infrared spectrophotometry	USEPA 415.2; USEPA (1987)
Conductivity	C	1 to 500 µS/cm	Electrolytic (conductance cell and meter)	USEPA 120.6; USEPA (1987)
Aluminum, total dissolved	C	10 to 1,000 µg/L	Atomic absorption spectroscopy (graphite furnace)	USEPA 202.2; USEPA (1987)
Aluminum, monomeric and organic monomeric	N	0 to 500 µg/L	Collection and analysis without exposure to atmosphere. Portion of sample passed through a cation exchange column before analysis to obtain estimate of organic-bound fraction. Colorimetric analysis (automated pyrocatechol violet)	APHA 3000-Al E.; APHA (1989); USEPA (1987)
		Major cations, dissolved		
Calcium	C	0.02 to 76 mg/L (1 to 3,800 µeq/L)	Atomic absorption spectroscopy (flame)	USEPA 200.6; USEPA (1987)
Magnesium	C	0.01 to 25 mg/L (1 to 2,000 µeq/L)		
Sodium	C	0.01 to 75 mg/L (0.4 to 3.3 µeq/L)		
Potassium	C	0.01 to 10 mg/L (0.3 to 250 µeq/L)		
Ammonium	N	0.01 to 5 mg/L (0.5 to 300 µeq/L)	Colorimetric (automated phenate)	USEPA 350.7; USEPA (1987)

Table 5. Analytical methodologies for water chemistry.—Continued

Property or constituent	Quality-assurance classification	Expected range	Summary of method	References
		Major anions, dissolved		
Chloride	C	0.03 to 100 mg/L (1 to 2,800 μeq/L)	Ion chromatography	
Sulfate	C	0.05 to 25 mg/L (1 to 500 μeq/L)		
Silica, dissolved	N	0.05 to 15 mg/L	Automated colorimetric (molybdate blue)	USEPA 370.1 (modified); USEPA (1987)
Phosphorus, total	C	0 to 1,000 μg/L	Acid-persulfate digestion with automated colorimetric determination (molybdate blue)	USGS I-4600-78; Skougstad and others (1979); USEPA (1987)
Nitrogen, total	N	0 to 25,000 μg/L	Alkaline persulfate digestion with determination of nitrate by cadmium reduction and determination of nitrite by automated colorimetry (EDTA/sulfanilimide)	USEPA 353.2 (modified); USEPA (1987)
True color	N	0 to 300 PCU	Visual comparison to calibrated glass color disks	USEPA 100.2 (modified); APHA 204 A.; USEPA (1987)
Turbidity	N	1 to 100 NTU	Nephelometric	APHA 214 A.; USEPA 180.1; USEPA (1987)
Total Suspended Solids (TSS)	N	1 to 200 mg/L	Gravimetric	USEPA 160.3; APHA (1989)

[1]For DIC, dissolved is defined as that portion passing through a 0.45-micron nominal pore-size filter. For other constituents, dissolved is defined as that portion passing through a 0.4-micron pore-size filter (Nucleopore or equivalent).

Table 6. Water-quality data for sites on Bear-in-the-Lodge and Black Pipe Creeks.

[NTU, nephelometric turbidity units; mg/L, milligrams per liter; µS/cm, microsiemens per centimeter at 25 degrees Celsius; deg. C, degrees Celsius; µeq/L, microiequivelents per liter; ft³/s, cubic feet per second; --, no data]

Site name (table 1)	Site number (fig. 3)	Date sampled	Turbidity (NTU)	Dissolved oxygen (mg/L)	pH, whole, field (standard units)	Specific conductance, field (µS/cm)	Temperature, air (deg. C)	Temperature, water (deg. C)	Calcium, dissolved (µeq/L)	Magnesium, dissolved (µeq/L)	Potassium, dissolved (µeq/L)	Sodium, dissolved (µeq/L)	ANC (µeq/L as $CaCO_3$)	Chloride, dissolved (µeq/L)
Upper Bear-in-the-Lodge Creek	1	06-15-04	--	9.3	7.7	503	24.0	22.1	--	--	--	--	--	--
Bear-in-the-Lodge Creek	3	06-15-04	168	9.1	7.4	507	25.0	20.5	2,146.1	428.4	295.5	2,790.1	5,103.4	114
Lower Bear-in-the-Lodge Creek	4	06-16-04	--	10.3	7.6	519	17.0	17.7	--	--	--	--	--	--
Upper Black Pipe Creek	5	06-08-04	--	9.3	7.1	434	18.0	17.4	--	--	--	--	--	--
Black Pipe Creek	6	06-09-04	43.7	8.2	7.4	590	14.0	17.0	2,248.1	440.4	306.3	3,811.0	5,997.3	174.6
Lower Black Pipe Creek	8	06-09-04	--	9.6	7.6	1,342	17.0	18.7	--	--	--	--	--	--

