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Compilation of Data to Support Development of a Pesticide Management Plan by the Yankton Sioux Tribe, Charles Mix County, South Dakota

Open-File Report 2004-1032

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

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By Bryan D. Schaap

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

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

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Conversion Factors, Datums, and Acronyms

Multiply	By	To obtain
acre	4,047	square meter
acre	0.4047	hectare
cubic foot per second	0.02832	cubic meter per second
foot	0.3048	meter
gallon per minute	0.06309	liter per second
inch	2.54	centimeter
inch	25.4	millimeter
square mile	259.0	hectare
square mile	2.590	square kilometer

Vertical coordinate information is referenced to the the National Geodetic Vertical Datum of 1929 (NGVD 29).

Horizontal coordinate information is referenced to either the North American Datum of 1927 (NAD 27) or the North American Datum of 1983 (NAD 83). See metadata of the individual data sets for specific horizontal datum.

CD-ROM	Compact Disk—Read Only Memory
DEM	Digital Elevation Model
ESRI	Environmental Systems Research Institute, Inc.
GIS	Geographical Information System
HTM	Hypertext Markup Language
HTML	Hypertext Markup Language
MRLC	Multi-Resolution Land Characteristics
MrSID	Multi-Resolution Seamless Image Data
NASS	National Agricultural Statistics Service
NCFAP	National Center for Food and Agricultural Policy
NLCD	National Land Cover Data
NRCS	U.S. Department of Agriculture, Natural Resource Conservation Service
NWIS	USGS National Water Information System
NWS	National Weather Service
OPP	Office of Pesticide Programs
PDF	Portable Document Format
PMP	Pesticide Management Plan
SDASS	U.S. Department of Agriculture, South Dakota Agricultural Statistics Service
USDA	U.S. Department of Agriculture
USEPA	U.S. Environmental Protection Agency
USGS	U.S. Geological Survey

Compilation of Data to Support Development of a Pesticide Management Plan by the Yankton Sioux Tribe, Charles Mix County, South Dakota

By Bryan D. Schaap

Abstract

The U.S. Environmental Protection Agency is working with the Yankton Sioux Tribe to develop a pesticide management plan to reduce potential for contamination of ground water that may result from the use of registered pesticides. The purpose of this study was to compile technical information to support development of a pesticide management plan by the Yankton Sioux Tribe for the area within the Yankton Sioux Reservation, Charles Mix County, South Dakota. Five pesticides (alachlor, atrazine, cyanazine, metolachlor, and simazine) were selected by the U.S. Environmental Protection Agency for the management plan approach because they had been identified as probable or possible human carcinogens and they often had been associated with ground-water contamination in many areas and at high concentrations.

This report provides a compilation of data to support development of a pesticide management plan. Available data sets are summarized in the text of this report, and actual data sets are provided in one Compact Disk—Read-Only Memory that is included with the report.

The compact disk contains data sets pertinent to the development of a pesticide management plan. Pesticide use for the study area is described using information from state and national databases. Within South Dakota, pesticides commonly are applied to corn and soybean crops, which are the primary row crops grown in the study area. Water-quality analyses for pesticides are summarized for several surface-water sites. Pesticide concentrations in most samples were found to be below minimum reporting levels. Topographic data are presented in the form of 30-meter digital elevation model grids and delineation of drainage basins. Geohydrologic data are provided for the surficial deposits and the bedrock units. A high-resolution (30-by-30 meters) land-cover and land-use database is provided and summarized in a tabular format. More than 91 percent of the study area is used for row crops, pasture, or hay, and almost 6 percent of the study area is covered by water or wetlands. Average monthly and yearly precipitation data are summarized in a tabular format. Irrigation information associated with permitted and licensed diversion points is provided. A composite of aerial photographs of Charles Mix County is provided. This report also describes and summarizes the data sets and files, and how the data are relevant to development of a pesticide management plan.

Introduction

Surface water and ground water are used for domestic, stock-watering, and irrigation purposes within Charles Mix County (Amundson, 2002). Various pesticides, including herbicides, insecticides, fungicides, and nematocides, are applied to row crops, which cover approximately 316 square miles, or about 46 percent of the historic Yankton Sioux Reservation. The U.S. Environmental Protection Agency (USEPA) is working with the Yankton Sioux Tribe to develop a pesticide management plan to reduce potential for contamination of ground water that may result from the use of registered pesticides. An important component of developing a pesticide management plan is to determine specific areas where ground water may be vulnerable to contamination.

The purpose of the study was to compile technical information in support of development of a pesticide management plan by the Yankton Sioux Tribe for Tribal lands. This study was performed by the U.S. Geological Survey (USGS) in cooperation with the USEPA.

Purpose and Scope

The purpose of this report is to provide information that can be used by the Yankton Sioux Tribe to develop a pesticide management plan for Tribal lands within the historic Yankton Sioux Reservation. The report provides a compilation of existing technical data relevant to the process including pesticide-use, water-quality, topographic, geohydrologic, land-cover and land-use, precipitation, and irrigation data, and orthophotos. The report contains descriptions and summaries of the data sets, and describes how they might be used to evaluate aquifer vulnerability to pesticide contamination. The report also describes the organization of the data sets that are provided on one Compact Disk—Read-Only Memory (CD-ROM) that is included with the report. Five pesticides (alachlor, atrazine, cyanazine, metolachlor, and simazine) were selected by the USEPA for the management plan approach because they had been identified as probable or possible human carcinogens and they often had been associated with ground-water contamination in many areas and at high concentrations (U.S. Environmental Protection Agency, 1996).

Description of Study Area

At one time, the Yankton Sioux Reservation consisted of the eastern part of Charles Mix County (fig. 1). As of 2003, Yankton Sioux Tribal lands were distributed throughout the historic Yankton Sioux Reservation. Information about ownership of individual parcels of land within the historic Yankton Sioux Reservation is not included in this report, but, when possible, the data have been presented in such a way that location-specific information can be retrieved. In this report, the historic Yankton Sioux Reservation is referred to as the study area.

The study area includes about 686 square miles, which includes the westernmost extent of continental glaciation and the eastern edge of the Great Plains (Bryce and others, 1998). This area includes parts of the Southern Missouri Coteau, Southern Missouri Coteau Slope, and Southern River Breaks ecoregions (fig. 1), which are distinguished on the basis of topography, soil types, and plant types. The Southern Missouri Coteau ecoregion is characterized by gradual changes in altitude and small areas of high density wetlands. The Southern Missouri Coteau Slope ecoregion is a transitional area between the Southern Missouri Coteau ecoregion to the north and the Southern River Breaks ecoregion to the south. The Southern River Breaks ecoregion, located along the Missouri River, is characterized by deciduous forest in the draws and northern aspects (Bryce and others, 1998).

The general geology of the study area consists of varying thickness of glacial drift on top of a bedrock shale. Glacial drift consists of till, glaciofluvial (stream) sediments, and glaciolacustrine (lake) sediments. Glacial till is a heterogeneous mixture of clay, silt, sand, gravel, and boulders, and is often very low in permeability. Glaciofluvial sediments include glacial-outwash deposits of sand and gravel deposited by flowing glacial meltwaters. Glaciolacustrine sediments are composed of layered deposits of clay, silt, and sand transported into ancient lakes by glacial meltwaters. Alluvium may be found along recent flood plains or lakebeds, and generally consists of deposits of silt, sand, and gravel. Loess and other wind-blown deposits are found on topographic highs near the Missouri River and consist of angular, well-sorted, fine-grained particles (Kume, 1977).

Data Sets

Several data sets are available for the study area and are included on the CD-ROM. Geospatial data are provided in Arc/Info coverages, which are compatible with several Geographical Information System (GIS) software packages. The geospatial coverages presented on the CD-ROM are in the Universal Transverse Mercator projection. Pesticide-use data are provided in Adobe Acrobat (.pdf) format or hypertext markup language (.htm). Water-quality data are presented in both Microsoft Excel Spreadsheet (.xls) format and tab-delimited text (.txt) format. A description and summary of each data set and relevance to a pesticide management plan are provided, along with any special comments regarding format on the CD-ROM. The contents of the CD-ROM are listed in the Supplemental Information section at the end of this report.

