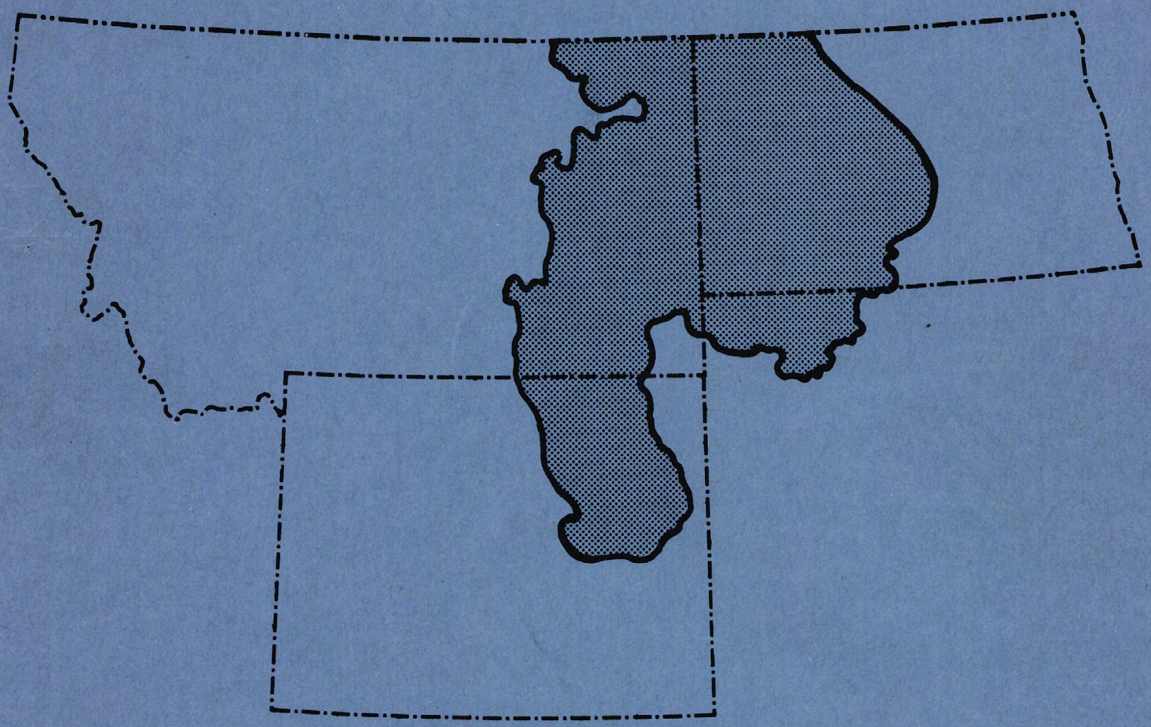
[redacted]

S-1

WATER RESOURCES INVESTIGATIONS
by the
U.S. GEOLOGICAL SURVEY
in the
NORTHERN GREAT PLAINS COAL REGION
of
WYOMING, MONTANA, AND NORTH DAKOTA,
1975



Prepared by

UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

OPEN - FILE REPORT

MAY 1975

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

WATER-RESOURCES INVESTIGATIONS OF THE U.S. GEOLOGICAL SURVEY IN THE NORTHERN GREAT PLAINS COAL REGION OF WYOMING, MONTANA, AND NORTH DAKOTA, 1975

By U.S. Geological Survey, Water Resources Division

Open-File Report

Denver, Colorado

May 1975

UNITED STATES DEPARTMENT OF THE INTERIOR

Rogers C. B. Morton, Secretary

GEOLOGICAL SURVEY

V. E. McKelvey, Director

CONTENTS

CONTENTS--continued

ILLUSTRATIONS

Water Resources Investigations

of the

U.S. Geological Survey

in the

Northern Great Plains Coal Region of

Wyoming, Montana, and North Dakota,

1975

INTRODUCTION

The Geological Survey's Water Resources Division has for many years maintained a program of water-resources investigations that includes the coal regions of Wyoming, Montana, and North Dakota. These programs have been supported by State and local agencies and by other agencies of the Federal government, largely to provide data for water-resources development projects, allocations of water, and to inventory of water resources for future planning.

The recent interest in coal has added new dimensions and greater intensity to the investigations. The work has expanded to include monitoring the environmental effects of coal mining and processing and to determine the availability of additional water supplies for coal-conversion plants and related demands.

New objectives are now reflected in the program. Much of the work is to assist the Bureau of Land Management in its responsibilities to minimize the possible detrimental effects of coal mining on the public resource lands. The Environmental Protection Agency also supports a significant part of the program. Their support is to assure that water-quality information is collected at key locations, with types of water-quality data and frequency of sampling needed by that agency in the discharge of its function. Relatively large increases in the program have been funded by direct appropriation to the Geological Survey.

This report describes the water-resources investigation program that is currently in operation. Locations of gaging stations and water-quality measuring sites, frequencies and parameters, and areas of ground-water studies are included in this report. Brief descriptions of coal-related studies by investigators who are headquartered outside the Northern Great Plains coal regions are also included. Such studies are research in topics related to coal extraction, water supply, and post-mining reclamation.

Additional information on the water-resources investigations program in each of the three states may be obtained from the following offices:

In Montana:

District Chief — Telephone: (406) 442-9040, Ext. 3263
U.S. Geological Survey
Water Resources Division
P.O. Box 1696
421 Federal Bldg., 316 N. Park
Helena, Montana 59601

In North Dakota:

District Chief — Telephone: (701) 255-4011, Ext. 227
U.S. Geological Survey
Water Resources Division
P.O. Box 778
Room 332, New Federal Building
Third Street and Rosser Avenue
Bismarck, North Dakota 58501

In Wyoming:

District Chief — Telephone: (307) 778-2220, Ext. 2111
U.S. Geological Survey
P.O. Box 2087
4015 Warren Avenue
Cheyenne, Wyoming 82001

The names, addresses, and telephone numbers of the principal investigator for the projects that are administered outside the above-listed offices follow the descriptions of those projects.

WYOMING

The U.S. Geological Survey currently has four data-collection activities and five water-resource appraisal projects active in the Northern Great Plains coal region of northeastern Wyoming (the Powder River structural basin).

The data-collection activities include: (1) streamflow measurements; (2) measurements of water levels in wells; (3) sampling and chemical analysis of water from streams and wells; and (4) sampling and sediment analysis of water from streams. This report contains lists of monitoring sites and maps showing the locations of the sites (figs. 1-8).

The water-resource appraisal projects include: (1) Water resources of Weston County, Wyoming; (2) Measurement of water losses to the Madison Limestone and associated rocks from streams in northeastern Wyoming; (3) Hydrology of Paleozoic rocks in the Powder River Basin and adjacent areas, northeastern Wyoming; (4) Water resources of the Powder River structural basin in Wyoming in relation to energy development; and (5) Availability of ground water from the Cretaceous and Tertiary aquifers of the Fort Union Coal Region. The objectives of these projects are described in the text, and the project locations are shown on figure 9. The streamflow measurement sites established for the study of water losses to the Madison Limestone are included in the list of "Streamflow and Reservoir Stations" (p. 11 and fig. 1).

A listing of selected reports by USGS authors is also included to give an indication of what has been done in the past.

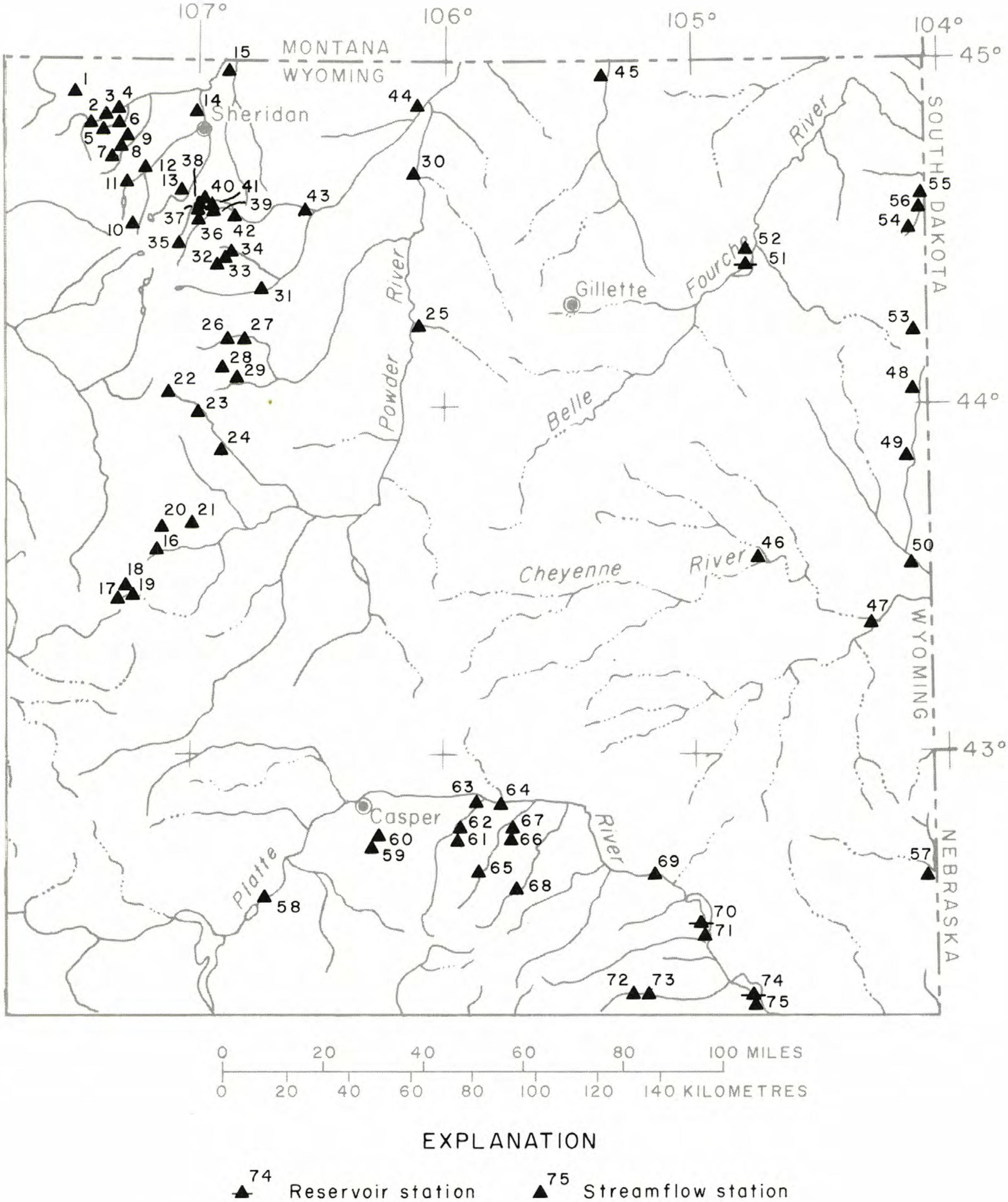


Figure 1.—Streamflow and reservoir stations.

DATA-COLLECTION ACTIVITIES

Streamflow and Reservoir Stations

Map number	Station number	Station name	Location	Section	Township	Range	Cooperator 1/
1	06289800	East Pass Creek near Parkman		4	57N	88W	028
2	06297480	Tongue River at Tongue Canyon Campground, near Dayton	SE¼NE¼NW¼	10	56N	87W	028
3	06297500	Highline ditch near Dayton	NE¼NE¼NE¼	11	56N	87W	WSE
4	06298000	Tongue River near Dayton	NE¼NE¼NE¼	11	56N	87W	WSE
5	06298480	Little Tongue River at Steamboat Point, near Dayton	SW¼SE¼SE¼	21	56N	87W	028
6	06298490	Little Tongue River above South Fork Little Tongue River, near Dayton	SW¼SE¼SW¼	24	56N	87W	028
7	06299480	Wolf Creek below Alden Creek, near Wolf	SW¼NW¼NE¼	7	55N	86W	028
8	06299490	Wolf Creek above Red Canyon Creek, at Wolf	NE¼SE¼SW¼	5	55N	86W	028
9	06299500	Wolf Creek at Wolf	NE¼SW¼NW¼	4	55N	86W	WSE
10	06300500	East Fork Big Goose Creek near Big Horn	SE¼SE¼NW¼	28	53N	86W	WSE
11	06301500	West Fork Big Goose Creek near Big Horn		35	54N	87W	WSE
12	06302000	Big Goose Creek near Sheridan	NW¼NE¼	35	55N	86W	WSE
13	06303500	Little Goose Creek in Canyon, near Big Horn	SE¼SW¼NE¼	1	53N	85W	WSE
14	06305500	Goose Creek below Sheridan	SE¼SW¼	15	56N	84W	WSE
15	06306250	Prairie Dog Creek near Acme	NE¼SW¼SW¼	23	58N	83W	WSE
16	06309200	Middle Fork Powder River near Barnum	SE¼SW¼NE¼	26	42N	86W	WSE
17	06309260	Buffalo Creek above North Fork Buffalo Creek, near Arminto	SW¼NW¼NE¼	20	40N	86W	028
18	06309270	North Fork Buffalo Creek near Arminto	SE¼SE¼NE¼	17	40N	86W	028
19	06309280	Buffalo Creek below North Fork Buffalo Creek, near Arminto	NE¼NW¼SE¼	21	40N	86W	028
20	06309450	Beaver Creek below Bayer Creek, near Barnum	SE¼SE¼NW¼	28	43N	85W	028
21	06309460	Beaver Creek above White Panther ditch, near Barnum	SE¼SW¼NW¼	16	43N	84W	028
22	06311000	North Fork Powder River near Hazelton	NW¼SE¼NW¼	21	47N	85W	WSE
23	06311060	North Fork Powder River below Bull Creek, near Hazelton	NE¼SE¼SW¼	25	47N	85W	028
24	06311400	North Fork Powder River below Pass Creek, near Mayoworth	NW¼NE¼SE¼	36	46N	84W	WSE
25	06313700	Dead Horse Creek near Buffalo	SW¼SE¼	15	49N	77W	WSE
26	06313950	North Fork Crazy Woman Creek below Pole Creek, near Buffalo	NW¼NE¼SW¼	28	49N	83W	DEPD
27	06314000	North Fork Crazy Woman Creek near Buffalo	SW¼SW¼NE¼	27	49N	83W	DEPD

See footnote at end of list, p. 14

Map number	Station number	Station name	Location	Section	Township	Range	Cooperator 1/
28	06315480	Poison Creek below Tetley Spring, near Mayoworth	SE¼NW¼NW¼	32	48N	83W	028
29	06315490	Poison Creek near Mayoworth	SW¼NE¼SW¼	3	47N	83W	028
30	06317000	Powder River at Arvada	NE¼NW¼	21	54N	77W	WSE
31	06318500	Clear Creek near Buffalo	SE¼SW¼NW¼	6	50N	82W	DEPD
32	06319470	South Rock Creek at forest boundary, near Buffalo	SW¼SW¼SW¼	25	52N	84W	028
33	06319480	South Rock Creek above Red Canyon, near Buffalo	SW¼SW¼SE¼	25	52N	84W	028
34	06320000	Rock Creek near Buffalo	NW¼NW¼NW¼	29	52N	83W	WSE
35	06320500	South Piney Creek at Willow Park		24	52N	85W	WSE
36	06321000	South Piney Creek near Story	NW¼NE¼NE¼	23	53N	84W	WSE
37	06321020	Mead-Coffeen ditch above fish hatchery, near Story	NE¼SW¼SW¼	13	53N	84W	028
38	06321040	Mead-Coffeen ditch below fish hatchery, near Story	NE¼SE¼NW¼	13	53N	84W	028
39	06321100	South Piney Creek below Mead-Coffeen ditch, near Story	SW¼SW¼SW¼	13	53N	84W	028
40	06321500	North Piney Creek near Story	NW¼SW¼	12	53N	84W	DEPD
41	06321800	Spring Creek near Story	NE¼SE¼NW¼	13	53N	84W	028
42	06323000	Piney Creek at Kearny	NE¼NE¼SW¼	26	53N	83W	WSE
43	06323500	Piney Creek at Ucross	SW¼	18	53N	80W	DEPD
44	06324000	Clear Creek near Arvada	SE¼	36	57N	77W	DEPD
45	06324970	Little Powder River above Dry Creek, near Weston	NW¼SW¼	13	57N	71W	WSE
46	06376300	Black Thunder Creek near Hampshire	NW¼NW¼	31	42N	65W	WSE
47	06386000	Lance Creek at Spencer		14	39N	62W	WSE
48	06392900	Beaver Creek at Mallo Camp, near Four Corners	NE¼NE¼	4	47N	60W	028
49	06392950	Stockade Beaver Creek near Newcastle	SW¼SE¼	19	45N	60W	028
50	06394000	Beaver Creek near Newcastle	NW¼	18	41N	60W	USGS
51	06427000	Keyhole Reservoir near Moorcroft	NW¼NW¼	27	51N	66W	MRB
52	06427500	Belle Fourche River below Keyhole Reservoir	NE¼SE¼SE¼	21	51N	66W	BRUM
53	06429500	Cold Spring Creek near Buckhorn	NW¼	9	48N	60W	028
54	06429900	Sand Creek at Ranch A, near Beulah	SW¼	18	52N	60W	028
55	06430000	Murray ditch at Wyoming-South Dakota State line	SW¼SW¼	7	7N	1E	WSE
56	06430500	Redwater Creek at Wyoming-South Dakota State line	NW¼NW¼	18	7N	1E	WSE