Site number (fig. 3)	Silica, dissolved (µeq/L)	Sulfate, dissolved (µeq/L)	Ammonia, dissolved (µeq/L)	Nitrate, dissolved (µeq/L)	Nitrogen, total (µg/L)	Phosphorous, total (µeq/L)	Selenium, dissolved (µeq/L)	Zinc, dissolved (µeq/L)	Color (PCU)	Dissolved organic carbon (mg/L)	Dissolved inorganic carbon (mg/L)	Hydroxide (µeq/L)	Bicarbonate (µeq/L)	Carbonate (µeq/L)	Total suspended solids (mg/L)	Discharge (ft3/s)
1	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	6.83
3	44.9	417.4	2.5	15	1,223	444	0.1	0.0	20	5.34	56.1	2.4	4,574.8	105.3	344.8	7.13
4	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	5.92
5	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	1.45
6	34.5	376.6	1.7	.0	872	147	.0	6.0	40	9.8	68.1	3.2	5,545.8	168.3	58.6	.383
8	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	.001

Table 7. Vertebrate information for Bear-in-the-Lodge Creek.

[--, no data]

Date	Species collected	Tally	Minimum length (millimeters)	Maximum length (millimeters)	Transect where found
			Upper Bear-in-the-Lodge Creek (site 1 in fig. 3)		
06–15–04	Flathead chub	26	69	143	A, B, C, D, E, I, J
	Longnose Dace	1	52	--	I
	Sand shiner	52	44	68	A, B, C, D, E G, I, J
	Shorthead redhorse	5	163	175	A, C, D
	Stonecat	4	121	183	D, E
	Unknown crayfish	12	--	--	A, D, E, I, J
			Bear-in-the-Lodge Creek (site 3 in fig. 3)		
06–15–04	Channel catfish	15	57	255	E, I, J
	Flathead chub	3	75	125	E
	Green sunfish	1	53	--	E
	Sand shiner	3	49	63	E, I, J
	Shorthead redhorse	3	156	159	A, D, I
	Stonecat	2	115	146	A, I
	Unknown crayfish	1	--	--	F
			Lower Bear-in-the-Lodge Creek (site 4 in fig. 3)		
06–16–04	Black bullhead	4	52	130	F, G, I
	Channel catfish	3	170	532	G, I
	Flathead chub	114	57	127	A, B, C, D, E, F, G, H, I, J
	Hybognathus spp	161	62	93	A, B, C, D, E, F, G, H, I, J
	Sand shiner	103	50	62	A, B, C, D, E, F, G, H, I, J
	Longnose dace	45	57	89	A, B, C, D, E, F, I, J
	Red shiner	1	47	--	I
	River carpsucker	1	241	--	I

Table 8. Vertebrate information for Black Pipe Creek.

[--, no data]

Date	Species collected	Tally	Minimum length (millimeters)	Maximum length (millimeters)	Transect where found
Upper Black Pipe Creek (site 5 in fig. 3)					
06–08–04	Creek Chub	6	64	142	G, I, F, H
	Long nose dace	5	55	84	F, H
	Sand shiner	1	69	--	G
	Unknown tapole	1	--	--	G
Black Pipe Creek (site 6 in fig. 3)					
06–09–04	Flathead chub	13	78	115	A, C, E, G, F, H
	Hybognathus spp	10	70	82	C, E, G, F
Lower Black Pipe Creek (site 8 in fig. 3)					
06–09–04	Channel catfish	5	155	310	B
	Flathead chub	38	62	100	B
	Hybognathus spp	56	51	69	B
	River carpsucker	4	144	152	B
	Sand shiner	8	40	59	B

Table 9. Physical habitat data for sites on Bear-in-the-Lodge Creek.