Data for this study were obtained from a variety of sources, and those sources are described as completely as possible. Some data came from published maps and reports, and these are cited using traditional formats. Some data were downloaded from Internet sites, and the address and date of downloading are reported for these sources. Some data were downloaded from links created to the U.S. Department of Agriculture (USDA) Geospatial Data Gateway (http://lighthouse.nrcs.usda.gov/gateway/gatewayhome.html). For this information, a request was submitted to the USDA Geospatial Data Gateway site, and a temporary link for downloading the data was created. Citing this link as the source of information would not be useful because it became inactive 5 days after it was created. For those data, the USDA Geospatial Data Gateway is cited as the source of the information, and the date that the data were downloaded also is cited.

Pesticide Use

Pesticide use within the study area mainly is to control weeds and insects on crops, although fungicides and nematocides may be used on certain crops. Information describing pesticide usage in the study area or parts of it were available from three sources. Herbicide-use data in 1987 by county for South Dakota are available from the USGS (Battaglin and Goolsby, 1994). Statewide pesticide-use data for South Dakota are available from the U.S. Department of Agriculture, South Dakota Agricultural Statistics Service (SDASS) (2001). A pesticide-use database for 1992 and 1997 is searchable by pesticide type, region, State, and crop (National Center for Food and Agricultural Policy Pesticide Use Database, 2001). Table 1 lists all of the pesticides that are included in at least one of these three sources of information or were analyzed for in the sampling programs described in the section “Pesticide Concentrations in Surface Water.” A description of the pesticide-use data from each source and its format on the CD-ROM follows.

A 1987 compilation of annual use estimates of 96 herbicides for all counties in the conterminous United States was published by Battaglin and Goolsby (1994). The data are published digitally and are intended for estimating regional herbicide use and for producing maps showing relative rates of herbicide use across regions (Battaglin and Goolsby, 1994). Estimated use of 31 herbicides in Charles Mix County in 1987 is shown in table 2. Use estimates show that 2,4-D was applied to the greatest number of acres, whereas EPTC was applied at the highest rate. Data downloaded from the South Dakota Agricultural Statistics Service web site (http://www.nass.usda.gov/sd/dnlds/dnld_c.htm) on August 28, 2003, show that 110,000 acres of corn, 23,300 acres of soybeans, and 38,000 acres of wheat were planted in Charles Mix County in 1987.

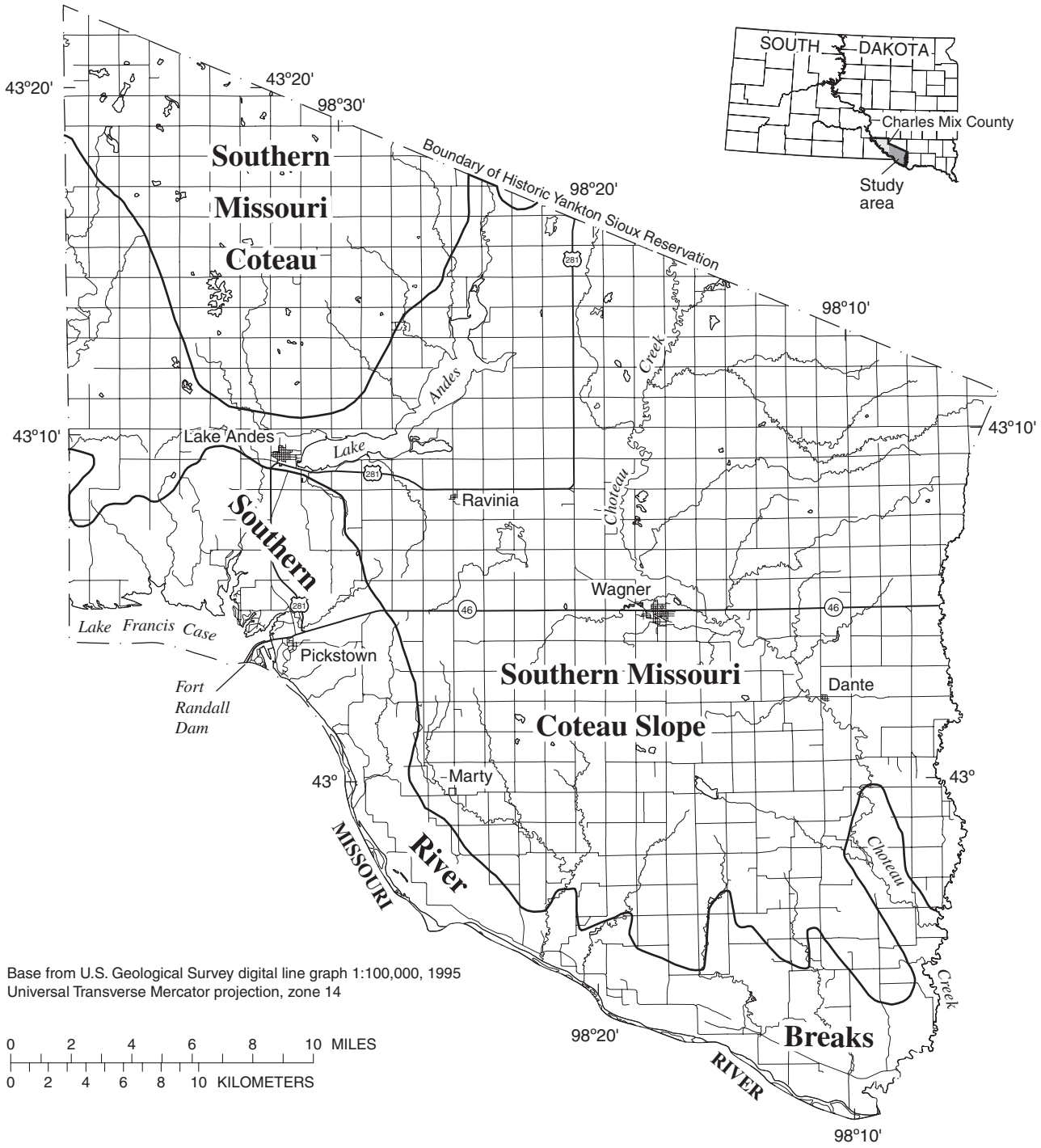

Figure 1. Location of the historic Yankton Sioux Reservation and ecoregions.

Table 1. Pesticide data available for this report.

[**Bold** indicates detections in water-quality studies. Shaded rows indicate the five pesticides selected for the pesticide management plan approach]

Pesticide	Source of data				
	Battaglin and Goolsby[1]	South Dakota Agricultural Statistics Service[2]	National Center for Food and Agricultural Policy[3]	Lake Andes[4]	Lake Francis Case/ Missouri River[5]
2,4-D	x	x	x	**X**[6,7]	
2,4-DB	x		x	x[7]	
2,4-DP				**X**[6]	
2,4,5-T				x[6,7]	
Acetochlor		x	x	**X**[7]	X
Acifluorfen	x		x	x[7]	
Alachlor	x		x	**X**[6,7]	x
Aldicarb				x[6,7]	
Aldicarb sulfone				x[6,7]	
Aldicarb sulfoxide				x[6,7]	
Aldrin				x[6]	
Alpha BHC				x[6,7]	x
Ametryne				**X**[6]	
2,6-Diethyl aniline				x[7]	x
Atrazine	x	x	x	**X**[6,7]	X
De-ethyl atrazine				**X**[6,7]	X
De-isopropyl atrazine				**X**[6]	
Methyl azinphos				x[7]	x
Benfluralin				x[7]	x
Beta benzene hexachloride				x[6]	
Bentazon	x	x	x	x[7]	
Bromacil				**X**[6,7]	
Bromoxynil	x	x	x	x[7]	
Butachlor				x[6]	
Butylate	x		x	x[6,7]	x
Carbaryl			x	x[6,7]	x
Carbofuran			x	x[6,7]	x
3-Hydroxy carbofuran				x[6,7]	
Carboxin				x[6]	
Chloramben	x				
Chlorethoxyfos			x		
Chlorimuron			x		
Chlordane				x[6]	
Chlorothalonil			x	x[6,7]	
Chlorpyrifos			x	**X**[6,7]	
Chlorsulfuron	x		x		
Clethodim		x	x		

Table 1. Pesticide data available for this report.—Continued

[**Bold** indicates detections in water-quality studies. Shaded rows indicate the five pesticides selected for the pesticide management plan approach]