See footnote at end of list, p. 14

Streamflow and Reservoir Stations--Continued

Map number	Station number	Station name	Location	Section	Township	Range	Cooperator 1/
57	06454000	Niobrara River at Wyoming-Nebraska State line	SE¼SW¼	15	31N	60W	
58	06642000	North Platte River at Alcova	NW¼NE¼NW¼	17	30N	82W	WSE
59	06645150	Smith Creek above Otter Creek, near Casper	SW¼SE¼NW¼	15	31N	78W	028
60	06645160	Smith Creek at Otter Creek, near Casper	NE¼NW¼SW¼	14	31N	78W	028
61	06646280	Little Deer Creek above East Cart Creek, near Glenrock	NW¼NW¼SW¼	28	32N	76W	028
62	06646300	Little Deer Creek below East Cart Creek, near Glenrock	NW¼NW¼NW¼	28	32N	76W	028
63	06646600	Deer Creek below Millar waste-way, at Glenrock	NW¼NW¼	4	33N	75W	WSE
64	06646800	North Platte River near Glenrock	NW¼NE¼	17	33N	74W	WSE
65	06647500	Box Elder Creek at Boxelder	Center	32	31N	75W	WSE
66	06647890	Little Box Elder Creek near Careyhurst	SE¼SW¼SE¼	8	32N	74W	028
67	06647900	Little Box Elder Creek at Little Box Elder Cave, near Careyhurst	NE¼SE¼NW¼	9	32N	74W	028
68	06649000	LaPrele Creek near Douglas	NW¼SE¼SW¼	5	31N	73W	WSE
69	06652000	North Platte River at Orin	SW¼SW¼	17	31N	69W	WSE
70	06652700	Glendo Reservoir near Glendo	SW¼NE¼	24	29N	68W	MRB
71	06652800	North Platte River below Glendo Reservoir	SW¼SW¼NW¼	30	29N	67W	WSE
72	06654510	Cottonwood Creek below Dagley Creek, near Binford	NW¼SE¼NE¼	15	27N	70W	028
73	06654520	Cottonwood Creek below tunnel outlet, near Binford	SE¼SW¼SW¼	14	27N	70W	028
74	06655500	Guernsey Reservoir near Guernsey	NE¼NW¼	27	27N	66W	MRB
75	06656000	North Platte River below Guernsey Reservoir	SE¼SE¼	27	27N	66W	WSE

1/ Cooperators

WSE	Wyoming State Engineer
DEPD	Wyoming Department of Economic Planning and Development
USGS	U. S. Geological Survey
MRB	U.S. Geological Survey - Missouri River Basin Program
BRUM	U.S. Bureau of Reclamation - Upper Missouri Region
028	Wyoming State Engineer (sponsored by Old West Regional Commission)

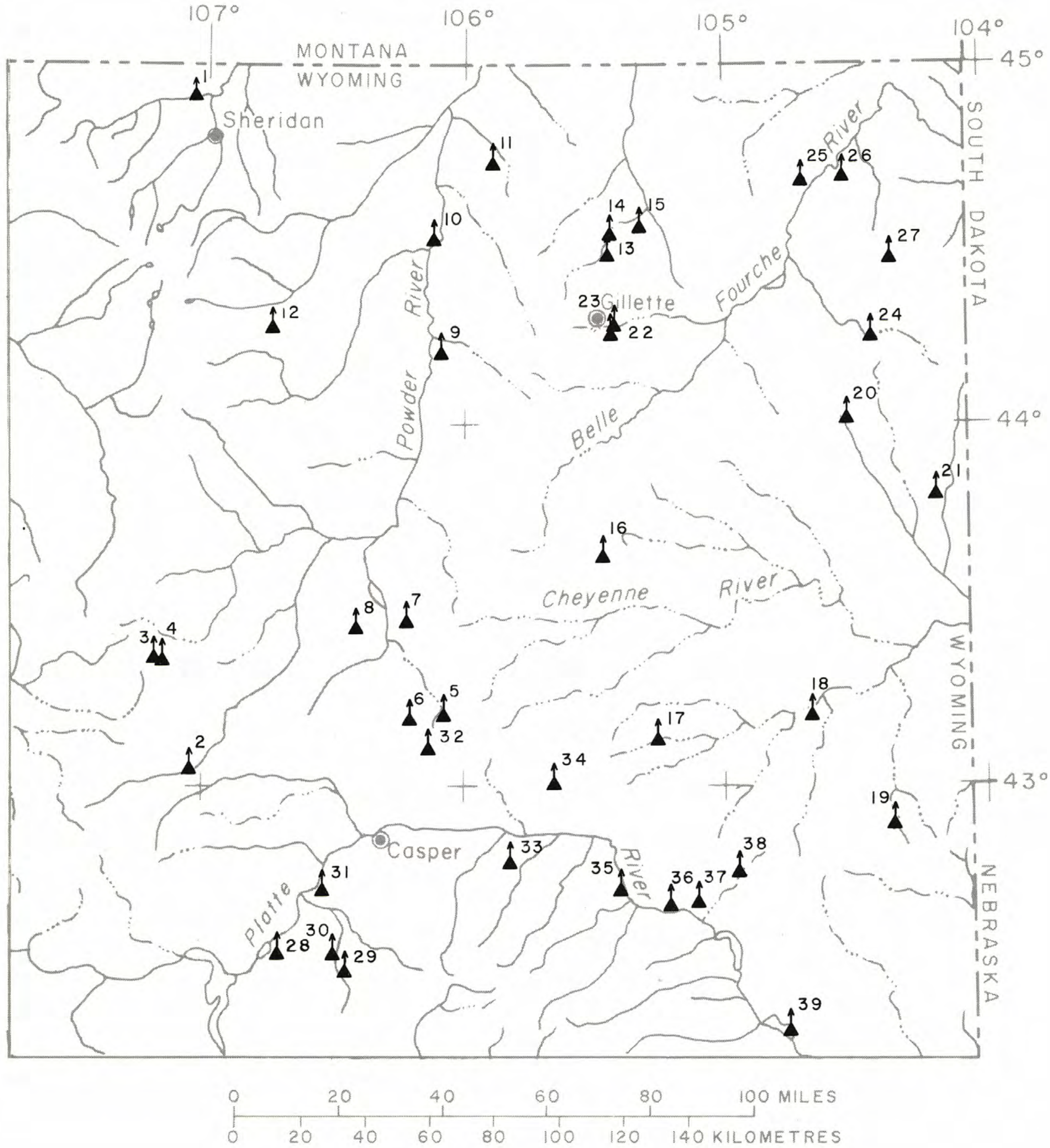


Figure 2.—Crest-stage stations.

Crest-Stage Stations

The crest-stage stations listed below are maintained in cooperation with the Wyoming Highway Department.

Map number	Station number	Station name	Location	Section	Township	Range
1	06299900	Slater Creek near Monarch	SE¼SW¼	18	57N	84W
2	06312700	South Fork Powder River near Powder River	SE¼NW¼	3	35N	85W
3	06312795	Sanchez Creek above reservoir near Arminto	NE¼NE¼	20	39N	86W
4	06312800	Sanchez Creek near Arminto	NW¼SE¼	21	39N	86W
5	06313020	Bobcat Creek near Edgerton	NW¼NW¼	10	37N	77W
6	06313050	East Teapot Creek near Edgerton	SE¼NE¼	16	37N	78W
7	06313100	Coal Draw near Midwest	NE¼SE¼	8	40N	78W
8	06313180	Dugout Creek tributary near Midwest	NE¼NW¼	14	40N	80W
9	06313630	Van Houten Draw near Buffalo	NE¼	33	49N	77W
10	06316700	Powder River tributary near Buffalo	NE¼NW¼	9	52N	77W
11	06317050	Spotted Horse Creek tributary near Spotted Horse	NW¼NE¼	28	55N	75W
12	06319100	Sand Creek near Buffalo	SW¼NE¼	29	50N	82W
13	06324800	Little Powder River tributary near Gillette	NE¼	36	52N	72W
14	06324900	Little Powder River tributary No. 2 near Gillette	NW¼	6	52N	71W
15	06324910	Cow Creek tributary near Weston	SE¼	26	53N	71W
16	06363700	Porcupine Creek near Turnercrest	SW¼NE¼	11	42N	72W
17	06379600	Box Creek near Bill	SW¼SE¼	9	36N	70W
18	06382200	Pritchard Draw near Lance Creek	SW¼NE¼	8	37N	65W
19	06385400	Cottonwood Creek at Hat Creek	NE¼	12	34N	63W
20	06387500	Turner Creek near Osage	SW¼SE¼	26	47N	64W
21	06388800	Blacktail Creek tributary near Newcastle	NE¼NE¼	16	44N	61W
22	06426195	Donkey Creek tributary above reservoir, near Gillette	NW¼SW¼	29	50N	71W
23	06426200	Donkey Creek tributary near Gillette	SW¼NW¼	29	50N	71W
24	06427700	Inyan Kara Creek near Upton	S½	17	49N	63W
25	06427880	Barlow Creek near Devils Tower	NW¼SW¼	20	54N	65W
26	06428100	Belle Fourche River tributary No. 2 near Hulett	SW¼SW¼	3	54N	64W
27	06429300	Ogden Creek near Sundance	SW¼SW¼	30	52N	62W
28	06641400	Bear Springs Creek near Alcova	SE¼SE¼	30	30N	82W
29	06642700	Lawn Creek near Alcova	SW¼SW¼	8	29N	80W
30	06642760	Stinking Creek near Alcova	SE¼NE¼	30	30N	80W
31	06643300	Coal Creek near Goose Egg	SW¼NW¼	27	32N	81W
32	06644840	McKenzie Draw tributary near Casper	SW¼NE¼	12	36N	78W
33	06646700	East Fork Dry Creek tributary near Casper	SW¼SW¼	26	33N	75W
34	06648780	Sage Creek tributary near Orpha	NE¼NW¼	18	35N	73W
35	06649900	North Platte River tributary near Douglas	SW¼NE¼	5	31N	71W
36	06651800	Sand Creek near Orin	NE¼SE¼	11	31N	70W
37	06652200	Shawnee Creek tributary near Orin	NW¼SW¼	2	31N	69W
38	06652400	Watson Draw near Lost Springs	SW¼SE¼	12	31N	68W
39	06655380	Fish Canyon near Guernsey	SE¼NW¼	15	27N	66W

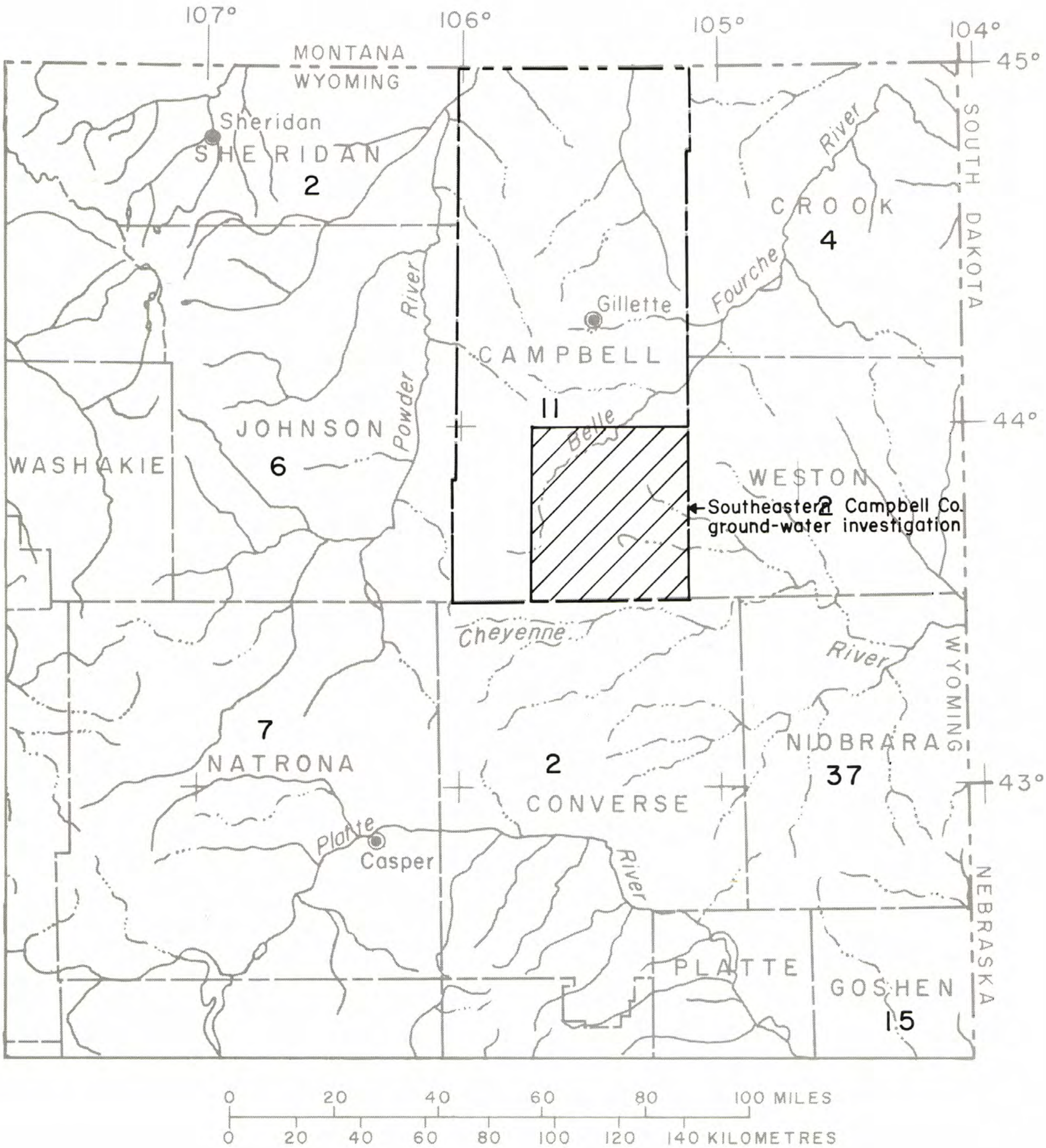


Figure 3.—Number of observation wells, by county.