[cm, centimeter; OV, overhanging vegetation; ST, small trees; G, grasses; BT, big trees; WD, woody dedris; NDC, no dominant cover; BD, barren dirt; M, marophytes; R, roots; WS, woody shrubs; --, no data]

Transect	Substrate composition	Fish cover (dominant)	Riparian cover left bank	Riparian cover right bank	Human influence	Maxiumum thalweg depth (cm)	Wetted width (meters)	Channel type
Upper Bear-in-the-Lodge Creek (site 1 in fig. 3)								
A	Silt/Clay	Absent/Sparse (OV)	Sparse/Moderate (ST,G)	Sparse/Moderate (G)	Pasture	50	3.6	Glide
B	Fine Gravel	Absent/Sparse (OV)	Sparse/Moderate (BT,G)	Sparse/Moderate (ST,G)	Pasture	35	3.4	Riffle
C	Coarse Gravel	Absent/Sparse (WD)	Sparse (NDC)	Sparse (BD)	Pasture	52	4.0	Riffle
D	Silt/Clay	Absent/Sparse (OV,WD,M)	Sparse/Moderate (NDC)	Sparse(G)	Pasture	45	2.6	Riffle
E	Fine/Coarse Gravel	Absent/Sparse (OV,WD,M)	Sparse/Moderate (G)	Sparse (BD)	Pasture	38	4.1	Riffle
F	Silt/Clay	Sparse/Moderate (OV,WD,M)	Moderate (BD)	Moderate (G,WS)	Pasture	40	3.3	Rapid
G	Coarse Gravel	Absent/Sparse (WD,R,OV)	Sparse/Moderate (G,WS)	Sparse/Moderate (G)	Pasture	30	4.8	Riffle
H	Coarse Gravel	Absent/Sparse (OV)	Sparse/Moderate (G,BD)	Sparse (G)	Pasture	23	4.5	Riffle
I	Fine Gravel	Sparse/Moderate (OV,WD,M)	Sparse/Moderate (G,WS)	Sparse/Moderate (G)	Pasture	53	5.3	Glide
J	Fine Gravel	Absent/Sparse (OV)	Sparse/Moderate (G)	Sparse/Moderate (G)	Pasture	62	4.0	Glide
K	Fine Gravel	Sparse/Moderate	Absent/Sparse	Sparse/Moderate	Pasture	--	--	--
Bear-in-the-Lodge Creek (site 3 in fig. 3)								
A	Silt/Clay	Absent/Sparse (NDC)	Moderate (NDC)	Moderate (NDC)	Pasture	77	3.9	Glide
B	Silt/Clay	Moderate (WD,OV)	Sparse (G)	Sparse (G)	Pasture	72	4.3	Glide
C	Silt/Clay	Sparse (NDC)	Sparse/Moderate (G)	Sparse/Moderate (G,BD)	Pasture	94	4.2	Glide
D	Silt/Clay	Absent/Sparse (NDC)	Sparse/Moderate (G)	Sparse/Moderate (G)	Pasture	67	3.7	Glide
E	Silt/Clay	Absent/Sparse (WD,OV)	Sparse/Moderate (G)	Sparse/Moderate (G)	Pasture	99	3.9	Glide
F	Silt/Clay	Sparse (M,OV)	Sparse/Moderate (ST,G)	Sparse/Moderate (G)	Pasture	71	3.3	Glide