Pesticide	Source of data				
	Battaglin and Goolsby[1]	South Dakota Agricultural Statistics Service[2]	National Center for Food and Agricultural Policy[3]	Lake Andes[4]	Lake Francis Case/ Missouri River[5]
Clomazone			x		
Clopyralid		x	x	x[7]	
Copper			x		
Cyanazine	x		x	**X**[6,7]	x
Cycloate				x[6]	
Cyfluthrin			x		
Dacthal				x[7]	
DCPA				x[7]	x
DEF				x[6]	
Delta benzene hexachloride				x[6]	
Diazinon				x[6,7]	x
Dicamba	x	x	x	x[7]	
Dichlobenil				x[7]	
Dichlorprop				x[7]	
Diclofop	x		x		
Dieldrin				x[6,7]	x
Difenzoquat	x		x		
Dimethenamid			x		
Dimethoate			x		
Dinoseb				x[7]	
Diphenamid				x[6]	
Diquat			x		
Disulfoton			x	x[6,7]	x
Diuron				**X**[7]	
DNOC				x[7]	
Endosulfan				x[6]	
Endrin				x[6]	
EPTC	x	x	x	**X**[7]	X
Esfenvalerate			x		
Ethalfluralin	x		x	x[7]	x
Ethion				x[6]	
Ethoprop			x	x[7]	x
Ethyl parathion			x		
Fenoxaprop			x		
Fenuron				x[7]	
Fluazifop	x		x		
Flumetsulam		x	x		

Table 1. Pesticide data available for this report.—Continued

[**Bold** indicates detections in water-quality studies. Shaded rows indicate the five pesticides selected for the pesticide management plan approach]

Pesticide	Source of data				
	Battaglin and Goolsby[1]	South Dakota Agricultural Statistics Service[2]	National Center for Food and Agricultural Policy[3]	Lake Andes[4]	Lake Francis Case/ Missouri River[5]
Flumiclorac			x		
Fluometuron				x[7]	
Fomesafen			x		
Fonofos			x	x[6,7]	x
Glyphosate	x	x	x		
Guthion				x[6]	
Halosulfuron			x		
Heptachlor epoxide				x[6]	
Hexazinone				x[6]	
Imazamethabenz			x		
Imazamox		x			
Imazapyr		x			
Imazaquin			x		
Imazethapyr	x	x	x		
Isoxaflutole		x			
Lactofen			x		
Lambdacyhalothrin			x		
Lindane				x[6,7]	x
Linuron				x[7]	x
Malathion			x	x[6,7]	x
Maleic hydrazide			x		
Mancozeb			x		
Maneb			x		
MCPA	x	x	x	x[7]	
MCPB				x[7]	
Metalaxyl			x		
Methiocarb				x[6,7]	
Methomyl				x[6,7]	
Methoxychlor				x[6]	
Methylmetsulfuron		x			
Methylparathion			x	x[6,7]	x
Methyltribenuron		x			
Methyltrithion				x[6]	
Metolachlor	x	x	x	**X**[6,7]	X
Metribuzin	x		x	**X**[6,7]	x
Metsulfuron	x		x		
Mirex				x[6]	

Table 1. Pesticide data available for this report.—Continued

[**Bold** indicates detections in water-quality studies. Shaded rows indicate the five pesticides selected for the pesticide management plan approach]

Pesticide	Source of data				
	Battaglin and Goolsby[1]	South Dakota Agricultural Statistics Service[2]	National Center for Food and Agricultural Policy[3]	Lake Andes[4]	Lake Francis Case/ Missouri River[5]
Molinate				x[7]	x
1-Napthol				x[6]	
Napropamide				x[7]	x
Neburon				x[7]	
Nicosulfuron		x	x		
Norflurazon				x[7]	
Oryzalin				x[7]	
Oxyamyl				x[6,7]	
P,P'-DDD				x[6]	
P,P'-DDE				x[6,7]	x
P,P'-DDT				x[6]	
Paraquat			x		
Parathion				x[6,7]	x
PCB				x[6]	
PCN				x[6]	
PCNS				x[6]	
Pebulate				x[7]	x
Pendimethalin	x	x	x	x[7]	x
Permethrin			x		
Permethrin cis				x[7]	x
Perthane				x[6]	
Phorate			x	x[6,7]	x
Picloram	x		x	x[7]	
Primisulfuron		x	x		
Prometone				**X**[6,7]	X
Prometryne				x[6]	
Pronamide				x[7]	x
Propachlor	x		x	x[6,7]	x
Propanil				x[7]	x
Propargite				x[7]	x
Propazine				x[6]	
Propham				x[6,7]	
Propiconazole			x		
Propoxur				x[6,7]	
Prosulfuron			x		
Quizalofop			x		
Rimsulfuron		x	x		

Table 1. Pesticide data available for this report.—Continued

[**Bold** indicates detections in water-quality studies. Shaded rows indicate the five pesticides selected for the pesticide management plan approach]

Pesticide	Source of data				
	Battaglin and Goolsby[1]	South Dakota Agricultural Statistics Service[2]	National Center for Food and Agricultural Policy[3]	Lake Andes[4]	Lake Francis Case/ Missouri River[5]
Sethoxydim	x	x	x		
Silvex				x[6,7]	
Simazine	x		x	**X**[6,7]	x
Simetryne				x[6]	
Sulfosate		x			
Tebuthiuron				x[7]	x
Tefluthrin			x		
Terbacil				x[6,7]	x
Terbufos			x	x[7]	x
Thiameturon	x				
Thifensulfuron		x	x		
Thiobencarb				x[7]	x
Thiophanate methyl			x		
Toxaphene				x[6]	
Tralomethrin			x		
Triallate	x		x	x[7]	x
Triasulfuron			x		
Tribenuron			x		
Triclopyr				x[7]	
Trifluralin	x	x	x	x[6,7]	x
Triphenyltin hyd			x		
Trithion				x[6]	
Vernolate				x[6]	

[1]Only includes those pesticides in this database for Charles Mix County (Battaglin and Goolsby, 1994).

[2]Accessed on the Internet at URL http://www.nass.usda.gov/sd/releases/agchem01.pdf on January 15, 2003. The report describes pesticide use in the State of South Dakota.

[3]Indicated for those pesticides with use greater than 0 pounds applied in 1997. Accessed on the Internet at URL http://pestdata.ncsu.edu/ncfap/search.cfm on February 25, 2003. Estimates are for the State of South Dakota.

[4]Sando and Neitzert (2003) and U.S. Geological Survey (1996-2003).

[5]Samples collected during April and May 2002 by the Yankton Sioux Tribe (U.S. Geological Survey, 2003).

[6]Samples collected during 1990-2000 (Sando and Neitzert, 2003).

[7]Samples collected during 2001-2002 (U.S. Geological Survey, 2002-2003).

Table 2. Estimated use of 31 herbicides in Charles Mix County, South Dakota, in 1987.

[Data from Battaglin and Goolsby (1994). Shaded rows indicate pesticides selected for the pesticide management plan approach]

Pesticide	Acres treated[1]	Pounds of active ingredient applied[2]	Pounds applied per treated acre[3]	Pounds used per square mile of Charles Mix County[4]
2,4-D	55,921	23,831	0.426	21.145
2,4-DB	357	357	1.000	.317
Acifluorfen	1,149	287	.250	.255
Alachlor	35,042	54,636	1.559	48.479
Atrazine	21,102	19,505	.924	17.307
Bentazon	4,135	3,473	.840	3.082
Bromoxynil	13,502	4,402	.326	3.906
Butylate	2,087	8,349	4.000	7.408
Chloramben	763	1,756	2.301	1.558
Chlorsulfuron	1,861	33	.018	.029
Cyanazine	9,393	11,178	1.190	9.918
Dicamba	51,220	13,709	.268	12.164
Diclofop	1,607	1,206	.750	1.070
Difenzoquat	203	152	.749	.135
EPTC	26,273	115,516	4.397	102.498
Ethalfluralin	2,519	2,291	.909	2.033
Fluazifop	230	46	.200	.041
Glyphosate	4,595	2,365	.515	2.098
Imazethapyr	2,297	115	.050	.102
MCPA	20,846	7,921	.380	7.028
Metolachlor	12,915	27,052	2.095	24.003
Metribuzin	2,482	953	.384	.846
Metsulfuron	2,355	24	.010	.021
Pendimethalin	5,931	8,018	1.352	7.114
Picloram	2,532	1,266	.500	1.123
Propachlor	6,338	30,571	4.823	27.126
Sethoxydim	459	92	.200	.082
Simazine	1,333	1,999	1.500	1.774
Thiameturon	2,217	44	.020	.039
Triallate	542	542	1.000	.481
Trifluralin	20,056	15,714	.784	13.943

[1]Rounded to nearest acre.