OBSERVATION WELLS

Well Location				Well depth (feet)	Geologic source 1/	Frequency of observation 2/
Town-ship	Range	Section	Location in section			
			CAMPBELL COUNTY			
44N	72S	22	SW¼SW¼	189	124 WSTC	Q
50N	71W	20	SE¼NE¼NW¼	--	124 WSTC	M
50N	71W	21	NW¼NW¼NW¼	125	125 FRUN	M
50N	71W	27	SW¼NE¼NE¼	18	111 ALVL	M
50N	71W	27	NE¼NE¼NW¼	491	125 FRUN	C
50N	71W	27	SW¼NE¼NW¼	2,651	--	C
50N	71W	27	SE¼NE¼NW¼	19	111 ALVL	M
50N	71W	33	SW¼NE¼NW¼-1	173.5	125 FRUN	C
50N	71W	33	SW¼NE¼NW¼-2	35	125 FRUN	M
50N	71W	33	SW¼NE¼NW¼-3	25.5	111 ALVL	M
50N	72W	20	SE¼SE¼NE¼	320	124 WSTC	BM
			CONVERSE COUNTY			
32N	71W	31	NE¼NE¼NE¼	84	124 WDRV	SA
32N	74W	3	SE¼SW¼NW¼	1,464	331 MDSN	C
			CROOK COUNTY			
50N	68W	36	SE¼NE¼	305	211 LNCE	BM
53N	65W	18	SW¼NE¼NW¼	468	317 MNKT	M
53N	65W	18	SE¼NW¼NW¼-1	63	237 SPRF	Q
53N	65W	18	SE¼NW¼NW¼-2	1,341	337 PHSP	Q
			GOSHEN COUNTY			
25N	62W	2	NW¼NW¼NW¼	28	111 TRRC	BM
25N	63W	9	NW¼SW¼SW¼	61	111 ALVL	BM
26N	62W	14	NE¼NW¼NW¼	39	111 ALVL	BM
26N	63W	32	SW¼NE¼SE¼	80	111 ALVL	BM
26N	64W	23	NE¼SE¼SW¼	24	111 ALVL	BM
26N	64W	28	NW¼NW¼NW¼	29	111 ALVL	M
26N	64W	29	NE¼SE¼NE¼	43	111 ALVL	M
29N	60W	29	SE¼NE¼SW¼	178	122 ARKR	M
29N	61W	8	SW¼SE¼SW¼	137	122 ARKR	BM
29N	61W	26	SW¼SW¼NE¼	137	122 ARKR	BM
29N	64W	27	SW¼SW¼NW¼	87	122 ARKR	M
30N	60W	4	NE¼NE¼SE¼	150	122 ARKR	M
30N	60W	29	SW¼NW¼NW¼	117	122 ARKR	M
30N	61W	2	NE¼NE¼NE¼	180	122 ARKR	M
30N	62W	33	NE¼SW¼SE¼	--	122 ARKR	BM

See footnote at end of list, p. 20

Well Location				Well depth (feet)	Geologic source 1/	Frequency of observation 2/
Town-ship	Range	Location in section				
			JOHNSON COUNTY			
42N	78W	14	NW¼SE¼SE¼	99	211 LNCE	SA
43N	84W	4	SE¼SE¼NE¼	750	317 TSLP	I
48N	83W	5	SW¼SE¼	1,115	374 FLTD	A
49N	83W	27	NE¼NW¼SE¼-1	1,636	311 MDSN	I
49N	83W	27	NE¼NW¼SE¼-2	1,507	311 MDSN	C
51N	83W	10	NW¼SW¼NE¼	275	124 WSTC	SA
			NATRONA COUNTY			
30N	85W	21	NW¼NE¼NW¼	27	122 ARKR	Q
31N	81W	18	NW¼NE¼NE¼	55	111 ALVL	BM
33N	77W	3	SW¼SE¼NW¼	20	111 ALVL	Q
33N	80W	4	NW¼NW¼NE¼	69	111 TRRC	BM
34N	80W	8	SW¼SW¼SW¼	26	111 TRRC	BM
35N	80W	31	SE¼SE¼SE¼	45	111 TRRC	BM
40N	78W	15	NW¼NE¼NE¼	317	211 FXHL	Q
			NIOBRARA COUNTY			
31N	60W	9	SE¼NW¼	130	122 ARKR	M
31N	60W	15	NE¼SE¼	110	122 ARKR	M
31N	61W	13	NE¼SW¼NE¼	100	122 ARKR	M
31N	61W	16	NW¼NE¼SW¼	--	122 ARKR	M
31N	61W	29	NW¼NW¼	280	122 ARKR	M
31N	62W	4	NE¼NW¼NW¼	425	122 ARKR	M
31N	62W	15	NE¼NE¼NE¼	76	122 ARKR	M
32N	60W	8	SE¼SW¼	--	122 ARKR	M
32N	60W	29	SW¼NW¼	270	122 ARKR	M
32N	61W	10	NW¼NE¼	230	122 ARKR	M
32N	61W	16	SE¼NW¼	150	122 ARKR	M
32N	61W	33	SE¼SW¼	52	122 ARKR	M
32N	62W	12	SE¼SW¼SW¼	160	122 ARKR	M
32N	62W	20	NW¼NE¼	127	122 ARKR	M
32N	62W	20	SE¼SE¼NW¼	150	122 ARKR	M
32N	62W	32	NW¼NW¼NW¼	485	122 ARKR	C
32N	62W	34	SW¼SW¼	28	122 ARKR	M
32N	62W	36	NW¼NE¼	60	122 ARKR	M
32N	63W	2	SW¼SW¼SW¼	200	122 ARKR	M
32N	63W	8	SW¼NE¼-6	62	122 ARKR	M
32N	63W	26	NW¼NE¼SE¼	55	122 ARKR	M
32N	63W	33	NW¼NW¼NW¼	205	122 ARKR	M
32N	64W	12	NE¼SE¼SE¼	--	122 ARKR	M

See footnote at end of list, p. 20

Well Location				Well depth (feet)	Geologic source 1/	Frequency of observation 2/
Town-ship	Range	Location in section				
NIOBRARA COUNTY--Continued						
32N	64W	18	SE¼NW¼	112	122 ARKR	M
32N	64W	22	NW¼NE¼	100	122 ARKR	M
32N	64W	24	NE¼SE¼-2	58	122 ARKR	M
32N	65W	1	NW¼SW¼	108	122 ARKR	M
33N	61W	30	NW¼SW¼	255	122 ARKR	M
33N	62W	29	NE¼NW¼SE¼	400	122 ARKR	M
33N	63W	17	SE¼SW¼	156	122 ARKR	M
33N	63W	24	NW¼NW¼NW¼	245	122 ARKR	M
33N	64W	10	SE¼NE¼SE¼	110	122 ARKR	M
33N	64W	10	SE¼SW¼	--	122 ARKR	M
33N	64W	32	SW¼SW¼	105	122 ARKR	M
33N	64W	35	SE¼NE¼SE¼	140	122 ARKR	M
36N	62W	28	NW¼NE¼	505	217 LKOT	C
40N	61W	21	NW¼NE¼NW¼	18	111 ALVL	M
SHERIDAN COUNTY						
53N	83W	7	SW¼SE¼NE¼	115	124 WSTC	Q
54N	81W	14	SW¼NW¼-2	121	124 WSTC	M
WESTON COUNTY						
46N	61W	29	SW¼NE¼NW¼	2,345	337 PHSP	BM
46N	63W	9	NW¼SE¼	670	217 LKOT	M

1/ Geologic Source

Code	Formation	Code	Formation
111 ALVL	Alluvial Deposits	217 LKOT	Lakota Formation
111 TRRC	Terrace Deposits	237 SPRF	Spearfish Formation
122 ARKR	Arikaree Formation	317 MNKT	Minnekahta Limestone
124 WDRV	Wind River Formation	317 TSLP	Tensleep Sandstone
124 WSTC	Wasatch Formation	331 MDSN	Madison Formation or Group
125 FRUN	Fort Union Formation	337 PHSP	Pahasapa Limestone
211 FXHL	Fox Hills Sandstone	374 FLTD	Flathead Quartzite or Sandstone
211 LNCE	Lance Formation		

2/ Frequency of Observation

C - Continuous recorder
M - Monthly observation
BM - Bimonthly observation
Q - Quarterly observation
SA - Semiannual observation
A - Annual observation
I - Infrequent observation as required

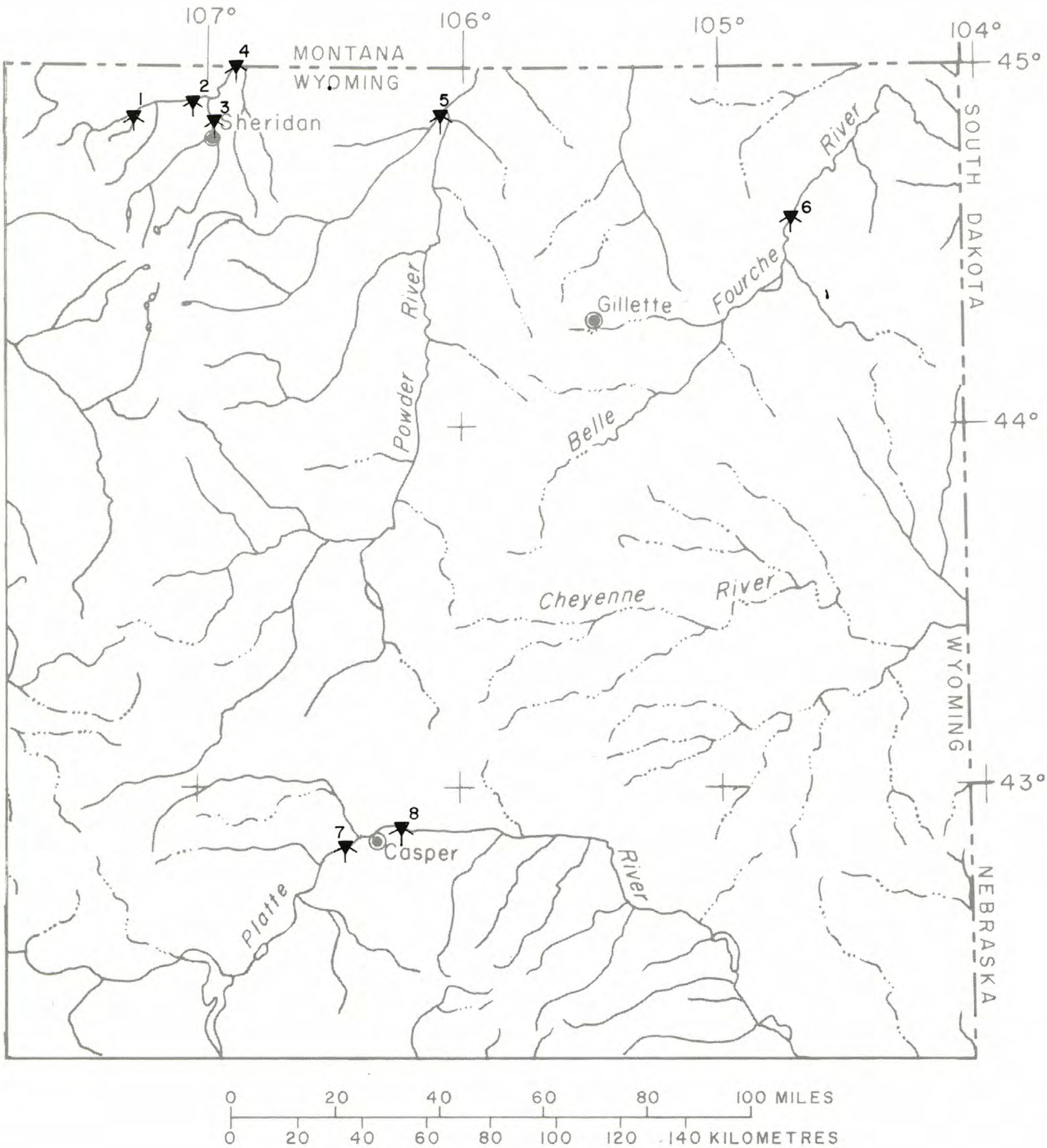


Figure 4.—Environmental Protection Agency water-quality surveillance stations.

Environmental Protection Agency Water-Quality Surveillance Program

Stations

Map number	Station number	Name	Location	Section	Township	Range
1	06298000	Tongue River near Dayton[1,2]	NE¼NE¼NE¼	11	56N	87W
2	06299980	Tongue River at Monarch[3]	NW¼SW¼NW¼	20	57N	84W
3	06305500	Goose Creek below Sheridan[1,2]	SE¼SW¼	15	56N	84W
4	06306300	Tongue River at State line, near Decker, Mont.[1,2]	NW¼NE¼	33	9S	40E
5	06324000	Clear Creek near Arvada[1]	SE¼	36	57N	77W
6	06427850	Belle Fourche River at Devils Tower[1,2]	NW¼SE¼SE¼	7	53N	65W
7	06644085	North Platte River at Mills[3]	NW¼NE¼SE¼	7	33N	79W
8	06645000	North Platte River below Casper[1,2]	NW¼NW¼	4	33N	78W

Parameter List for Stations 06298000, 06305500, 06306300, 06324000, 06427850

Monthly

Chemical - total ammonia, total nitrite plus nitrate, total kjeldahl nitrogen, biochemical oxygen demand.
Physical - specific conductance, pH.

Quarterly

Chemical - lead, copper, mercury, selenium, aluminum, zinc, boron.

Parameter List for Station 06299980

Monthly

Chemical - calcium, magnesium, sodium, potassium, silica, fluoride, bicarbonate, carbonate, chloride, sulfate, nitrite, nitrate, total phosphorous, dissolved solids, total kjeldahl nitrogen, total ammonia.
Physical - specific conductance, pH, turbidity.

Quarterly

Chemical - lead, copper, mercury, selenium, aluminum, zinc, boron.

Parameter List for Stations 06644085, 06645000

Biweekly

Chemical - chemical oxygen demand, dissolved solids, total organic carbon.
Physical - temperature, specific conductance, dissolved oxygen, turbidity.
Biological - total coliform, fecal coliform.

Quarterly

Chemical - calcium, magnesium, sodium, potassium, silica, fluoride, bicarbonate, carbonate, chloride, sulfate, nitrite, nitrate, total phosphorous, dissolved solids, total kjeldahl nitrogen, total ammonia.

---

[1] Additional data obtained through the Wyoming Department of Agriculture cooperative program.

[2] Additional data obtained through the Wyoming Department of Environmental Quality cooperative program.

[3] Additional data obtained through the Geological Survey Water-Quality program.

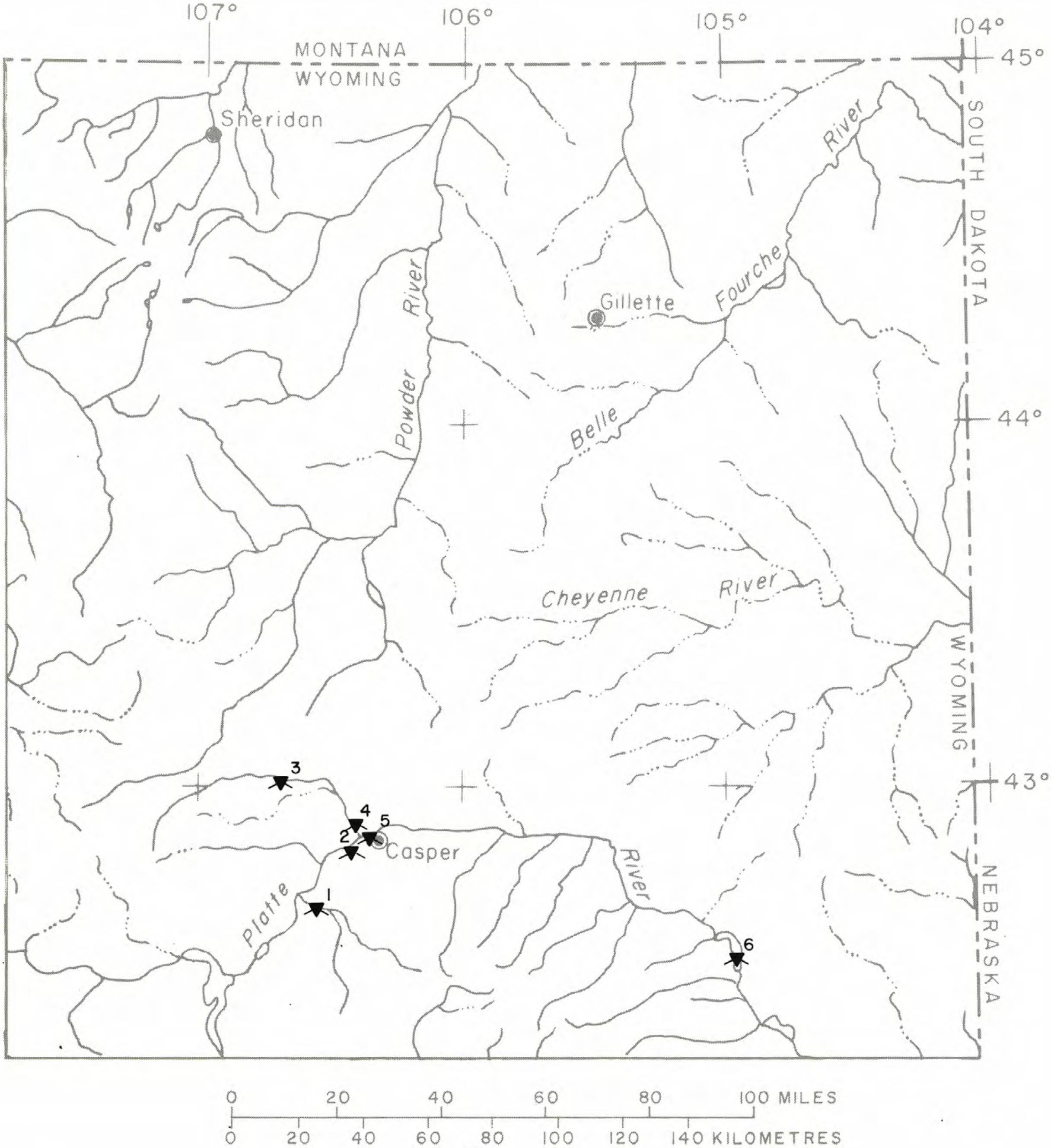


Figure 5.—Geological Survey water-quality stations.