Table 9. Physical habitat data for sites on Bear-in-the-Lodge Creek.—Continued

Transect	Substrate composition	Fish cover (dominant)	Riparian cover left bank	Riparian cover right bank	Human influence	Maxiumum thalweg depth (cm)	Wetted width (meters)	Channel type
Bear-in-the-Lodge Creek (site 3 in fig. 3)—Continued								
G	Silt/Clay	Sparse/Moderate (WD,OV)	Moderate (G)	Sparse/Moderate (G)	Pasture	75	3.6	Glide
H	Silt/Clay	Absent/Sparse (NDC)	Sparse/Moderate (NDC)	Sparse/Moderate (G)	Pasture	84	2.9	Glide
I	Silt/Clay	Absent/Sparse (M.WD,OV)	Sparse (G)	Sparse (ST,G)	Pasture	120	5.5	Glide
J	Silt/Clay	Absent/Sparse (OV)	Moderate (NDC)	Moderate (G)	Pasture	38	4.5	Riffle
K	Silt/Clay	Absent/Sparse	Sparse	Sparse	Pasture	--	--	--
Lower Bear-in-the-Lodge Creek (site 4 in fig. 3)								
A	Sand/Coarse Gravel	Absent (M,OV)	Sparse (BD)	Sparse (BD)	Pasture	30	6.1	Riffle
B	Hardpan/Silt	Absent/Sparse (M,OV)	Moderate (NDC)	Absent (BD)	Pasture	30	5.5	Glide
C	Hardpan	Absent (R,OV)	Sparse (BD)	Sparse (BD)	Pasture	30	4.4	Glide
D	Coarse Gravel	Absent (OV)	Absent/Sparse (BD)	Absent/Sparse (BD)	Pasture	36	4.9	Glide/Riffle
E	Silt/Clay	Absent (OV)	Sparse (BD)	Absent/Sparse (BD)	Pasture	64	5.6	Glide/Riffle
F	Hardpan/Silt	Absent (NDC)	Absent/Sparse (BD)	Sparse (BD)	Pasture	35	5.6	Glide
G	Sand	Absent (M,OV)	Sparse (BD)	Sparse (BD)	Pasture	76	6.0	Glide
H	Silt/Sand	Absent (M,OV)	Sparse (BD)	Sparse/Moderate (BD)	Pasture	63	6.2	Glide
I	Silt/Clay	Absent (OV)	Absent/Sparse (G,BD)	Absent/Sparse (G,BD)	Pasture	90	5.7	Glide
J	Silt/Clay	Absent/Sparse (M,OV)	Sparse/Moderate (G,BD)	Sparse/Moderate (G,BD)	Pasture	60	7.2	Glide/Riffle
K	Silt/Sand	Absent/Sparse	Absent/Sparse	Absent	Sparse	--	--	--

Table 10. Physical habitat data for sites on Black Pipe Creek.

[cm, centimeter; OV, overhanging vegetation; ST, small trees; G, grasses; BT, big trees; WD, woody dedris; NDC, no dominant cover; BD, barren dirt; M, macrophytes; R, roots; WS, woody shrubs; --, no data; FA, filamentous algae]

Transect	Substrate composition	Fish cover (dominant)	Riparian cover left bank (dominant)	Riparian cover right bank (dominant)	Human influence	Maxiumum thalweg depth (cm)	Wetted width (meters)	Channel type
Upper Black Pipe Creek (site 5 in fig. 3)								
A	Silt/Clay	Sparse/Moderate (M,WD)	Absent/Sparse (G)	Absent/Sparse (G)	Pasture	36	1.6	Riffle
B	Fine Gravel	Absent/Sparse (FA,WD)	Sparse/Moderate (G)	Sparse/Moderate (WS,G)	Pasture	39	1.9	Riffle
C	Sand	Sparse (FA)	Moderate (WS,G)	Moderate (WS,G)	Pasture	33	2.1	Glide
D	Silt/Sand	Sparse (NDC)	Sparse (G)	Sparse (G)	Pasture	22	2.7	Glide
E	Silt/Sand	Sparse/Moderate (FA,M,OV)	Sparse/Moderate (G)	Sparse (WS)	Pasture	25	2.4	Glide
F	Silt/Sand	Sparse/Moderate (FA,M,OV)	Sparse (G)	Sparse (G)	Pasture	30	3.9	Glide
G	Silt/Sand	Sparse/Moderate (WD,OV)	Sparse/Moderate (WS,G)	Sparse/Moderate (WS,G)	Pasture	35	2.1	Glide
H	Silt/Sand	Sparse (OV)	Sparse/Moderate (WS)	Absent (G)	Trash/Pasture	23	2.5	Glide
I	Sand	Absent/Sparse (OV)	Sparse (WS,G)	Sparse (WS,G)	Pasture	41	2.3	Glide
J	Silt/Sand	Sparse (OV)	Sparse (G)	Sparse (G)	Trash/Pasture	24	2.1	Glide/Riffle
K	Silt/Gravel	Sparse	Sparse/Moderate	Sparse	Trash/Pasture	--	--	--
Black Pipe Creek (site 6 in fig. 3)								
A	Silt/Clay	Sparse (NDC)	Sparse (G)	Sparse (G)	Pasture	47	2.0	Glide
B	Silt/Clay	Sparse (NDC)	Sparse (G)	Sparse (G)	Pasture	66	2.4	Glide
C	Silt/Clay	Sparse (NDC)	Sparse (G)	Sparse (G)	Pasture	50	2.8	Riffle
D	Coarse Gravel	Sparse/Moderate (WD,OV)	Sparse/Moderate (WS,G)	Sparse/Moderate (WS,G)	Pasture	78	2.2	Glide/Riffle
E	Silt/Clay	Sparse (OV)	Sparse/Moderate (WS,G)	Sparse/Moderate (WS,G)	Pasture	87	1.8	Glide
F	Coarse Gravel	Sparse (OV)	Moderate/Heavy (WS,G)	Sparse (G)	Pasture	50	1.8	Glide/Riffle
G	Silt/Clay	Sparse/Moderate (WD,OV)	Sparse (G,BD)	Sparse (WS,G)	Trash/Pasture	82	1.9	Glide
H	Silt/Clay	Sparse (OV)	Sparse (G)	Sparse (G)	Pasture	36	2.0	Glide
I	Sand/Silt	Sparse (OV)	Sparse (NDC)	Sparse (NDC)	Trash/Pasture	36	1.7	Riffle
J	Fine Gravel	Sparse (OV)	Moderate (G,WS)	Sparse (BD)	Pasture	16	1.2	Glide
K	Coarse Gravel	Sparse	Moderate	Sparse	Pasture	--	--	--