[2]Rounded to nearest pound.

[3]Calculated for this report from columns 2 and 3.

[4]Rounded to three decimal places.

Because Battaglin and Goolsby (1994) used cropping data from the 1987 Census of Agriculture, it is possible that crop management practices, herbicide use, and application methods have changed and the data may no longer represent current pesticide use. However, other available data sets do not give pesticide-use data on a county basis and are less specific in relating data to the study area. The Battaglin and Goolsby data are provided as a GIS coverage on the CD-ROM in the /pestuse/battaglin/ directory.

Statewide pesticide usage information (South Dakota Agricultural Statistics Service, 2001) shows that herbicides were applied to 100 percent of corn acreage in South Dakota and insecticides were applied to 15 percent of corn acreage in 2000. Atrazine was the most common herbicide applied, used on 42 percent of corn acreage, while acetolachlor was used on 34 percent of corn acreage. In 2000, herbicides were used on 98 percent of all soybean acreage, with glyphosate used on 67 percent of soybean acreage (South Dakota Agricultural Statistics Service, 2001). SDASS data for 2000 indicated that 120,000 acres of corn and 141,700 acres of soybeans, with fewer acres of wheat, hay, oats, and sunflowers, were harvested in Charles Mix County (South Dakota Agricultural Statistics Service, 2003a). SDASS data for 2002 indicated that 79,300 acres of corn and 128,800 acres of soybeans were harvested in Charles Mix County (South Dakota Agricultural Statistics Service, 2003b).

The National Center for Food and Agricultural Policy has a web-based database of pesticide use that is accessible at URL http://pestdata.ncsu.edu/ncfap/search.cfm. The database was constructed using available published reports of pesticide use and a survey of Extension Service specialists; thus, this database may overlap other data sources presented in this report.

Pesticide Concentrations in Surface Water

Surface water in the study area has been sampled for pesticides by the USGS and the Yankton Sioux Tribe at selected locations (fig. 2). Lake Andes was sampled from 1990-2002 by the USGS. Table 3 summarizes selected total pesticide concentrations in Lake Andes during 1990-2000, and table 4 summarizes selected dissolved pesticide concentrations in Lake Andes during 2001-2002. Because of changes in analytical methods over time for some constituents, the minimum reporting level is not consistent for all samples. Figure 3 shows concentrations for selected pesticides at Lake Andes above Ravinia (station 06452390) from 1990-2002. Figure 4 shows atrazine concentrations at four Lake Andes sampling sites from 1990-2002. For both figures 3 and 4, concentrations less than the minimum reporting level were plotted at one-half of the minimum reporting level. Samples were collected during April, May, or June. A total of 116 pesticides and pesticide metabolites were analyzed for in samples from Lake Andes, and 17 of these were detected at least once (table 1).

The Yankton Sioux Tribe started sampling Lake Francis Case and the Missouri River at Fort Randall Dam in 2002 (fig. 2). Table 5 summarizes selected pesticide concentrations in Lake Francis Case and the Missouri River in April and May 2002. A total of 46 pesticides and pesticide metabolites were analyzed for in samples from Lake Francis Case and the Missouri River, and six of these analytes were detected in at least one sample (table 1).

Analytical results for samples collected from Lake Andes, Lake Francis Case, and the Missouri River at Fort Randall Dam are provided on the CD-ROM in the /watqual/ directory in Microsoft Excel Spreadsheet (.xls) format and tab-delimited text (.txt) format. The QWDATA.xls and QWDATA.txt files present the pesticides results, and the yst_organics.xls and yst_organics.txt files present the organics results, including pesticides.

Topographic Data

Topographic data for the study area are from the USGS 30-meter Digital Elevation Model (DEM) and are available on the CD-ROM. The DEM can be used to determine the altitude of the land surface at any point within the study area. For the study area, the minimum altitude is about 1,211 feet above NGVD 29, the maximum altitude is about 1,944 feet above NGVD 29, and the mean altitude is about 1,523 feet above NGVD 29. If the water-table altitude for a location within the study area is known, the DEM can be used to calculate the depth to the water table for that location. Slope determinations also can be made, which is a determining factor in the amount of runoff. Precipitation that falls on an area of steeper slope is more likely to run off into surface water and less likely to infiltrate into an aquifer than precipitation that falls on an area of lesser slope. The DEM also can be used to determine drainage patterns, delineate drainage basins, and generate summary statistics, such as minimum, maximum, and mean altitudes for selected areas.

The study area includes parts of the 10140101 Fort Randall Reservoir and 10170101 Lewis and Clark Lake hydrologic units (fig. 2). These hydrologic units were defined at a scale of 1:250,000, and the data were accessed on the Internet on April 25, 2003, at URL http://water.usgs.gov/GIS/huc.html. Within the study area, the primary surface-water features of hydrologic unit 10140101 are Lake Andes and Lake Francis Case, and the primary surface-water features of hydrologic unit 10170101 are Choteau Creek and the Missouri River.

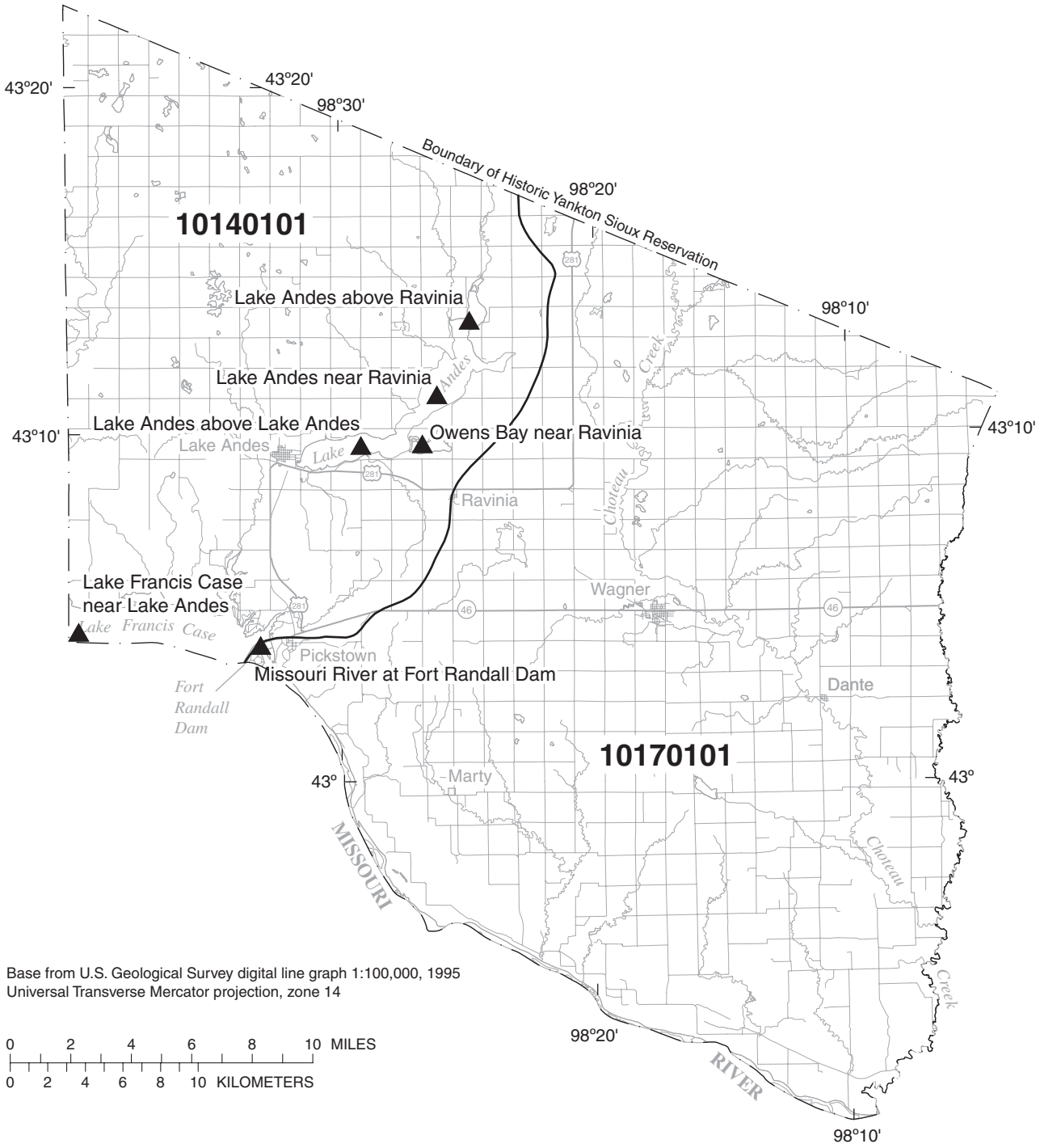

Figure 2. Locations of selected water-quality sampling sites and hydrologic units.