Geological Survey Water-Quality Program

(Missouri River Basin Program)

Stations

Map number	Station number	Name	Location	Section	Township	Range
1	06643000	Bates Creek near Alcova	SE¼SE¼	1	31N	82W
2	06644085	North Platte River at Mills [1]	NW¼NE¼SE¼	7	33N	79W
3	06644120	Middle Fork Casper Creek near Bucknum [2]	NE¼	12	35N	82W
4	06644500	Casper Creek at Casper [2,3]	NW¼NE¼	7	33N	79W
5	06644550	North Platte River at Casper [3]	SE¼SE¼NW¼	4	33N	79W
6	06652700	Glendo Reservoir near Glendo [4]	SW¼NE¼	24	29N	68W

Parameter List

Monthly

Physical - temperature, specific conductance, dissolved oxygen, pH.

---

[1] Additional data obtained through the Environmental Protection Agency program.

[2] Samples collected annually for calcium, magnesium, sodium, potassium, fluoride, bicarbonate, carbonate, chloride, sulfate, nitrite, nitrate.

[3] Samples collected weekly during irrigation season, monthly during remainder of year.

[4] Sampled monthly (during ice-free months) for temperature, dissolved oxygen, total nitrite plus nitrate, total phosphorous, total ammonia, total dissolved solids.

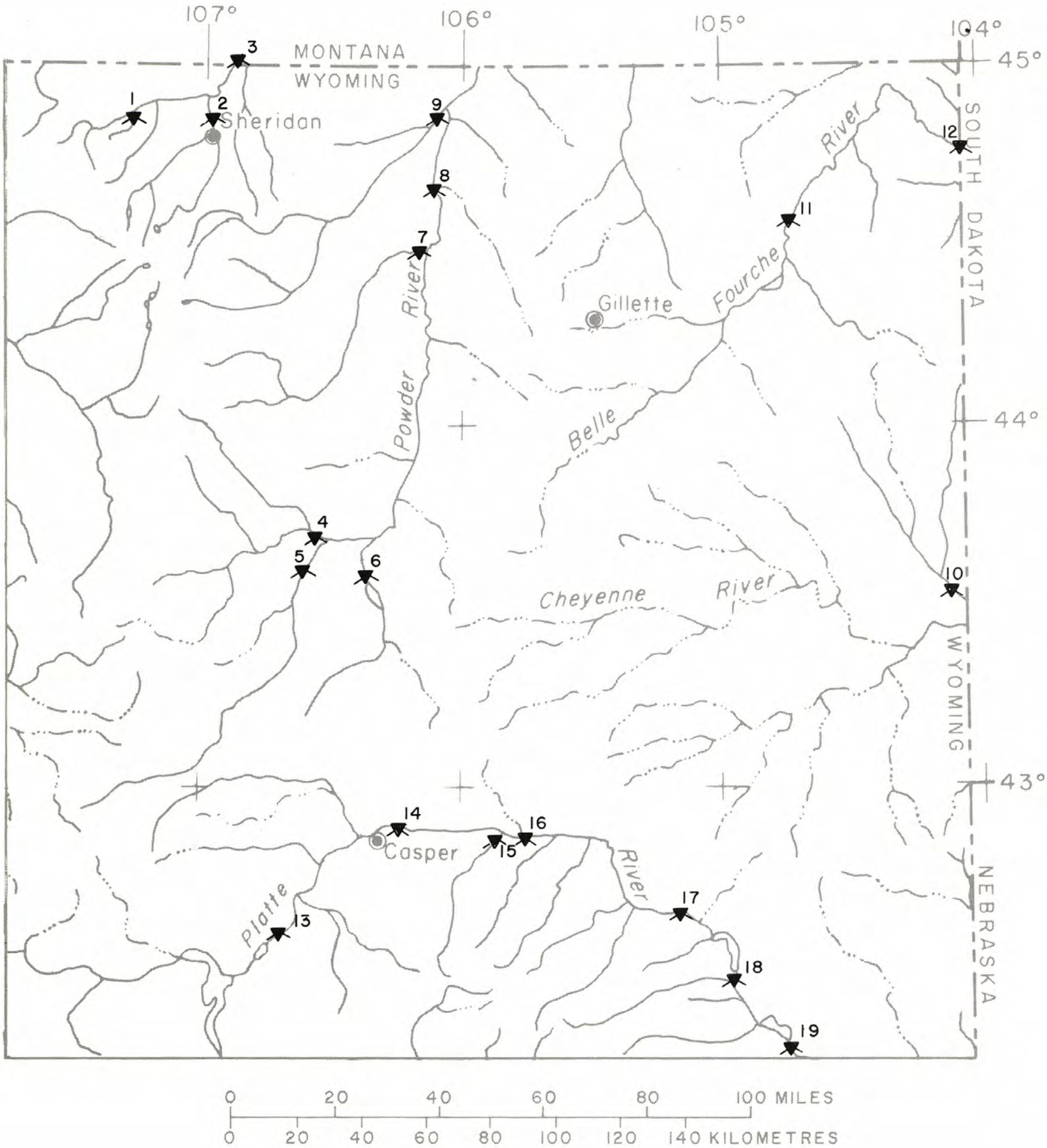


Figure 6.–Geological Survey–Wyoming Department of Agriculture cooperative program water-quality stations.

Geological Survey - Wyoming Department of Agriculture Cooperative Program

Stations

Map number	Station number	Name	Location	Section	Township	Range
1	06298000	Tongue River near Dayton [1,2]	NE¼NE¼NE¼	11	56N	87W
2	06305500	Goose Creek below Sheridan [1,2]	SE¼SW¼	15	56N	84W
3	06306300	Tongue River at State line, near Decker, Mont. [1,2,3]	NW¼NE¼	33	9S	40E
4	06312500	Powder River near Kaycee [2]	NE¼NW¼SW¼	13	43N	81W
5	06313000	South Fork Powder River near Kaycee	NE¼SE¼	9	42N	81W
6	06313400	Salt Creek near Sussex	NE¼NE¼SE¼	8	42N	79W
7	06316400	Crazy Woman Creek at upper station, near Arvada	NW¼	18	52N	77W
8	06317000	Powder River at Arvada [1,2]	NE¼NW¼	21	54N	77W
9	06324000	Clear Creek near Arvada [1]	SE¼	36	57N	77W
10	06394000	Beaver Creek near Newcastle	NW¼	18	41N	60W
11	06427850	Belle Fourche River at Devils Tower [1,2]	NW¼SE¼SE¼	7	53N	65W
12	06428500	Belle Fourche River at Wyoming-South Dakota State line [2,3]	NE¼NW¼NW¼	18	9N	1E
13	06642000	North Platte River at Alcova [2]	NW¼NE¼NW¼	17	30N	82W
14	06645000	North Platte River below Casper [1,2]	NW¼NW¼	4	33N	78W
15	06646600	Deer Creek below Millar wasteway, at Glenrock [3]	NW¼NW¼	4	33N	75W
16	06646800	North Platte River near Glenrock [3]	NW¼NE¼	17	33N	74W
17	06652000	North Platte River at Orin [2]	SW¼SW¼	17	31N	69W
18	06652800	North Platte River below Glendo Reservoir [2]	SW¼SW¼NW¼	30	29N	67W
19	06656000	North Platte River below Guernsey Reservoir	SE¼SE¼	27	27N	66W

Parameter List

Monthly

Chemical - calcium, magnesium, sodium, potassium, sulfate, bicarbonate, carbonate, chloride, fluoride, nitrate, silica, and total phosphorus.

Physical - temperature, specific conductance, and pH.

---

[1] Additional data obtained through the Environmental Protection Agency program.

[2] Additional data obtained through the Geological Survey - Wyoming Department of Environmental Quality cooperative program.

[3] Samples collected daily for specific conductance and water temperature.

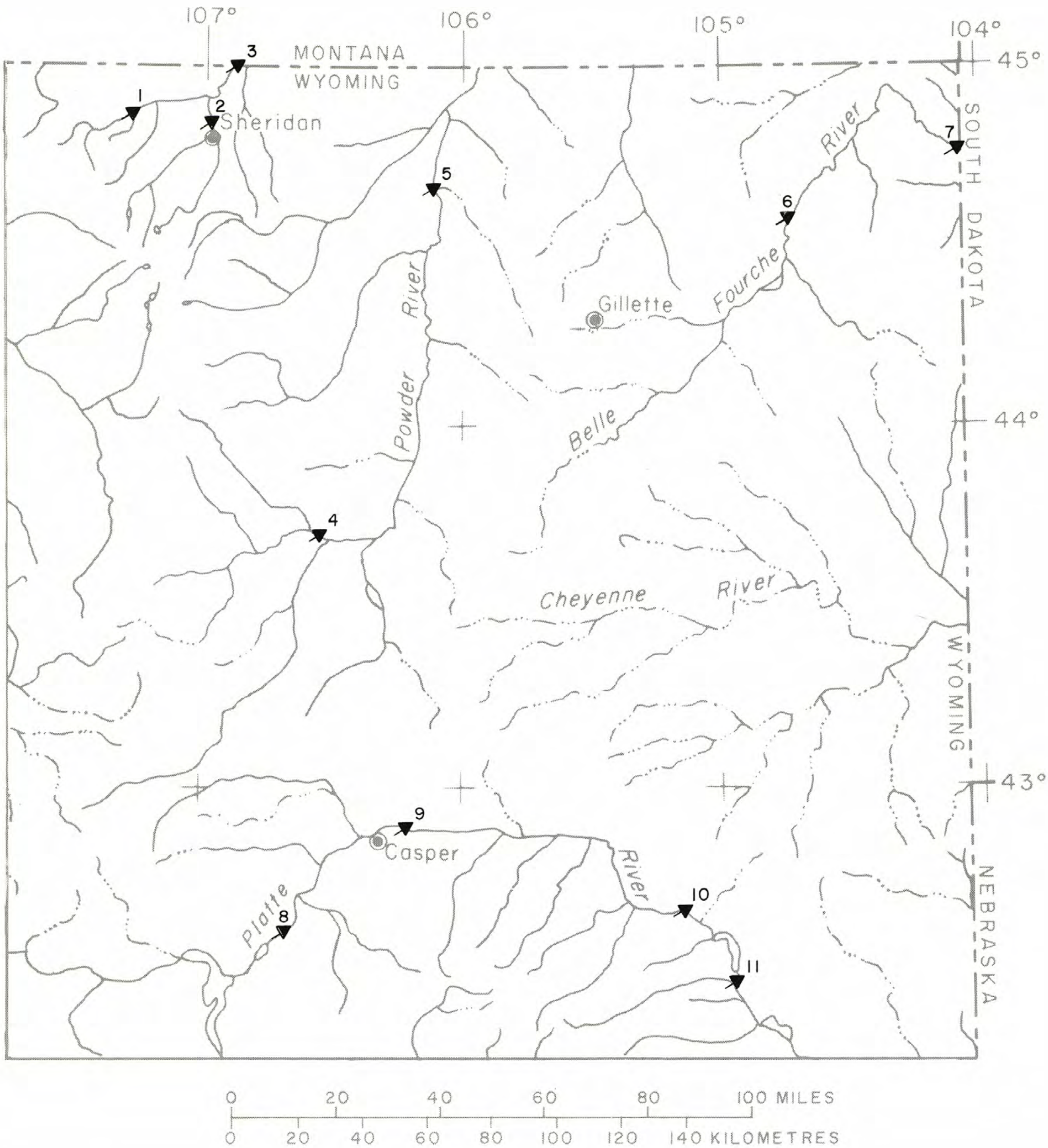


Figure 7.- Geological Survey-Wyoming Department of Environmental Quality water-quality surveillance stations.

Geological Survey - Wyoming Department of Environmental Quality
Cooperative Program

Stations

Map number	Station number	Name	Location	Section	Township	Range
1	06298000	Tongue River near Dayton[1,2]	NE¼NE¼NE¼	11	56N	87W
2	06305500	Goose Creek below Sheridan[1,2]	SE¼SW¼	15	56N	84W
3	06306300	Tongue River at State line, near Decker, Mont.[1,2]	NW¼NE¼	33	9S	40E
4	06312500	Powder River near Kaycee[2]	NE¼NW¼SW¼	13	43N	81W
5	06317000	Powder River at Arvada[2,3]	NE¼NW¼	21	54N	77W
6	06427850	Belle Fourche River at Devils Tower[1,2]	NW¼SE¼SE¼	7	53N	65W
7	06428500	Belle Fourche River at Wyoming-South Dakota State line[2,3]	NE¼NW¼NW¼	18	9N	1E
8	06642000	North Platte River at Alcova[2]	NW¼NE¼NW¼	17	30N	82W
9	06645000	North Platte River below Casper[1,2]	NW¼NW¼	4	33N	78W
10	06652000	North Platte River at Orin[2]	SW¼SW¼	17	31N	69W
11	06652800	North Platte River below Glendo Reservoir[2]	SW¼SW¼NW¼	30	29N	67W

Parameter List

Monthly

Physical - temperature, dissolved oxygen, turbidity.

Biological - fecal coliform.

---

[1]Additional data obtained through the Environmental Protection Agency program.
[2]Additional data obtained through the Geological Survey - Wyoming Department of Agriculture cooperative program.
[3]Sampling at this site is quarterly instead of monthly.

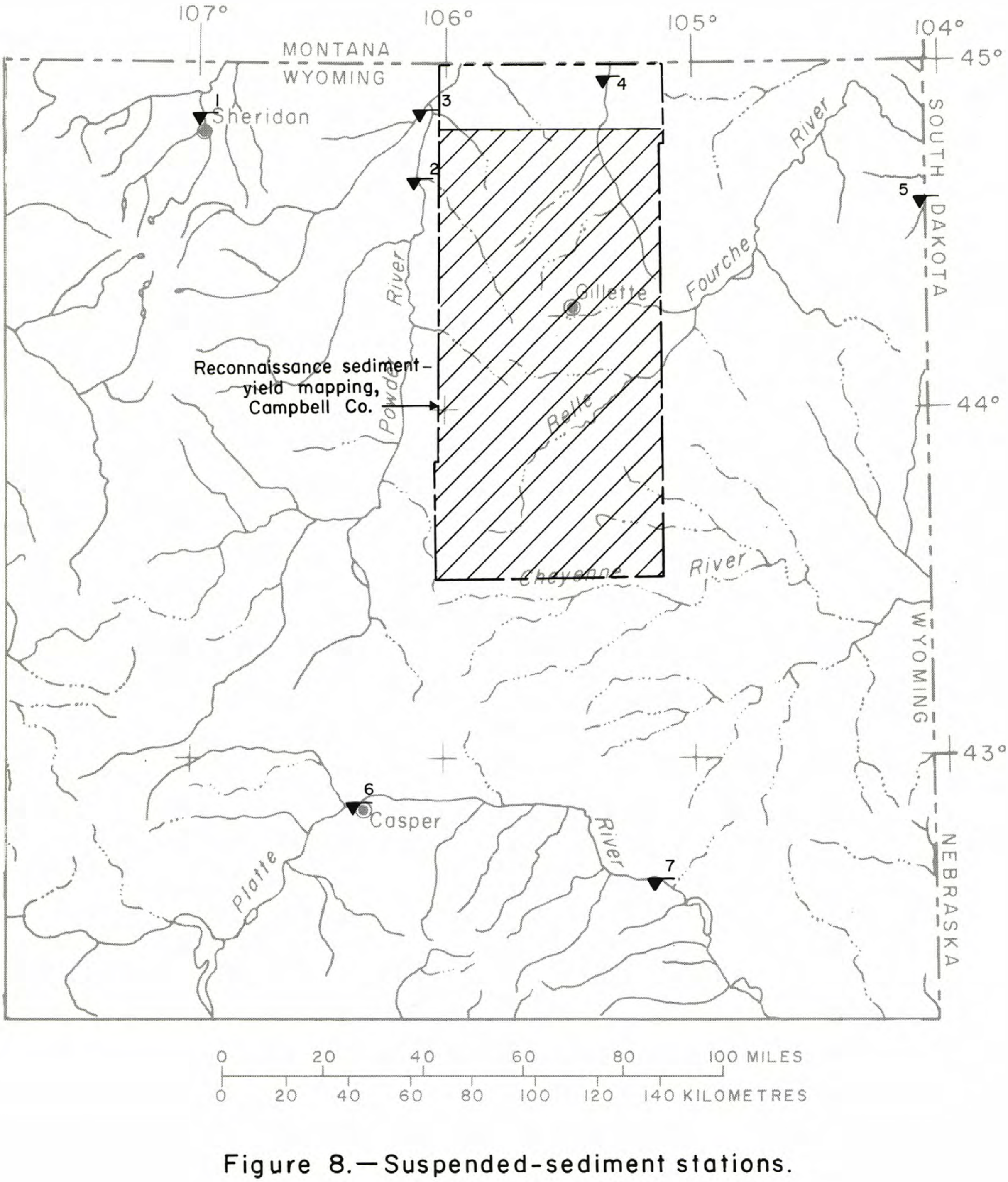


Figure 8.—Suspended-sediment stations.