Table 10. Physical habitat data for sites on Black Pipe Creek.—Continued

Transect	Substrate composition	Fish cover (dominant)	Riparian cover left bank (dominant)	Riparian cover right bank (dominant)	Human influence	Maxiumum thalweg depth (cm)	Wetted width (meters)	Channel type
Lower Black Pipe Creek (site 8 in fig. 3)								
A	Sand	Sparse (M,OV)	Absent/Sparse (G,BD)	Absent (BD)	Trash/Pasture/ Riprap/ Bridge	22	4.2	Pool
B	Sand	Absent/Sparse (M,OV)	Absent/Sparse (G,BD)	Absent (BD)	Trash/Pasture/ Riprap/ Bridge	15	2.1	Pool
C	Sand	Absent/Sparse (M,OV)	Absent/Sparse (G,BD)	Absent (BD)	Trash/Pasture/ Riprap/ Bridge	13	3.5	Pool
D	Fine Gravel	Absent (OV)	Sparse (G,BD)	Absent (BD)	Trash/Pasture/ Riprap/ Bridge	26	2.1	Pool
E	Hardpan/Sand	Absent/Sparse (G)	Absent/Sparse (G)	Absent (BD)	Trash/Pasture/ Riprap/ Bridge	20	2	Pool/Riffle
F	Sand	Absent/Sparse (M,OV)	Absent/Sparse (G,BD)	Absent (BD)	Trash/Pasture/ Riprap/ Bridge	7	2.2	Pool
G	Sand	Absent/Sparse (M)	Absent/Sparse (G,BD)	Absent/Sparse (BD)	Trash/Pasture/ Riprap/ Bridge	6	1	Pool
H	Fine Gravel	Absent/Sparse (M,OV)	Sparse/Moderate (G,BD)	Absent/Sparse (BD)	Trash/Pasture/ Riprap/ Bridge	10	0.7	Glide/Riffle
I	Fine Gravel	Absent/Sparse (M,OV)	Sparse/Moderate G,BD)	Absent/Sparse (BD)	Trash/Pasture/ Riprap/ Bridge	12	2.6	Pool
J	Sand	Absent/Sparse (M,OV)	Sparse/Moderate (G,BD)	Absent/Sparse (BD)	Trash/Pasture/ Riprap/ Bridge	10	1.4	Pool/Riffle
K	Sand	Absent/Sparse	Sparse/Moderate	Absent/Sparse	Trash/Pasture/ Riprap/ Bridge	--	--	--

Table 11. Rapid habitat assessment ratings for sites on Bear-in-the-Lodge and Black Pipe Creeks.

[O, optimal; SO, sub-optimal; M, marginal; P, poor; --, no data]

Site number	Epifaunal substrate cover	Embeddedness	Velocity/depth regime	Sediment deposition	Channel flow status	Channel alteration	Riffle frequency	Bank stability right/left	Vegetative protection right/left	Riparian vegetative zone width right/left
Bear-in-the-Lodge Creek										
1	O	O	O	SO	O	SO	SO	O/O	O/O	SO/SO
3	O	P	M	O	O	O	P	SO/SO	O/O	O/O
4	O	O	O	SO	SO	O	O	P/M	P/M	O/O
Black Pipe Creek										
5	--	--	--	--	--	--	--	--	--	--
6	O	SO	O	SO	SO	O	O	SO/SO	O/O	O/SO
8	P	SO	M	P	P	M	M	SO/SO	M/M	M/M