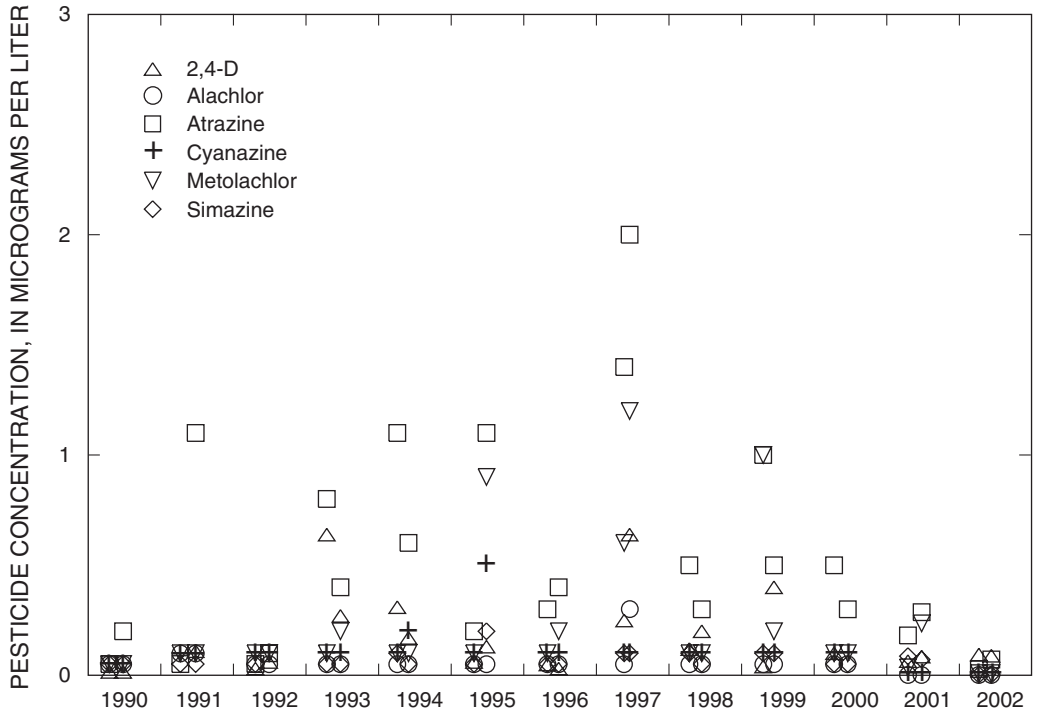

Figure 3. Concentrations of selected pesticides at Lake Andes above Ravinia (06452390), 1990-2002.

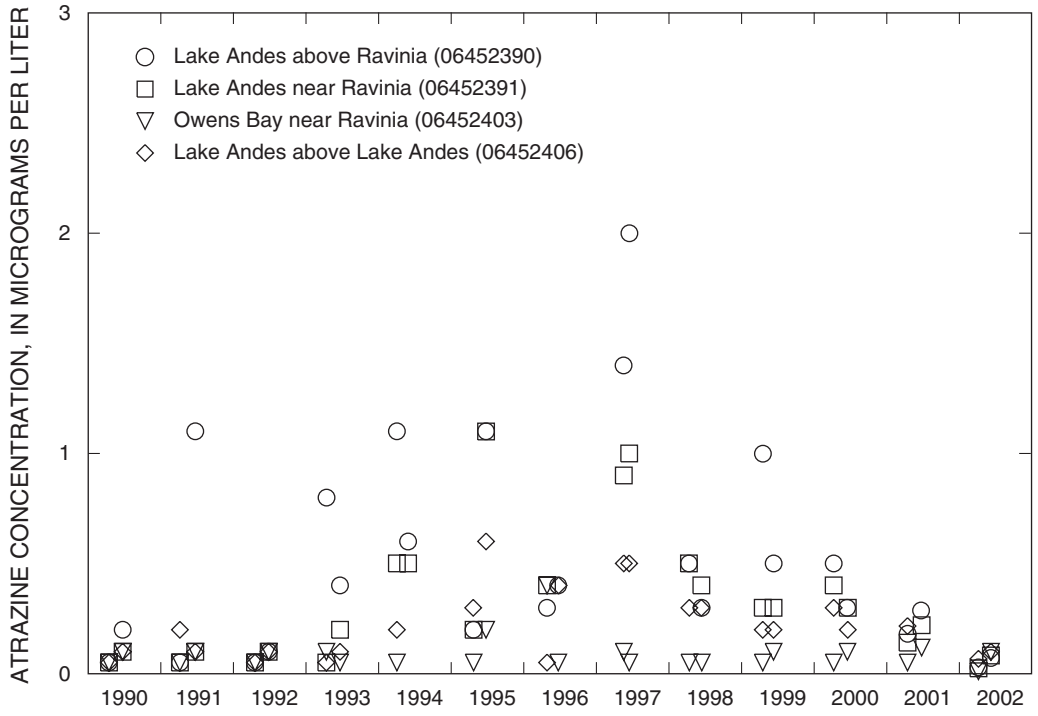

Figure 4. Atrazine concentrations at selected Lake Andes sites, 1990-2002.

Table 3. Statistical summaries of analytical results for selected total pesticide constituents for Lake Andes stations, 1990-2000.

[Shaded columns indicate pesticides selected for the pesticide management plan approach. Location of stations shown in figure 2. All constituents in micrograms per liter. <, less than; NA, not applicable. Results from study described by Sando and Neitzert (2003)]