Suspended-Sediment Program

Stations

Map number	Station number	Name	Location	Section	Township	Range
1	06305500	Goose Creek below Sheridan (U.S. Geological Survey-Wyoming State Engineer cooperative program, monthly samples)	SE¼SW¼	15	56N	84W
2	06317000	Powder River at Arvada (U.S. Geological Survey Program, daily samples)	NE¼NW¼	21	54N	77W
3	06324000	Clear Creek near Arvada (U.S. Geological Survey program, daily samples)	SE¼	36	57N	77W
4	06324970	Little Powder River above Dry Creek, near Weston (U.S. Geological Survey-Wyoming State Engineer cooperative program, monthly samples)	NW¼SW¼	13	57N	71W
5	06430500	Redwater Creek at Wyoming-South Dakota State line (U.S. Geological Survey-Wyoming State Engineer cooperative program, monthly samples)	NW¼NW¼	18	7N	1E
6	06644550	North Platte River at Casper (U.S. Geological Survey-Wyoming State Engineer cooperative program, monthly samples)	SE¼SE¼NW¼	4	33N	79W
7	06652000	North Platte River at Orin (U.S. Geological Survey-Wyoming State Engineer cooperative program, monthly samples)	SW¼SW¼	17	31N	69W

Parameter List

Daily stations:

Physical - Daily suspended sediment and temperature, bed material 3 times per year.

Monthly stations:

Physical - Monthly suspended sediment and temperature, bed material 3 times per year.

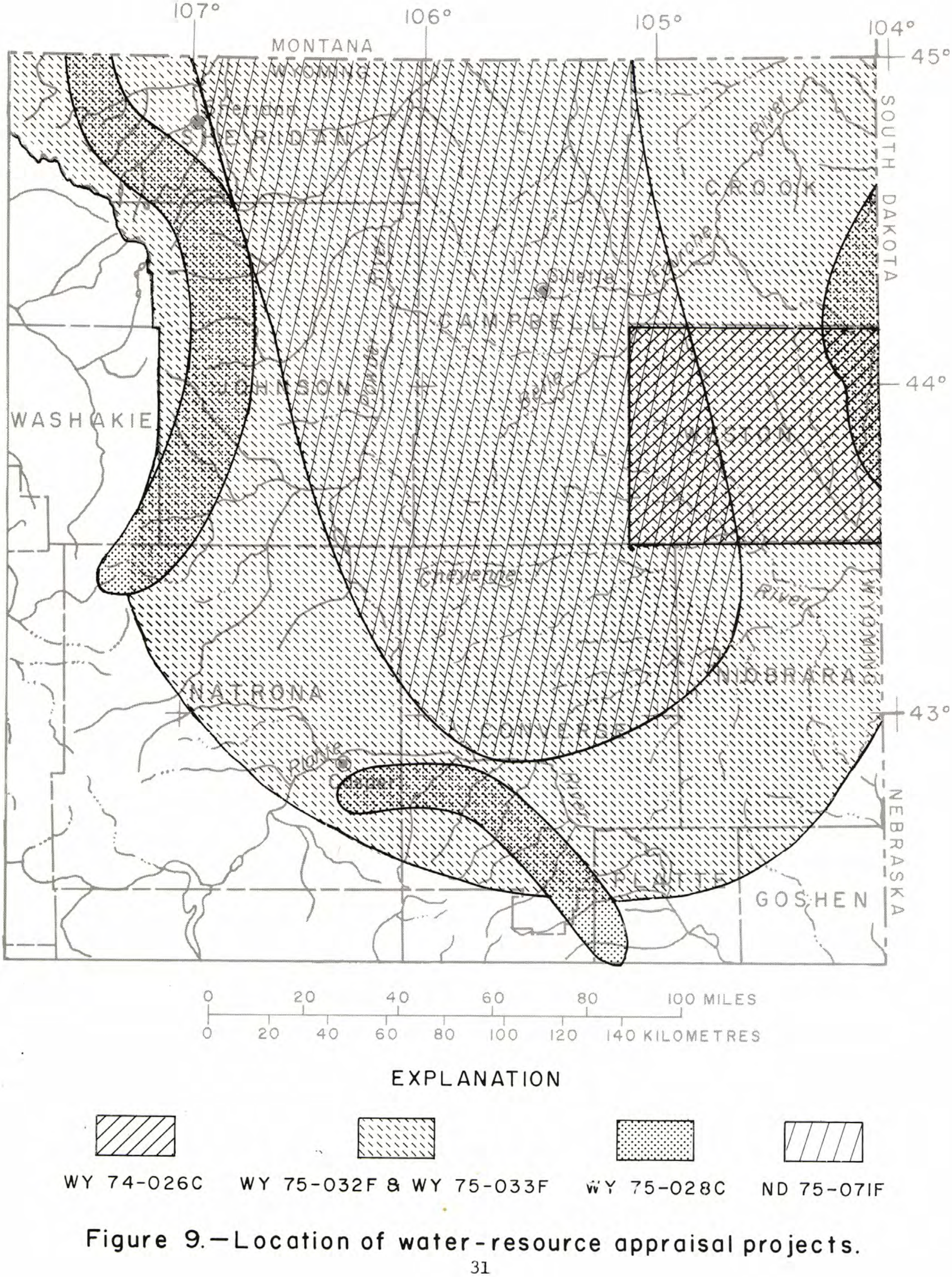


Figure 9.—Location of water-resource appraisal projects.

WATER-RESOURCES APPRAISAL PROJECTS

Water Resources of Weston County, Wyoming

(Project WY 74-026C)

Funds: Wyoming State Engineer and U.S. Geological Survey

The objectives of the project are to determine occurrence, availability, and chemical quality of water in the county. Because formations exposed in Weston County occur at depth to the west in the Powder River Basin, the data obtained during the course of this project will have large transfer value to other areas.

A basic-data report that will be the final product of the study will include isopach maps, structure-contour maps, and maps or other graphic portrayals of potentiometric surfaces in principal aquifers and sand-shale ratios. Tables will include water-well data and chemical quality of water.

The location of this project is shown in figure 9.

Measurement of water losses to the Madison Limestone and associated rocks from streams in northeastern Wyoming

(Project WY 75-028C)

Funds: Wyoming State Engineer (sponsored by Old West Regional Commission)

A study is being made of water losses from streams that cross outcrops of the Madison Limestone and associated rocks around the perimeter of the Powder River Basin. The project is designed to provide data for evaluating recharge to the Madison Limestone. Stream-gaging stations have been established at 32 locations in the Bighorn Mountains, Black Hills, and the northern end of the Laramie Mountains. These stations are included in the list of "Streamflow and Reservoir Stations" (Cooperator 028) and are shown in figure 1. Five existing gaging stations were incorporated into the project. A reconnaissance of the geologic and hydrologic conditions of perennial streams crossing Madison outcrops dictated the location of the gaging stations. In addition, three sets of streamflow measurements will be made each year on 30 additional streams at sites above and below the outcrop of the Madison and associated rocks.

The project is primarily a basic-data collection project, the objectives of which are: (1) Determination of magnitude and distribution of losses to the Madison by streams that cross the outcrop areas; (2) determination of precipitation, runoff, infiltration relations in outcrop areas; and (3) establishment of baseline streamflow conditions prior to possible increased development of water supplies from the Madison Limestone.

The location of this project (three areas) is shown in figure 9.

Water Resources of the Powder River structural basin in Wyoming in relation to energy development (Project WY 75-032F)

Funds: U.S. Geological Survey, with basic-data support funds from U.S. Bureau of Land Management

The objectives of the project are twofold. The first phase will be to determine the adequacy of existing data to describe water availability and assess impact of development, and to identify subjects that should be studied by the District. The findings of the first phase will be used to identify thrusts for the second phase. The study area is nearly the same as that of project WY 75-033F, but will not include rocks of Paleozoic age, as they are being studied in project WY 75-033F.

Approaches that will be examined in the first phase of the project include quantifying geophysical logs as a means of construction of transmissivity maps. Surface geophysical studies will be made to determine their applications to water-resource investigations. The recharge-discharge relationships will be examined to define the movement of water, hence, impact of development.

Potentiometric maps of aquifers of Lower Cretaceous and Jurassic age will be prepared in a small area by use of drill-stem tests and other data. The aquifers themselves are of only minor importance but the knowledge of possible vertical movement of water is necessary to modeling of more important aquifers.

Emphasis in quality of water will be on sampling for trace elements to determine existing levels and monitor for possible change, biologic assay to note change in quality-of-surface water that may be too subtle for other methods to detect, and isotopic ratios and carbon-14 dating to determine the relative age and movement of water.

The study of possible impact of mining will be continued at the Wyodak plant, a program started with Northern Great Plains Resources program funds. The effects of reclamation on shallow ground water is still a concern and, in the first phase of the study, an area near Sheridan, Wyoming will be evaluated as to its suitability for additional study.

Because alluvial aquifers are of local importance to agriculture, they will be studied by use of aquifer tests, auger drilling, and surface electrical and gravimetric geophysical methods.

Deterministic and (or) stochastic models will be used to determine the availability of surface water, evaluate the impacts of energy development in the Powder River Basin, and provide input for the long-term quality-of-water monitoring network.

Infiltration and evaporation can be studied by use of rainfall-runoff data previously collected and study of pan evaporation at existing weather stations. To obtain better nonseasonal data, a reconnaissance will be made of some of the 10- to 20-acre internal drainage basins to determine the feasibility of using mass balance techniques to better define evaporation and (or) infiltration.

In the first phase of the project, the feasibility of making intense surveys of sediment-related activities in relatively small drainage areas for the purpose of transferring the data and methods similar to, but not as intensively studied, drainages will be investigated.

The location of this project is shown in figure 9.

Hydrology of Paleozoic rocks in the Powder River Basin and adjacent areas, northeastern Wyoming

(Project WY 75-033F)

Funds: U.S. Geological Survey

An investigation of the hydrology of the Paleozoic rocks in the Powder River Basin in Wyoming is underway to evaluate the Paleozoic rocks as a potential source of large quantities of water for energy development, primarily coal development and attendant conversions to both gaseous and liquid forms of energy and the generation of electric power. The principal effort will concentrate on the Madison Limestone, but both the underlying and overlying rock strata, mostly carbonate or sandstone, will be included.

The thickness of the Paleozoic rocks ranges from about 2,600 feet in the northern part of the project area to about 200 feet in the southern part. Paleozoic rocks crop out along the perimeter of the basin but underlie the central part of the basin at depths exceeding 10,000 feet below land surface.

The project area consists of about 25,000 square miles in the approximate northeast quarter of Wyoming, and includes the Powder River structural basin and the associated uplifts and mountain ranges on the perimeter of the basin such as the Black Hills and Hartville uplifts on the east and southeast and the Laramie Mountains and Bighorn Mountains on the south and west.

The project is designed to derive a conceptual model of the Madison Limestone as an aquifer and the relation of the Madison to the aquifers in the associated formations of Paleozoic age. Geologic parameters to be determined include distribution, thickness, and physical properties of the rock strata and the processes that developed the present distribution of aquifer parameters. Hydrologic-parameter determinations will include the potentiometric surfaces, chemical quality of the water, and the intrarelation of the Paleozoic aquifers to determine how and to what extent the Paleozoic rocks act as a single aquifer system. The effects of increased water development from the aquifer system will be evaluated.

Approaches will include borehole and surface geophysical surveys to evaluate and correlate physical properties of the aquifer system to water-yielding properties; streamflow analysis to evaluate recharge and underground flow regime; natural tracers to determine rate and direction of underground flow; water-temperature differences with depth to evaluate vertical movement of water; and digital simulation models will aid in interpreting the aquifer system and predict responses to future stresses on the aquifer system.

The location of this project is shown in figure 9.

Availability of Ground Water from the Cretaceous and Tertiary Aquifers of the Fort Union Coal Region

(Project ND 75-071F)

Funds: U.S. Geological Survey

This investigation is a compilation of existing data from South Dakota, North Dakota, Montana, and Wyoming of the Tertiary rocks and aquifers overlying the Pierre Shale. The objectives of the investigation are: (1) to determine the location, extent, and nature of the aquifers and confining beds; (2) to evaluate the occurrence and movement of ground water, including the sources of recharge and discharge; and (3) to determine the chemical quality of the ground water. This project is being done by the North Dakota District, Water Resources Division, USGS, headquartered in Bismarck, North Dakota.

The location of this project is shown in figure 9.

Hydrologic Considerations in Evaluating the Reclamation Potential of Strip-mined Lands in the Hanna Basin, Wyoming

Funds: U.S. Bureau of Land Management

This study by the U.S. Bureau of Reclamation and the U.S. Geological Survey is to provide data and their interpretations that are necessary to guide land restoration after strip mining. The Bureau of Reclamation is providing drilling and coring services and analyses of soils and rock.

The Geological Survey is providing an assessment of the water resources of the site. Rainfall-runoff relationships are being determined, and the transmissivity and the storage coefficient of shallow ground water in the vicinity of the site are being measured. Samples of surface and sub-surface water are being analyzed for chemical quality, and sediment-level characteristics of local streams are being determined.

The location of the site is shown on figure 8.

See, also, page 106 for a description of additional studies of the soils-vegetation-erosion relationships.

SELECTED REFERENCES

Babcock, H. M., and Morris, D. A., 1953, Ground water in the vicinity of Edgerton, Wyoming: U.S. Geol. Survey open-file rept., 9 p., 1 fig.

Boner, F. C., Lowry, M. E., Lines, G. C., and Powell, J. E., ___, Progress report on measurement of water losses to the Madison Limestone from streams in northeastern Wyoming: U.S. Geol. Survey open-file rept. (in preparation, 1975).

Crist, M. A., and Lowry, M. E., 1972, Ground-water resources of Natrona County, Wyoming: U.S. Geol. Survey Water-Supply Paper 1897, 92 p.

Culler, R. C., Hadley, R. F., and Schumm, S. A., 1961, Hydrology of the upper Cheyenne River basin -- Part A. Hydrology of stock-water reservoirs in upper Cheyenne River basin, by R. C. Culler; Part B. Sediment sources and drainage-basin characteristics in upper Cheyenne River basin, by R. F. Hadley and S. A. Schumm: U.S. Geol. Survey Water-Supply Paper 1531, 198 p.

Frickel, D. G., and Shown, L. M., 1974, Annual streamflow in northeastern Wyoming and southeastern Montana: U.S. Geol. Survey Miscellaneous Investigations Map I-847-B, 1 sheet.

Hodson, W. G., 1971a, Logs of wells in Campbell County: Wyoming State Engineer, Wyoming Water Planning Program Report no. 8, 210 p.