	2,4-D	2,4-DP	Aceto-chlor	Alachlor	Ametryne	Atra-zine	De-ethyl atrazine	De-iso-propyl atrazine	Brom-acil	Chlor-pyrifos	Cyana-zine	Diuron	EPTC	Meto-lachlor	Metri-buzin	Prome-tone	Simazine
Lake Andes above Ravinia, SD (06452390)																	
Number of samples	20	19	0	20	21	22	18	19	20	10	22	0	0	22	22	22	21
Percent detections	90.0	5.3	0	4.5	14.3	86.4	50.0	15.8	.0	.0	9.1	0	0	31.8	.0	.0	33.3
Median	.11	<.01	NA	<.1	<.1	.45	.20	<.2	<.2	<.01	<.2	NA	NA	<.2	<.1	<.2	<.1
Minimum	<.01	<.01	NA	<.1	<.1	<.1	<.2	<.2	<.2	<.01	<.2	NA	NA	<.2	<.1	<.2	<.1
Maximum	.63	.2	NA	.3	.1	2	.5	.2	<.2	<.01	.5	NA	NA	1.2	<.1	<.2	.2
Lake Andes near Ravinia, SD (06452391)																	
Number of samples	20	19	0	19	20	21	18	18	19	10	21	0	0	21	21	21	21
Percent detections	90.0	5.0	0	.0	10.0	81.0	16.7	5.6	.0	.0	14.3	0	0	19.0	4.8	.0	19.0
Median	.07	<.01	NA	<.1	<.1	.3	<.2	<.2	<.2	<.01	<.2	NA	NA	<.2	<.1	<.2	<.1
Minimum	<.01	<.01	NA	<.1	<.1	<.1	<.2	<.2	<.2	<.01	<.2	NA	NA	<.2	<.1	<.2	<.1
Maximum	.33	.13	NA	<.1	.1	1.1	.4	.2	<.2	<.01	.6	NA	NA	1.5	.2	<.2	.2
Owens Bay near Ravinia, SD (06452403)																	
Number of samples	18	18	0	19	21	21	18	18	19	10	21	0	0	21	21	21	21
Percent detections	57.9	.0	0	.0	.0	38.1	5.6	.0	5.3	.0	14.3	0	0	.0	.0	.0	9.5
Median	.04	<.01	NA	<.1	<.1	<.1	<.2	<.2	<.2	<.01	<.2	NA	NA	<.2	<.1	<.2	<.1
Minimum	<.01	<.01	NA	<.1	<.1	<.1	<.2	<.2	<.2	<.01	<.2	NA	NA	<.2	<.1	<.2	<.1
Maximum	.19	<.01	NA	<.1	<.1	.4	.2	<.2	.2	<.01	.4	NA	NA	<.2	<.1	<.2	.2
Lake Andes above Lake Andes, SD (06452406)																	
Number of samples	18	18	0	19	21	21	18	18	19	10	21	0	0	21	21	21	21
Percent detections	84.2	.0	0	4.8	4.8	81.0	11.1	11.1	.0	.0	14.3	0	0	23.8	.0	.0	9.5
Median	.08	<.01	NA	<.1	<.1	.2	<.2	<.2	<.2	<.01	<.2	NA	NA	<.2	<.1	<.2	<.1
Minimum	<.01	<.01	NA	<.1	<.1	<.1	<.2	<.2	<.2	<.01	<.2	NA	NA	<.2	<.1	<.2	<.1
Maximum	.25	<.01	NA	.1	.1	.6	.3	.2	<.2	<.01	.5	NA	NA	.5	<.1	<.2	.2

Table 4. Analytical results for selected dissolved pesticide constituents for Lake Andes stations, 2001-2002.

[Shaded columns indicate pesticides selected for the pesticide management plan approach. Location of stations shown in figure 2. All constituents in micrograms per liter. <, less than; --, no data; E, estimated. Data from U.S. Geological Survey (2002, 2003)]

Date	2,4-D	2,4-DP	Aceto-chlor	Ala-chlor	Ame-tryne	Atra-zine	De-ethyl atra-zine	De-iso-propyl atra-zine	Bro-macil	Chlor-pyri-fos	Cyana-zine	Diuron	EPTC	Meto-lachlor	Metri-buzin	Prome-tone	Sima zine
Lake Andes above Ravinia, SD (06452390)																	
April 18, 2001	<0.11	--	<0.004	<0.002	--	0.181	E.028	--	<0.54	<0.005	<0.018	<0.06	<0.002	0.036	<0.006	E0.013	0.087
June 26, 2001	<.15	--	.015	<.002	--	.286	<.006	--	<.17	<.005	<.018	<.06	.003	.235	<.006	.015	.072
April 9, 2002	<.17	--	<.006	<.004	--	.028	E.005	--	<.09	<.005	<.018	<.12	<.002	E.010	<.006	<.01	<.005
June 11, 2002	<.16	--	<.006	<.004	--	.071	E.012	--	<.09	<.005	<.018	<.12	.013	E.010	<.006	<.01	<.005
Lake Andes near Ravinia, SD (06452391)																	
April 18, 2001	<0.14	--	<0.004	<.002	--	.141	E.032	--	<.45	<.005	<.018	<.13	<.002	E.017	<.006	E.007	.018
June 27, 2001	<.96	--	.026	<.002	--	.220	<.006	--	<.11	<.005	<.018	<.06	.005	.340	<.006	E.008	.032
April 9, 2002	<.16	--	<.006	<.004	--	.024	E.004	--	<.09	<.005	<.018	<.12	<.002	<.013	<.006	E.01	<.005
June 11, 2002	<.16	--	<.006	<.004	--	.083	E.015	--	<.09	<.005	<.018	E.04	<.002	E.012	<.006	<.01	<.005
Owens Bay near Ravinia, SD (06452403)																	
April 18, 2001	<.11	--	<.004	<.002	--	.051	E.012	--	<.26	<.005	<.018	<.06	<.002	E.012	<.006	<.015	.031
June 27, 2001	<.11	--	.039	<.002	--	.119	<.006	--	<.09	E.002	<.018	<.06	E.002	.022	<.006	<.015	.018
April 9, 2002	<.21	--	<.006	<.004	--	.011	E.002	--	<.09	<.005	<.018	<.12	<.002	E.005	<.006	<.01	<.005
June 11, 2002	<.16	--	.024	<.004	--	.100	E.019	--	<.09	<.005	<.018	<.12	<.002	E.011	<.006	<.01	<.005
Lake Andes above Lake Andes, SD (06452406)																	
April 18, 2001	<.11	--	<.004	<.002	--	.216	E.032	--	<.42	<.005	<.018	<.11	<.002	E.010	<.006	E.007	E.010
June 27, 2001	<.82	--	--	--	--	--	--	--	<.09	--	--	<.06	--	--	--	--	<0.1
April 9, 2002	<.23	--	.007	<.004	--	.068	E.008	--	<.14	<.005	<.018	<.18	<.002	E.011	<.006	E.01	.005
June 11, 2002	<.16	--	.021	<.004	--	.100	E.020	--	<.09	<.005	<.018	<.13	.005	.023	<.006	E.01	<.008

Table 5. Analytical results for selected dissolved pesticide constituents for Lake Francis Case and the Missouri River, 2002.

[Shaded columns indicate pesticides selected for the pesticide management plan approach. Location of stations shown in figure 2. All constituents in micrograms per liter. <, less than; --, no data; E, estimated. Data from U.S. Geological Survey (2003)]

Date	2,4-D	2,4-DP	Aceto-chlor	Ala-chlor	Ame-tryne	Atra-zine	De-ethyl atra-zine	De-iso-propyl atra-zine	Bro-macil	Chlor-pyri-fos	Cyana-zine	Diuron	EPTC	Meto-lachlor	Metri-buzin	Pro-me-tone	Sima-zine
Lake Francis Case near Lake Andes, SD (430419098401600)																	
April 22, 2002	--	--	<0.006	<0.004	--	0.023	E0.006	--	--	--	<0.018	--	<0.002	E0.010	<0.006	E0.01	<0.005
May 20, 2002	--	--	E.005	<.004	--	.025	E.004	--	--	--	<.018	--	.004	E.005	<.006	<.01	<.005
Missouri River at Fort Randall Dam, SD (06453000)																	
April 23, 2002	--	--	<.006	<.004	--	.021	E.005	--	--	--	<.018	--	<.002	E.009	<.006	<.01	<.005
May 21, 2002	--	--	.009	<.004	--	.027	E.005	--	--	--	<.018	--	.003	E.006	<.006	<.01	<.005

Geohydrologic Data

Coverages for geohydrologic data for the study area include generalized geology, extent of surficial aquifers, thickness of surficial deposits, estimated potential yield of surficial deposits, and extent of bedrock units (table 6). These coverages were produced by scanning, registering, and digitizing the published figures. A boundary for the Codell aquifer, which is a bedrock aquifer, is not provided because it underlies the entire study area (Kume, 1977). The geohydrologic data can be used to determine which areas are vulnerable to pesticide contamination.

The polygon coverage representing the generalized geology of the study area is based on Kume (1977, fig. 4). The coverage shows that most of the study area is covered with Quaternary-age deposits of alluvium, outwash, loess, and till. The alluvium generally is along Choteau Creek and the Missouri River. The outwash areas are generally along the alluvium of Choteau Creek. The mapped loess deposits are along the Missouri River. Most of the study area is covered with till. The Cretaceous-age deposits of Pierre Shale and Niobrara Marl are primarily along Lake Francis Case and the Missouri River in the southern part of the study area. Narrow areas of Niobrara Marl were mapped between the Missouri River alluvium and the Pierre Shale.

The polygon coverage representing the surficial aquifers of the study area is based on Kume (1977, fig. 11). These aquifers (Choteau, Corsica, Geddes, Tower, Greenwood, Delmont, and minor aquifers) are composed of Quaternary-age sand and gravel deposits. A comparison with the generalized geology coverage shows that some of these aquifers approximately correspond to units in the general geology coverage. For example, the Delmont aquifer is associated with the alluvium deposits along Choteau Creek, and the Tower and Greenwood aquifers are associated with mapped alluvium along the Missouri River. Other aquifers, such as the Choteau aquifer, which covers the largest area of any of the surficial aquifers, consist of several layers within the till (Kume, 1977, p. 16).

The arc coverage representing the thickness of the Quaternary-age surficial deposits is based on Kume (1977, fig. 9). The arcs indicate areas where the surficial deposits are 50, 100, 200, 300, and 400 feet thick. The areas with thicknesses of 50 feet or less of surficial deposits are primarily along Lake Francis Case and the Missouri River. In the northwestern part of the study area, the surficial deposits are more than 300 feet thick, and in the northeastern part of the study area, the surficial deposits are more than 400 feet thick.

The polygon coverage representing the estimated potential yield of surficial deposits is based on Kume (1977, fig. 16). The polygons indicate areas where the estimated potential yield ranges from less than 50 gallons per minute to more than 500 gallons per minute. The estimates are based on aquifer properties (thickness, extent, and material grain size) and reported yields of irrigation and municipal wells (Kume, 1977, p. 18). Most of the study area (49 percent) has an estimated potential yield of less than 50 gallons per minute, but about 17 percent of the study area has an estimated potential yield of more than 500 gallons per minute. Some of the area with an estimated potential yield of more than 500 gallons per minute is along the Missouri River and is associated with the Tower

Table 6. Summary of geohydrologic data sets for the study area.

Geohydrologic data set	Arc/Info coverage name	Contents of coverage
Generalized geology	geology	Polygon coverage of alluvium, loess, till, outwash, Pierre Shale, and Niobrara Marl (Kume, 1977, fig. 4)
Extent of surficial aquifers	surficial_aq	Polygon coverage of the Choteau, Corsica, Geddes, Tower, Greenwood, Delmont, and minor surficial aquifers (Kume, 1977, fig. 11)
Thickness of surficial deposits	thicknessdep	Arc coverage of thickness of surficial deposits (50, 100, 200, 300, and 400 feet) (Kume, 1977, fig. 9)
Estimated potential yield of surficial deposits	est_yield	Polygon coverage of estimated potential yield (less than 50, 50 to 100, 100 to 150, 150 to 250, 250 to 500, and more than 500 gallons per minute) (Kume, 1977, fig. 16)
Extent of bedrock units	bedrock	Polygon coverage of Ogallala undifferentiated, Pierre Shale, Niobrara Marl, and Carlile Shale (Hedges, 1975, fig. 5)

and Greenwood aquifers, but most of this area appears to be associated with the Choteau and Delmont aquifers and surficial deposits with thicknesses of more than 200 feet.

The polygon coverage representing the bedrock geology of the study area is based on Hedges (1975, fig. 5). For most of the study area, the uppermost bedrock unit is the Cretaceous-age Carlile Shale, Niobrara Marl, or Pierre Shale. The Carlile Shale is found along the Missouri River and Choteau Creek. The Niobrara Marl is found to the north of the Carlile Shale along the Missouri River and in an irregularly shaped body trending northwest to southeast. The Pierre Shale is the uppermost bedrock unit in the rest of the study area, except for some isolated areas of Tertiary-age Ogallala undifferentiated deposits (Hedges, 1975).

Land Cover and Use

Land-cover data were developed for the Multi-Resolution Land Characteristics (MRLC) Consortium, an interagency project involving the USGS, the USEPA, the National Oceanographic and Atmospheric Administration, and the USDA, Forest Service. The National Land Cover data sets are high-resolution (30-by-30-meters) digital data describing land cover for the conterminous United States. Twenty-one general land-cover classes were developed for mapping 30-meter Landsat thematic mapper satellite data. Only 13 of the 21 land-cover classes were present within the study area. The data are organized by State and were downloaded with the metadata from the Internet on January 16, 2003, using links to the Geospatial Data Gateway. The National Land Cover data set for South Dakota was preliminary at the time this study was completed; therefore, the accuracy assessment of the data set was not completed. Land-cover and land-use data can be used to determine where pesticides and fertilizers are likely to be applied, where crops are irrigated, and where urban development is located. Land-cover and land-use data for Charles Mix County and the study area are summarized in table 7. Information for Charles Mix County is included because some information, including pesticide use, is only available on a county-by-county basis. Using the number of acres within Charles Mix County and within the study area, estimates can be made of the pesticide use within the study area.

Within the study area, three categories account for more than 91 percent of the land cover and use. Row crops (46.02 percent) cover the most area of any category, followed by pasture/hay (33.20 percent) and grasslands/herbaceous plants (11.86 percent).

Table 7. Land cover and use.

Land cover and use	Charles Mix County		Within historic reservation boundary	
	Acres	Percent	Acres	Percent
Row crops (corn, soybeans, sunflowers, etc.)	313,356.7	42.53	202,115.5	46.02
Pasture/hay (may be used for grazing or seed/hay crops)	237,796.2	32.27	145,811.0	33.20
Grasslands/herbaceous plants (grasses and forbs often utilized for grazing)	104,155.0	14.14	52,090.4	11.86
Open water	38,660.2	5.25	15,528.7	3.54
Deciduous forest	17,295.8	2.35	10,516.7	2.39
Emergent herbaceous wetlands	17,099.6	2.32	9,200.9	2.10
Evergreen forest	4,502.2	.61	1,390.3	.32
Commercial/industrial/transportation (infrastructure, such as roads and railroads)	1,787.3	.24	1,004.0	.23
Low intensity residential (most commonly single-family housing)	750.2	.10	367.0	.08
Small grains (wheat, barley, oats, etc.)	733.8	.10	560.9	.13
Woody wetlands	445.1	.06	410.4	.09
Urban/recreational grasses (parks, lawns, golf courses, air strips, etc.)	184.2	.02	124.6	.03
Bare rock, sand, clay	38.5	.01	29.8	.01
Total	736,793.6	100.00	439,150.2	100.00

Precipitation

Precipitation data can be used to determine when pesticides are likely to be applied. The data also may be used to estimate recharge to the ground-water system, which is often used as a factor in assessing sensitivity of ground-water systems to contamination (Focazio and others, 2002).

Precipitation data from 1961-90 for six National Weather Service (NWS) stations in or near the study area are presented in table 8. The average monthly values were downloaded from the Internet on February 13, 2003, at URL http://climate.sdstate.edu/web/GIS_index.htm. Two of the stations, Pickstown and Wagner (fig. 1), are within the study area and represent the smallest and second-largest annual precipitation totals, respectively, of the group. The average annual precipitation during the 30-year period was 22.25 inches at Pickstown and 25.20 inches at Wagner. For all six stations, the largest monthly averages were during May, June, or July and ranged from 3.63 to 4.10 inches. The smallest monthly averages for all six stations were during January and ranged from 0.32 to 0.58 inches.

Irrigation

Irrigation information was obtained from the South Dakota Department of Environment and Natural Resources, Water Rights Program (Ron Duvall, written commun., 2003). That information was used to create an Arc/Info point coverage with the data fields and values described in table 9. Irrigation data can be used to determine when and where pesticides are likely to be applied. Irrigation data also may be used to improve recharge estimates.

The irrigation point coverage contains information about 58 permits (39 ground water and 19 surface water) for a total of 66 diversion points. Of the 58 permits, 51 have been licensed and the remaining 7 have not yet received the license from the State. The licensed irrigation withdrawals are for a total of 9,187.1 acres and 102.13 cubic feet per second. Of the 39 ground-water permits, 32 are for the Choteau aquifer, 3 are for the Delmont aquifer, 2 are for Pleistocene series aquifers, and 2 are for the Geddes aquifer. It should be noted that these aquifer designations are assigned by the State of South Dakota, and the locations of the withdrawals may be known only to the nearest 160 acres.

Orthophotos

The orthophotos data set for Charles Mix County is a composite of aerial photographs that have been registered to the Universal Transverse Mercator coordinate system. The photographs were taken from August 14, 1991, through September 3, 1998. The orthophoto data set was downloaded with the metadata from the Internet on February 21, 2003, using a link to the Geospatial Data Gateway.