_____ 1971b, Chemical analyses of ground water in the Powder River basin and adjacent areas, northeastern Wyoming: Wyoming Dept. Economic Planning and Development report, 20 p.

_____ 1974, Records of water wells, springs, oil- and gas-test holes, and chemical analyses of water for the Madison Limestone and equivalent rocks in the Powder River basin and adjacent areas, northeastern Wyoming: Wyoming State Engineer report, 27 p.

Hodson, W. G., Pearl, R. H., and Druse, S. A., 1974, Water resources of the Powder River basin and adjacent areas, northeastern Wyoming: U.S. Geol. Survey Hydrologic Investigations Atlas HA-465, 4 sheets.

King, N. J., 1974, Occurrence of ground water in the Gillette area, Campbell County, Wyoming: U.S. Geol. Survey Miscellaneous Investigations Map I-848-E, 1 sheet.

Littleton, R. L., 1950, Ground-water conditions in the vicinity of Gillette, Wyoming, with a section on the quality of ground water, by H. A. Swenson: U.S. Geol. Survey Circ. 76, 43 p.

Lowry, M. E., 1973, Hydrology of the uppermost Cretaceous and lowermost Paleocene rocks in the Hilight oil field, Campbell County, Wyoming: U.S. Geol. Survey open-file rept., 60 p, 5 pl.

Lowry, M. E., and Cummings, T. R., 1966, Ground-water resources of Sheridan County, Wyoming: U.S. Geol. Survey Water-Supply Paper 1807, 73 p.

Rennick, K. B., 1966, Floods of May - June, 1965, in east-central Wyoming: U.S. Geol. Survey open-file rept., 22 p.

Ringen, B. H., 1973, Records of ground-water levels in Wyoming, 1940-1971: Wyoming State Engineer, Wyoming Water Planning Program Report no. 13, 479 p.

_____ 1974, Ground-water levels in Wyoming, 1972-1973: Wyoming State Engineer, Wyoming Water Planning Program Report no. 13, suppl. no. 1, 158 p.

Swenson, F. A., Hodson, W. G., Miller, W. R., and Visher, F. N., ____, Water in the Madison Group, Powder River, Wyoming and Montana: U.S. Geol. Survey Miscellaneous Investigations Map (in preparation, 1975).

U.S. Geological Survey, Water resources data for Wyoming -- Part 1, Surface water records; Part 2, Water quality records, 1965-1972 (published annually): U.S. Geol. Survey open-file reports. (For information about records prior to 1965, contact nearest USGS office.)

Warner, D. A., 1946, Geology and ground-water resources of the Ranchester area, Wyoming: U.S. Geol. Survey open-file rept., 11 p.

Whitcomb, H. A., 1960, Investigation of declining artesian pressures in the vicinity of Osage, Weston County, Wyoming: U.S. Geol. Survey open-file rept., 11 p., 1 fig.

_____ 1963, Decreasing yields of flowing wells in the vicinity of Newcastle, Weston County, Wyoming: U.S. Geol. Survey open-file rept., 22 p., 1 fig.

_____ 1965, Ground-water resources and geology of Niobrara County, Wyoming, with a section on Chemical quality of the ground water, by T. R. Cummings: U.S. Geol. Survey Water-Supply Paper 1788, 97 p.

Whitcomb, H. A., Cummings, T. R., and McCollough, R. A., 1966, Ground-water resources and geology of northern and central Johnson County, Wyoming: U.S. Geol. Survey Water-Supply Paper 1806, 99 p.

Whitcomb, H. A., and Gordon, E. D., 1964, Availability of ground water at Devils Tower National Monument, Wyoming: U.S. Geol. Survey open-file rept., 61 p., 7 figs.

Whitcomb, H. A., and Morris, D. A., 1964, Ground-water resources and geology of northern and western Crook County, Wyoming, with a section on The Chemical quality of the ground water, by R. H. Langford: U.S. Geol. Survey Water-Supply Paper 1698, 92 p.

Whitcomb, H. A., Morris, D. A., Gordon, E. D., and Robinove, C. J., 1958, Occurrence of ground water in the eastern Powder River basin and western Black Hills, northeastern Wyoming, _in_ Powder River basin: Wyoming Geol. Assoc. Guidebook, 13th Ann. Field Conf., p. 245-260.

Williams, C. C., 1948, Water-supply possibilities from wells at Newcastle, Wyoming: U.S. Geol. Survey open-file rept., 19 p.

MONTANA

The Northern Great Plains coal region of eastern Montana has become an area of intense interest for coal companies, utilities, State and Federal agencies, universities, landowners, and environmental groups. The possibility of large-scale mining of coal for energy or hydrocarbons has caused concern about the environmental effects on the region and has resulted in many studies to resolve the myriad of environmental questions and problems. This report presents the water data-collection program and interpretive hydrologic investigations that are being conducted by the U.S. Geological Survey.

In 1967, there were 33 surface-water and 8 water-quality data-collection stations in the coal region of the lower Yellowstone and Missouri Rivers. In October 1974, there were 39 surface-water and 47 water-quality stations in the region for collection of streamflow, chemical-quality, sediment, and temperature data. These stations are located on all types of streams from the mainstem Yellowstone and Missouri Rivers to small ephemeral and intermittent streams that drain proposed mine areas. Types of data collected at these stations differ according to the needs of the agencies requesting the information.

Ground-water investigations are being conducted to determine the areal hydrology of the Madison Group and associated Paleozoic rocks and the areal and site hydrology of shallow aquifers in the Fort Union Formation, including the coal beds. Available data, mostly from oil tests, indicate that the Madison may yield water suitable for use in energy development in the Northern Great Plains coal region. The Madison study is directed toward developing a plan for a comprehensive investigation to begin in the near future, using oil-well logs and geophysical data but progressively supplementing this information with data from new test wells.

At the present time (spring 1975) most of the fieldwork in the shallow ground-water study has been a partial data inventory of wells and springs and construction of a few wells for water sampling, aquifer testing, and water-level measurements. These data and data from future test wells will be used to construct models of the shallow hydrologic system and to attempt to predict the effects of (1) mining and (2) restoration of mined lands on the ground-water system. Considerable effort has been made to coordinate this study with the work of other agencies and groups.

A computer model is being constructed to determine the effect on stream temperature of selected increases in withdrawal rates, and thus reduced flow, of the Yellowstone River from Billings to Sidney, Montana.

Subsequent sections of this report list the parameters measured in the data-collection program and show the location of stations (figs. 10-16). Most water-quality stations are separated according to Federal agency program under which the Geological Survey collects the data; suspended-sediment and surface-water stations are presented according to data type. Background and objectives for each of the four interpretive studies, with a map showing location of areas (fig. 17), are also included.

The planning and financial support for the data collection and interpretive studies are shared by the U.S. Geological Survey and the following State of Montana and Federal agencies: Montana Department of Natural Resources and Conservation, Montana Bureau of Mines and Geology, Montana Department of Highways, Montana State University, Montana Department of Intergovernmental Relations, U.S. Bureau of Reclamation, U.S. Army Corps of Engineers, U.S. Bureau of Land Management, and Environmental Protection Agency.

DATA-COLLECTION PROGRAMS

National Stream Quality Accounting Network Water-Quality Stations

The National Stream Quality Accounting Network was designed to meet the needs of agencies or groups involved in water-quality planning and management on a national or regional scale. Loads of major inorganic chemical constituents and dissolved solids are calculated from daily records of specific conductance and streamflow. Periodic analyses are made for inorganic constituents and suspended sediment. Nutrients, organic constituents, bacterial content, and minor inorganic elements will be measured periodically to provide information on concentration ranges and variability. The information obtained for each accounting unit in the network will provide a balanced nationwide base of water-quality data.

Stations

Map number	Station number	Name	Location	Section	Township	Range
1	06130500	Musselshell River at Mosby	NW¼NW¼	11	14N	30E
2	06132000	Missouri River below Fort Peck Dam	NW¼	6	26N	42E
3	06174500	Milk River at Nashua	NE¼NE¼	1	27N	41E
4	06185500	Missouri River near Culbertson	SE¼NW¼	3	27N	56E
5	06214500	Yellowstone River at Billings[1]	NE¼NE¼	34	1S	26E
6	06294700	Bighorn River at Bighorn	NE¼NE¼	33	5N	34E
7	06308500	Tongue River at Miles City	SE¼	23	7N	47E
8	06326500	Powder River near Locate	NW¼SW¼	14	8N	51E
9	06329500	Yellowstone River near Sidney[2,3]	SW¼NE¼SW¼	9	22N	59E

Parameter List

Daily

Physical - Temperature, specific conductance.

Monthly

Chemical - Bicarbonate, carbonate, calcium, magnesium, fluoride, sodium, potassium, dissolved solids, silica, chloride, sulfate, total phosphorous, total nitrate-nitrite, total Kjeldahl nitrogen.

Physical - Turbidity, pH, dissolved oxygen, suspended sediment.

Biological - Fecal coliform, fecal streptococci, phytoplankton.

Parameter List (cont'd)

Quarterly

Chemical - Total organic carbon, total and dissolved metals (arsenic, cadmium, chromium, calcium, copper, iron, lead, manganese, mercury, selenium, zinc).

Biological - Periphyton, chlorophyll.

[1] Samples collected periodically for radiochemical analysis.
[2] Samples collected periodically for pesticide analysis.
[3] Station is also part of Environmental Protection Agency program.

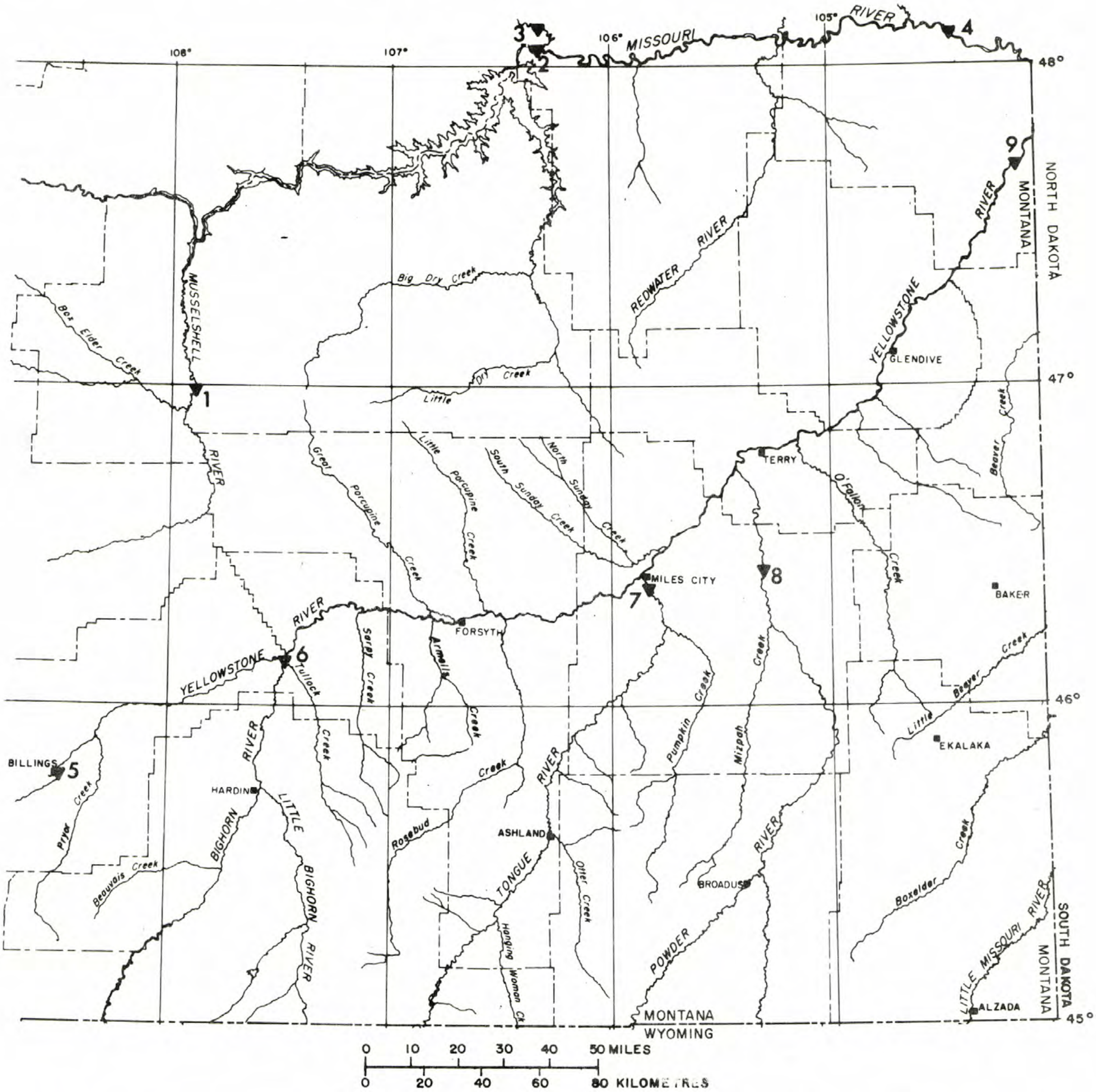


Figure 10.--National Stream Quality Accounting Network program water-quality stations.

Geological Survey Water-Quality Stations

Stations

Map number	Station number	Name	Location	Section	Town-ship	Range
1	06177500	Redwater River at Circle[1]	SW¼SW¼	11	19N	48E
2	06217750	Fly Creek at Pompeys Pillar[2]	NW¼SE¼	23	3N	30E
3	06287000	Bighorn River near St. Xavier[2]	NW¼NE¼	16	6S	31E
4	06290500	Little Bighorn River below Pass Creek near Wyola[2]	W½SW¼	35	7S	35E
5	06294000	Little Bighorn River near Hardin[2]	NE¼NE¼	19	1S	34E
6	06294980	East Fork Armells Creek near Colstrip	SE¼SW¼SW¼	28	3N	41E
7	06294991	West Fork Armells Creek near Forsyth	SW¼SW¼NW¼	21	4N	40E
8	06294995	Armells Creek near Forsyth[1]	SE¼NW¼NE¼	26	6N	39E
9	06295250	Rosebud Creek near Colstrip	SE¼SW¼NE¼	8	1S	42E
10	06295400	Rosebud Creek above Pony Creek near Colstrip	NE¼SE¼SE¼	29	2N	43E
11	06295500	Rosebud Creek near Rosebud	SW¼NE¼SW¼	12	4N	42E
12	06296003	Rosebud Creek at mouth, near Rosebud[1]	SW¼NW¼NE¼	21	6N	42E
13	06296120	Yellowstone River near Miles City[2,3]	SE¼SW¼	31	8N	47E
14	06307830	Tongue River below Brandenberg Bridge, near Ashland[1]	NE¼SW¼NW¼	6	1N	45E
15	06324500	Powder River at Moorhead[1]	NW¼	8	9S	48E

Parameter List

Monthly

Chemical - Calcium, magnesium, sodium, potassium, silica, fluoride, iron, bicarbonate, carbonate, chloride, sulfate, alkalinity, total nitrate-nitrite, total phosphorous, dissolved solids, boron, total Kjeldahl nitrogen, total ammonia, biochemical oxygen demand.

Physical - Temperature, specific conductance, dissolved oxygen, pH, suspended sediment.

Quarterly

Chemical - Total metals (arsenic, beryllium, cadmium, chromium, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, vanadium).

Annual

Chemical - Dissolved metals (aluminum, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, manganese, nickel, zinc).

---

[1] Samples collected annually for radiochemical and spectrographic analyses.
[2] Samples collected daily for temperature and specific conductance only; samples collected monthly for common constituents only.
[3] Additonal data obtained through the Environmental Protection Agency program.