The orthophotos can be used to compare surface features, such as roads and buildings, to subsurface information, such as estimated potential yield. They also can be used to compare reported irrigation diversion point locations to areas where the water is used and to observe changes in roads, drainages, land use, etc., over time.

Table 8. Normal precipitation (1961-90), in inches, for selected South Dakota stations within and near the historic Yankton Sioux Reservation area.

[Monthly values retrieved from URL http://climate.sdstate.edu/web/GIS_index.htm on Feb. 13, 2003]

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Annual
Armour	0.52	0.69	1.67	2.34	3.18	3.88	3.12	2.16	2.38	1.56	0.84	0.72	23.06
Bonesteel	.32	.65	1.79	2.78	4.10	3.96	3.35	2.75	2.82	1.66	.83	.53	25.54
Pickstown	.40	.52	1.57	2.35	2.97	3.97	2.74	2.28	2.46	1.51	.84	.64	22.25
Platte	.48	.62	1.72	2.46	3.69	3.77	2.83	2.31	2.27	1.54	.86	.66	23.21
Tyndall	.43	.64	1.55	2.31	3.38	3.60	3.63	2.41	2.56	1.50	1.05	.71	23.77
Wagner	.58	.79	1.68	2.56	3.61	3.84	3.12	2.45	2.87	1.70	1.09	.91	25.20

Table 9. Irrigation within the study area.

[Data from the South Dakota Department of Environment and Natural Resources, Water Rights Program (Ron Duvall, written commun., 2003). PLSS, public land survey system]

Field name in Arc/Info coverage	Description	Values
permit	Permit identifier, alphanumeric	Various
totaldp	Total number of diversion points for the permit	1, 2, or 3
dpnum	Number of the specified diversion point for the permit	1, 2, or 3
qq	Sub-section identifiers	A, B, C, D, or L (lot)
section	Section number of the PLSS description	1-6, 8, 10-17, 19-22, 25-30, 32-36
township	Township number of the PLSS description, all are N (north)	93, 94, 95, 96, 97, or 98
range	Range number of the PLSS description, all are W (west)	62, 63, 64, 65, or 66
latitude	Latitude in decimal degrees	42.85796 - 43.32386
longitude	Longitude in decimal degrees	98.11019 - 98.67093
aquifer	Aquifer code	CH (Choteau) PS (Pleistocene Series) D (Delmont) GE (Geddes)
unit	Management unit (for ground-water withdrawals only)	W (Wagner) M (Missouri River)
diversion	Diversion name	GROUNDWATER MISSOURI RIVER CHOTEAU CREEK BULL CREEK DRAINAGE WELL & DUGOUT SLOUGH
status2003	Permitted or licensed status as of March 2003	LC (licensed) PE (permitted)
permit_acres	Permitted acres (permits are issued prior to licenses)	0.0 - 600.0
license_acres	Licensed acres (licensed values take precedence over permit values)	0.0 - 660.0
permit_cfs	Permitted withdrawals in cubic feet per second	0.00 - 8.57
license_cfs	Licensed withdrawals in cubic feet per second	0.00 - 9.43
HUC	Hydrologic unit code	10140101 (Fort Randall Reservoir) 10170101 (Lewis and Clark Lake)

Selected References

Amundson, F.D., 2002, Estimated use of water in South Dakota: U.S. Geological Survey Open-File Report 02-440, 17 p.

Battaglin, W.A., and Goolsby, D.A., 1994, Spatial data in geographic information systems format on agricultural chemical use, land use, and cropping practices in the United States: U.S. Geological Survey Water-Resources Investigations Report 94-4176, 87 p. (available online at URL http://water.usgs.gov/pubs/wri/wri944176/).

Bryce, S.A., Omernik, J.M., Pater, D.E., Ulmer, Michael, Schaar, Jerome, Freeouf, Jerry, Johnson, Rex, Kuck, Pat, and Azevedo, S.H., 1998, Ecoregions of North Dakota and South Dakota: Dynamac Corporation, 1 sheet.

Environmental Systems Research Institute, Inc., 2000, ArcDoc version 8.0.2, patch 1: Redlands, Calif., ESRI.

Focazio, M.J., Reilly, T.E., Rupert, M.G., and Helsel, D.R, 2002, Assessing ground-water vulnerability to contamination—Providing scientifically defensible information for decision makers: U.S. Geological Survey Circular 1224, 33 p.

Hedges, L.S., 1975, Geology and water resources of Charles Mix and Douglas Counties, South Dakota—Part 1, Water resources: South Dakota Geological Survey Bulletin 22, 43 p.

Kolpin, D.W., Burkart, M.R., and Thurman, E.M., 1994, Herbicides and nitrate in near-surface aquifers in the midcontinental United States, 1991: U.S. Geological Survey Water-Supply Paper 2413, 34 p.

Kume, Jack, 1972, Major aquifers in Charles Mix and Douglas Counties, South Dakota: South Dakota Geological Survey Information Pamphlet No. 2, 6 p.

Kume, Jack, 1977, Geology and water resources of Charles Mix and Douglas Counties, South Dakota—Part 2, Water resources: South Dakota Geological Survey Bulletin 22, 31 p.

National Center for Food and Agricultural Policy Pesticide Use Database, 2001, accessed on July 31, 2001, at URL http://pestdata.ncsu.edu/ncfap/search.cfm

Neitzert, K.M., 1995, Records of wells and chemical analyses of ground water in Charles Mix and Douglas Counties, South Dakota: U.S. Geological Survey Open-File Report 95-153, 129 p.

Sando, S.K., and Neitzert, K.M., 2003, Water and sediment quality of the Lake Andes and Choteau Creek Basins, South Dakota: U.S. Geological Survey Water-Resources Investigations Report 03-4148, 114 p.

South Dakota Agricultural Statistics Service, 2001, South Dakota 2000 agricultural chemical usage: U.S. Department of Agriculture, accessed on August 28, 2003, at URL http://www.nass.usda.gov/sd/releases/agchem01.pdf

South Dakota Agricultural Statistics Service, 2003a, Snapshot of county 023: U.S. Department of Agriculture, accessed on August 28, 2003, at URL http://www.nass.usda.gov/sd/cp/cpco0230.htm

South Dakota Agricultural Statistics Service, 2003b, Snapshot of county 023: U.S. Department of Agriculture, accessed on August 28, 2003, at URL http://www.nass.usda.gov/sd/cp/cpco0232.htm

U.S. Environmental Protection Agency, 1996, Pesticides and ground water state management plan regulation: Federal Register, June 26, 1996, v. 61, no. 124, p. 33259-33301.

U.S. Geological Survey, 1996-2003, Water resources data, South Dakota, water years, 1995-2002: U.S. Geological Survey Water-Data Reports SD-95-1 to SD-02-1 (published annually).

Supplemental Information

Disk 1

A_document (contains metadata in HTML format for coverages on the disk)

A_notice.txt

bedrock
- bedrock (polygon coverage)
- info

dem
- dem_ft (grid format)
- info
- dem_ft.aux

estimated_yield
- est_yield (polygon coverage)
- info

geology
- geology (polygon coverage)
- info

huc
- hucs (polygon coverage)
- info

irrigation
- info
- irrigation (point coverage)

landuse
- ecoregions (polygon coverage)
- info
- landuse_grid (grid format)
- landuse_grid.aux

orthophotos
- info
- ortho1-1_sd023.aux
- ortho1-1_sd023.sdw
- ortho1-1_sd023.sid (MrSID format)
- ortho1-1_sd023.sid.xml

pestuse
- battaglin
  - cm_agchem (polygon coverage)
  - cm_herb1 (polygon coverage)
  - cm_herb2 (polygon coverage)
  - cm_herb3 (polygon coverage)
  - cm_herb4 (polygon coverage)
  - cm_herb5 (polygon coverage)
  - info
- agchem2000.pdf
- cmco1997.htm
- cmco1998.htm
- cmco1999.htm
- cmco2000.htm

surficial_aquifers
- info
- surficial_aq (polygon coverage)

thickness
- info
- thicknessdep (arc coverage)

watqual
- yst_organics.xls
- yst_organics.txt
- info
- QWDATA.xls
- QWDATA.txt
- wq_sites (point coverage)