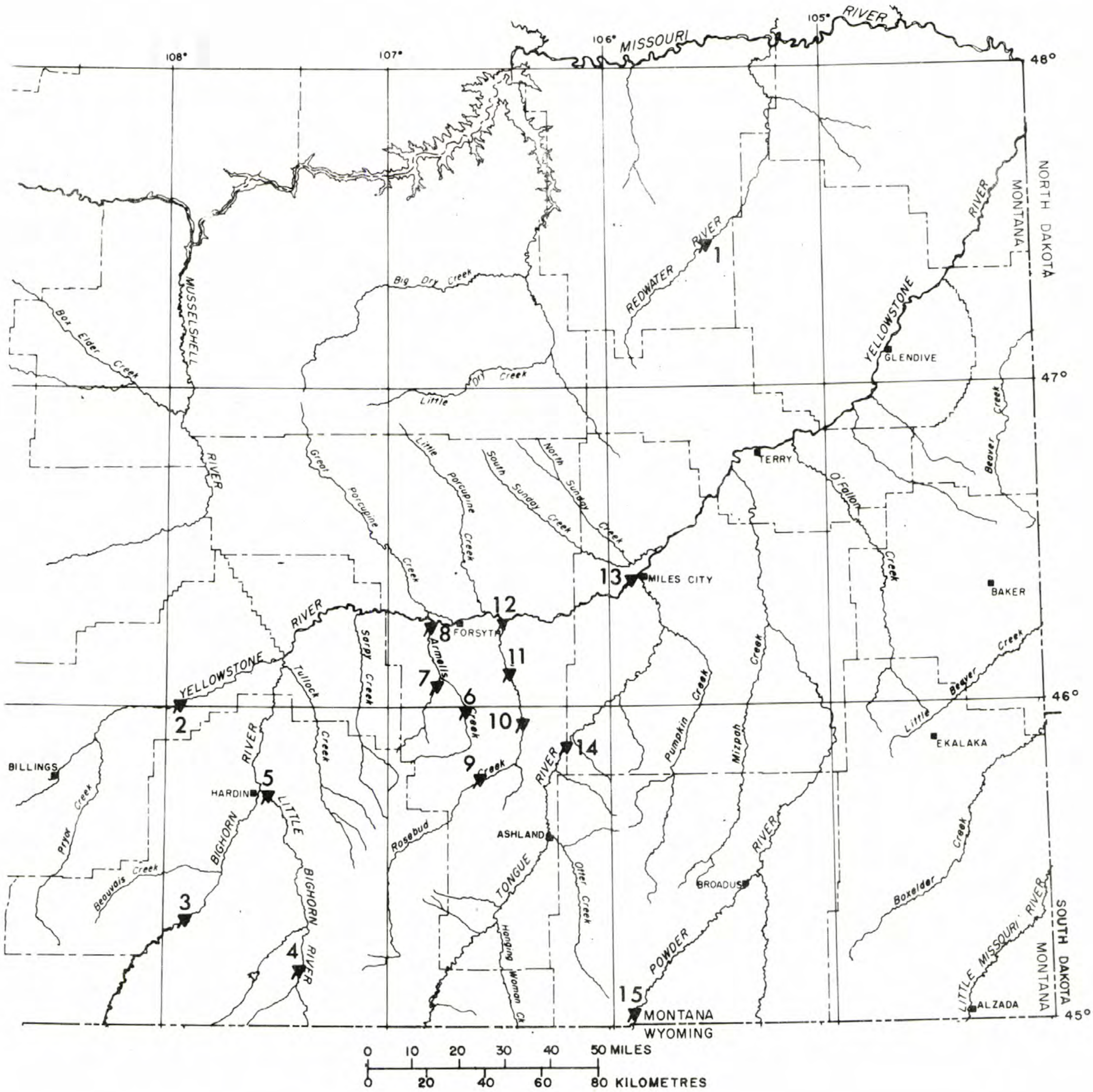


Figure 11 .--Geological Survey program water-quality stations.

Environmental Protection Agency Water-Quality Surveillance Stations

Stations

Map number	Station number	Name	Location	Section	Town-ship	Range
1	06205200	Yellowstone River at Laurel	SW¼SW¼SW¼	15	2S	24E
2	06217500	Yellowstone River at Huntley	N½SW¼	24	2N	27E
3	06296120	Yellowstone River near Miles City[1]	SE¼SW¼	31	8N	47E
4	06329500	Yellowstone River near Sidney[2]	SW¼NE¼SW¼	9	22N	59E

Parameter List

Biweekly

Chèmical - Dissolved solids, chemical oxygen demand, total Kjeldahl nitrogen, total ammonia, total organic carbon, total phosphorous, total nitrate, total nitrate-nitrite.

Physical - Suspended sediment, turbidity, temperature, specific conductance, pH, dissolved oxygen.

Biological - Total coliform, fecal coliform.

Monthly

Chemical - Biochemical oxygen demand.

Quarterly

Chemical - Bicarbonate, carbonate, calcium, magnesium, potassium, silica, sodium, sulfate, chloride.

The Environmental Protection Agency, under the Northern Great Plains Resource Program, is funding for 1 year ending in April 1975 a water-quality data-collection program. The program consists of monthly samples for common constituents and nutrients, quarterly samples for total metals, and annual samples for dissolved metals at the following stations:

5	06294840	Yellowstone River at Myers	SW¼SW¼SE¼	21	6N	35E
6	06295000	Yellowstone River at Forsyth	SE¼NE¼NE¼	22	6N	40E
7	06307610	Tongue River below Hanging Woman Creek, near Birney	SW¼SE¼SE¼	1	6S	42E
8	06326530	Yellowstone River near Terry	SE¼SW¼	10	12N	51E

Collection of samples for additional parameters at seven other continuing surface-water sites within the energy area is funded by this program.

[1]Additional data obtained through the Geological Survey program.
[2]Additional data obtained through the National Stream Quality Accounting Network program.

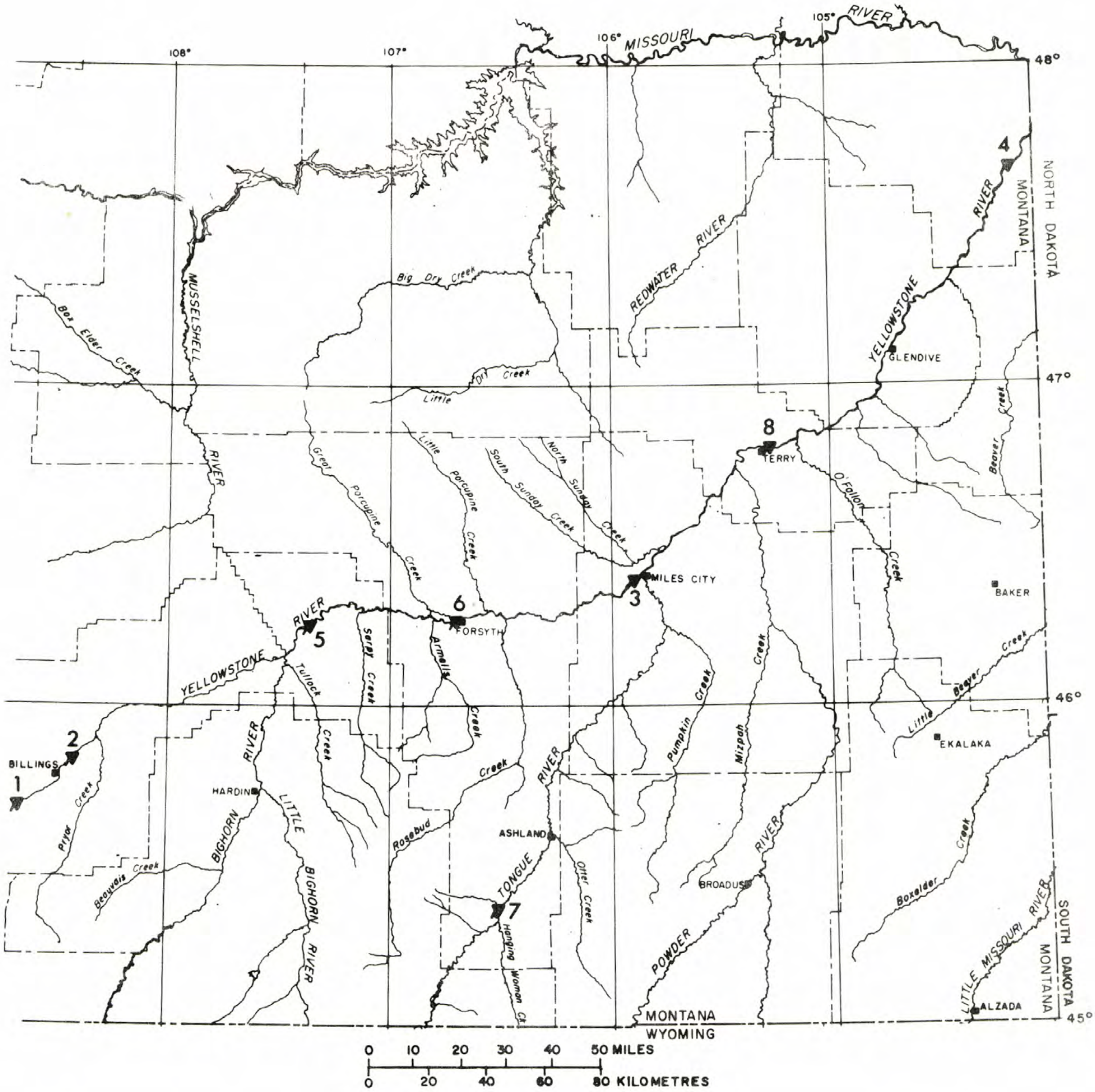


Figure 12 .--Environmental Protection Agency program water-quality surveillance stations.

Bureau of Land Management Water-Quality Stations

Stations

Map number	Station number	Name	Location	Section	Town-ship	Range
1	06294940	Sarpy Creek near Hysham[1]	SE¼SE¼	30	6N	37E
2	06295350	Greenleaf Creek near Colstrip	NW¼NW¼NW¼	29	1N	43E
3	06306300	Tongue River at State Line, near Decker[2]	NW¼NE¼	33	9S	40E
4	06306800	Deer Creek near Decker	NW¼SW¼SW¼	10	9S	41E
5	06307510	Fourmile Creek near Birney	NE¼NW¼NE¼	28	7S	41E
6	06307530	Bull Creek near Birney	NE¼SW¼NW¼	28	6S	42E
7	06307600	Hanging Woman Creek near Birney	N½NW¼SE¼	19	6S	43E
8	06307615	Cook Creek near Birney	SW¼NE¼NW¼	25	5S	42E
9	06307670	Bear Creek at Otter	N½	2	7S	45E
10	06307730	Threemile Creek near Ashland	NW¼SE¼SE¼	3	4S	45E
11	06307740	Otter Creek at Ashland[1]	NE¼NE¼SE¼	11	3S	44E
12	06307810	Beaver Creek near Ashland	NW¼SE¼NE¼	34	1N	44E
13	06307830	Tongue River below Brandenberg Bridge, near Ashland[2]	NE¼SW¼NW¼	6	1N	45E
14	06307840	Liscom Creek near Ashland	SE¼NW¼NW¼	27	2N	45E
15	06307890	Foster Creek near Volborg	NE¼SE¼NW¼	12	3N	46E

Parameter List

Monthly

Chemical - Calcium, magnesium, sodium, potassium, silica, fluoride, iron, bicarbonate, carbonate, chloride, sulfate, alkalinity, total nitrate-nitrite, total phosphorous, dissolved solids, boron, total Kjeldahl nitrogen, total ammonia, biochemical oxygen demand.

Physical - Temperature, specific conductance, dissolved oxygen, pH, suspended sediment.

Quarterly

Chemical - Total metals (arsenic, beryllium, cadmium, chromium, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, selenium, vanadium).

Annual

Chemical - Dissolved metals (aluminum, arsenic, beryllium, cadmium, chromium, copper, lead, mercury, manganese, nickel, zinc).

---

[1] Samples collected annually for radiochemical and spectrographic analyses.
[2] Continuous monitoring of temperature, pH, specific conductance, and dissolved oxygen only.

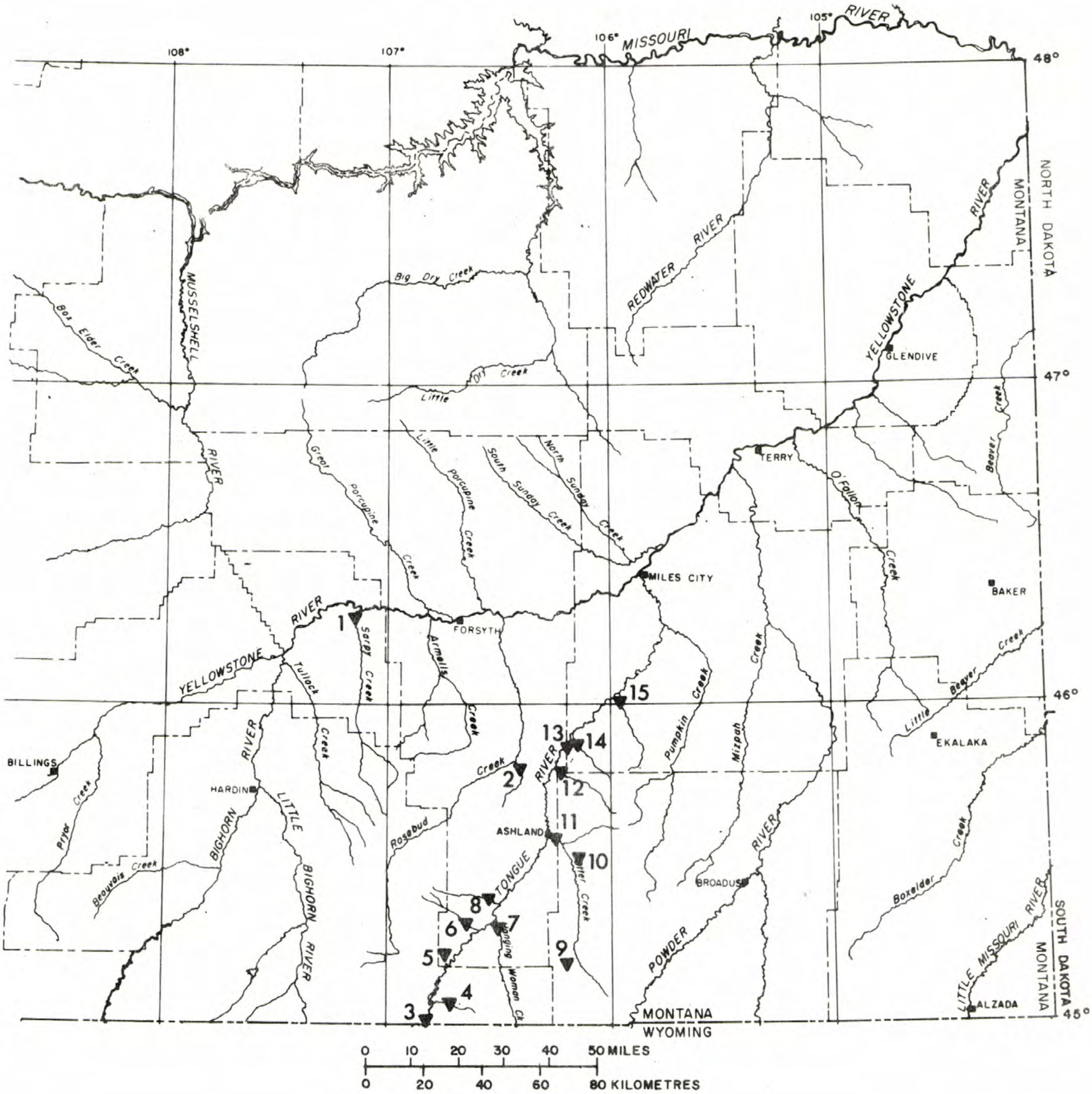


Figure 13.--Bureau of Land Management program water-quality stations.

Suspended-Sediment Daily Stations

Stations

Map number	Station number	Name	Location	Section	Town-ship	Range
1	06115200	Missouri River near Landusky	NW¼NE¼	31	22N	24E
		(U.S. Geological Survey-U.S. Army Corps of Engineers cooperative program)				
2	06185500	Missouri River near Culbertson	SE¼NW¼	3	27N	56E
		(U.S. Geological Survey-U.S. Army Corps of Engineers cooperative program)				
3	06294000	Little Bighorn River near Hardin	NE¼NE¼	19	1S	34E
		(U.S. Geological Survey program)				
4	06307830	Tongue River below Brandenberg Bridge, near Ashland	NE¼SW¼NW¼	6	1N	45E
		(U.S. Geological Survey program)				
5	06324500	Powder River at Moorhead	NW¼	8	9S	48E
		(U.S. Geological Survey program)				
6	06326500	Powder River near Locate	NW¼SW¼	14	8N	51E
		(U.S. Geological Survey program)				
7	06329500	Yellowstone River near Sidney	SW¼NE¼SW¼	9	22N	59E
		(U.S. Geological Survey-U.S. Army Corps of Engineers cooperative program)				

Parameter List

Daily

Physical - Suspended sediment, temperature.

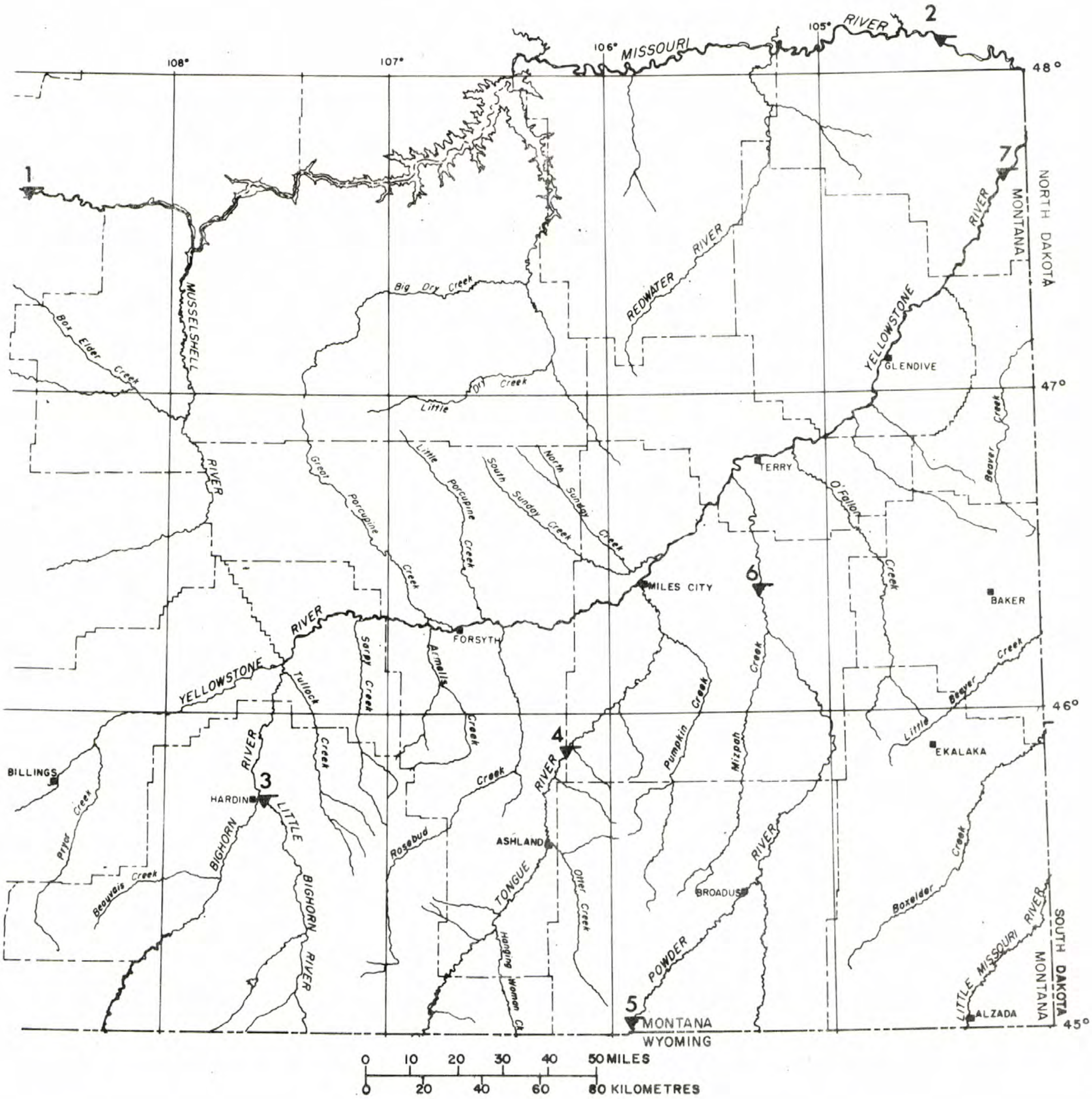


Figure 14.--Suspended-sediment daily stations.

Streamflow Stations

Map number	Station number	Name	Location	Section	Township	Range
1	06115200	Missouri River near Landusky	NW¼NE¼	31	22N	24E
2	06127500	Musselshell River at Musselshell	S½SW¼	20	9N	29E
3	06130500	Musselshell River at Mosby	NW¼NW¼	11	14N	30E
4	06131000	Big Dry Creek near Van Norman	NW¼SE¼NW¼	3	18N	42E
5	06131500	Fort Peck Lake at Fort Peck		14	26N	41E
6	06132000	Missouri River below Fort Peck Dam	NW¼	6	26N	42E
7	06174500	Milk River at Nashua	NE¼NE¼	1	27N	41E
8	06177000	Missouri River near Wolf Point	SW¼NW¼	28	27N	48E
9	06177500	Redwater River at Circle	SW¼SW¼	11	19N	48E
10	06185500	Missouri River near Culbertson	SE¼NW¼	3	27N	56E
11	06214500	Yellowstone River at Billings	NE¼NE¼	34	1N	26E
12	06216000	Pryor Creek at Pryor	NE¼NW¼NE¼	5	5S	26E
13	06217750	Fly Creek at Pompeys Pillar	NW¼SE¼	23	3N	30E
14	06286400	Bighorn Lake near St. Xavier	SW¼SE¼	18	6S	31E
15	06237000	Bighorn River near St. Xavier	NW¼NE¼	16	6S	31E
16	06288200	Beauvais Creek near St. Xavier	West line	15	4S	30E
17	06289000	Little Bighorn River at State Line, near Wyola	SW¼NW¼	36	9S	33E
18	06290500	Little Bighorn River below Pass Creek, near Wyola	W½SW¼	35	7S	35E
19	06294000	Little Bighorn River near Hardin	NE¼NE¼	19	1S	34E
20	06294690	Tullock Creek near Bighorn	NE¼NE¼NE¼	19	4N	35E
21	06294700	Bighorn River at Bighorn	NE¼NE¼	33	5N	34E
22	06294940	Sarpy Creek near Hysham	SE¼SE¼	30	6N	37E
23	06294995	Armells Creek near Forsyth	SE¼NW¼NE¼	26	6N	39E
24	06295250	Rosebud Creek near Colstrip	SE¼SW¼NE¼	3	1S	42E
25	06296003	Rosebud Creek at mouth near Rosebud	SW¼NW¼NE¼	21	6N	42E
26	06306250	Prairie Dog Creek near Acme, Wyo.	NE¼SW¼SW¼	23	58N	83W
27	06306300	Tongue River at State Line, near Decker	NW¼NE¼	33	9S	40E
28	06307500	Tongue River at Tongue River Dam, near Decker	NE¼	13	8S	40E
29	06307600	Hanging Woman Creek near Birney	N½NW¼SE¼	19	6S	43E
30	06307740	Otter Creek at Ashland	NE¼NE¼SE¼	11	3S	44E
31	06307830	Tongue River below Brandenberg Bridge, near Ashland	NE¼SW¼NW¼	6	1N	45E
32	06308400	Pumpkin Creek near Miles City	SE¼NW¼SW¼	35	6N	48E
33	06308500	Tongue River at Miles City	SE¼	23	7N	47E
34	06309000	Yellowstone River at Miles City	SW¼NW¼	28	8N	47E
35	06309075	Sunday Creek near Miles City	NW¼SW¼SW¼	3	8N	47E
36	06324500	Powder River at Moorhead	NW¼	8	9S	48E
37	06326300	Mizpah Creek near Mizpah	NW¼NE¼SW¼	24	6N	51E
38	06326500	Powder River near Locate	NW¼SW¼	14	8N	51E
39	06329500	Yellowstone River near Sidney	SW¼NE¼SW¼	9	22N	59E

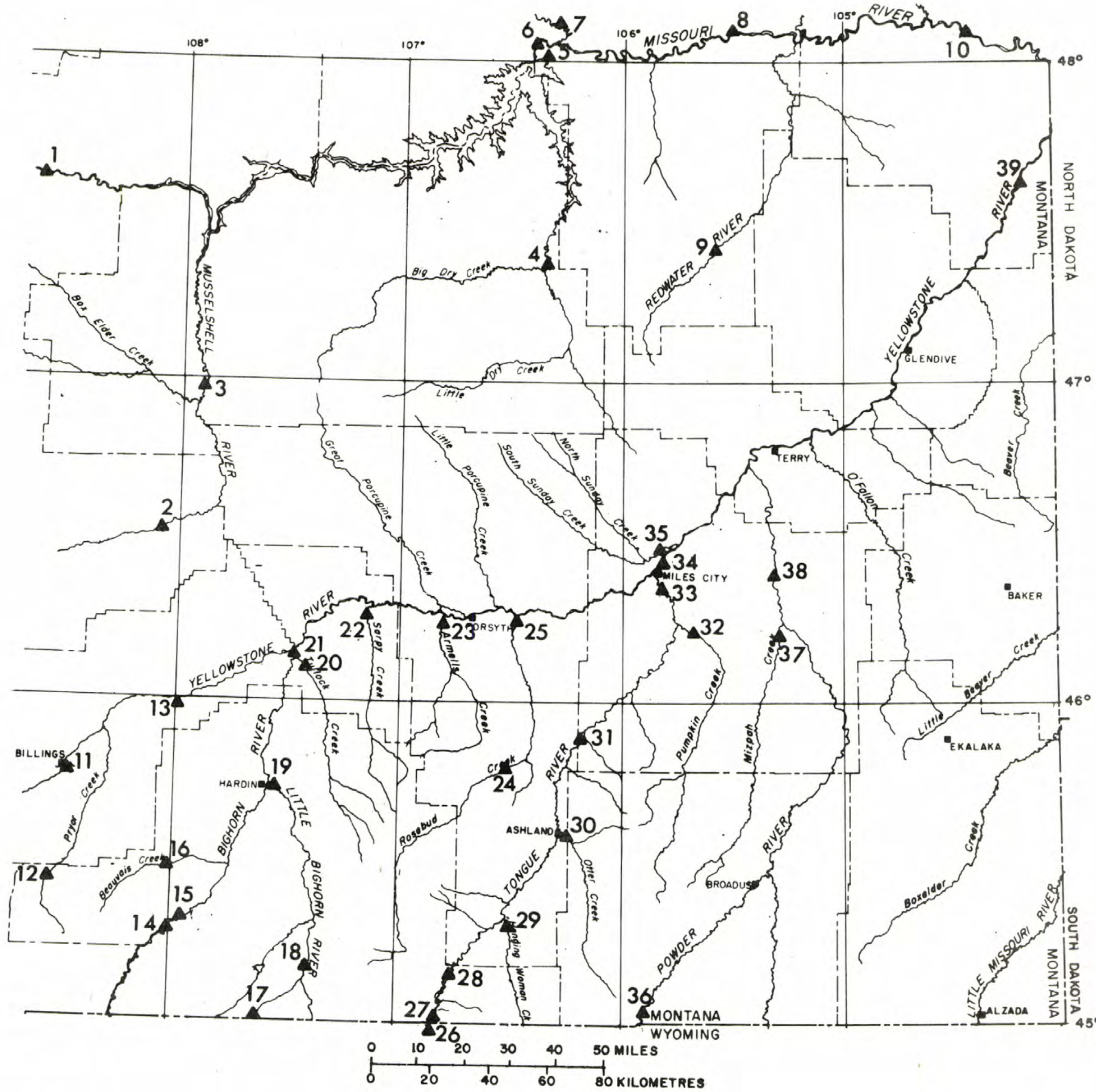


Figure 15.--Streamflow stations.

Crest-Stage Stations

The crest-stage stations listed below are maintained in cooperation with the Montana Department of Highways.

Map number	Name	Location	Section	Township	Range
1	Fish Creek near Musselshell	NW¼SW¼	9	8N	29E
2	Musselshell River tributary near Musselshell	SW¼	30	9N	28E
3	Butts Coulee near Melstone	Center E½	9	10N	31E
4	Gorman Coulee near Cat Creek	SW¼SW¼	31	15N	29E
5	Home Creek near Sumatra	SE¼NW¼	7	10N	33E
6	Bair Coulee near Mosby	NE¼NE¼	23	15N	32E
7	Second Creek tributary No. 2 near Jordan	NE¼	25	17N	38E
8	Russian Coulee near Jordan	SW¼NE¼	11	18N	39E
9	Thompson Creek tributary near Cohagen	NW¼SW¼	19	14N	42E
10	Spring Creek tributary near Van Norman	NW¼NE¼	12	17N	42E
11	Timber Creek tributary near Van Norman	SE¼NE¼	24	19N	43E
12	McGuire Creek tributary near Van Norman	NE¼SE¼	2	21N	43E
13	East Fork Sand Creek near Vida	NW¼	31	24N	48E
14	Cow Creek tributary near Vida	SE¼	36	23N	48E
15	East Fork Duck Creek near Brockway	W½	31	17N	47E
16	West Fork Sullivan Creek near Richey	SW¼SW¼	31	21N	51E
17	Wolf Creek tributary near Vida	SE¼	15	25N	48E
18	Missouri River tributary No. 6 near Wolf Point	NW¼NW¼	32	27N	48E
19	North Fork East Redwater River tributary near Richey	SE¼NE¼	36	25N	51E
20	Missouri River tributary No. 3 near Culbertson	Center	8	27N	56E
21	Little Bighorn River tributary near Wyola	SE¼NW¼	14	8S	35E
22	Long Otter Creek near Lodgegrass	NW¼SE¼	28	4S	35E
23	Andresen Coulee near Custer	W½	30	4N	34E
24	Tullock Creek tributary near Hardin	NW¼NW¼	33	1N	36E
25	Sarpy Creek tributary near Colstrip	SW¼SW¼	16	2N	37E
26	Buckingham Coulee near Myers	SW¼	25	6N	35E
27	Unknown Creek near Bighorn	SE¼	12	5N	34E
28	Armells Creek tributary near Colstrip	SE¼SE¼	26	4N	40E
29	Rosebud Creek tributary near Busby	NE¼	13	3S	39E
30	Spring Creek near Decker	SE¼	33	8S	40E
31	Leaf Rock Creek near Kirby	Center	35	7S	39E
32	Canyon Creek near Birney	SW¼	11	7S	41E
33	Tie Creek near Birney	SW¼SE¼	22	4S	42E
34	Cow Creek near Fort Howes Ranger Station near Otter	SW¼NW¼	30	6S	46E
35	Brian Creek near Ashland	SW¼SW¼	11	5S	45E
36	Spring Creek near Ashland	NW¼	27	3S	44E
37	Walking Horse Creek near Ashland	NW¼	3	3S	44E
38	Stebbins Creek near Ashland	Center	34	2S	43E
39	Stebbins Creek at mouth, near Ashland	NW¼	27	2S	44E
40	Jack Creek near Volborg	NE¼NW¼	26	4N	47E

Crest-Stage Stations (cont'd)

Map number	Name	Location	Section	Township	Range
41	Sixmile Creek tributary near Epsie	SW¼SW¼	36	3S	48E
42	Basin Creek tributary near Volborg	NW¼	31	2N	49E
43	Deer Creek tributary near Volborg	SW¼SW¼	4	3N	50E
44	LaGrange Creek near Volborg	NE¼NW¼	18	4N	50E
45	Middle Fork Froze to Death Creek tributary near Ingomar	NE¼	35	10N	34E
46	Anderson Creek at Vananda	SE¼NE¼	6	7N	38E
47	Short Creek near Forsyth	NW¼	12	6N	40E
48	Snell Creek near Hathaway	NW¼	7	6N	45E
49	Reservation Creek near Miles City	SE¼NE¼	9	7N	46E
50	North Fork Sunday Creek tributary at Rock Springs	SE¼	1	12N	43E
51	Dry House Creek near Angela	SE¼SW¼	22	11N	44E
52	North Fork Sunday Creek tributary No. 2 near Angela	NE¼	4	9N	45E
53	Tree Coulee near Kinsey	NE¼NW¼	10	9N	47E
54	Deep Creek near Kinsey	SE¼SE¼	1	9N	48E
55	Ash Creek near Locate	N½	17	7N	50E
56	Badger Creek at Biddle	NW¼SE¼	4	9S	52E
57	Sand Creek near Broadus	SE¼	5	5S	51E
58	Cut Coulee near Mizpah	NE¼SW¼	36	5N	52E
59	Meyers Creek near Locate	SE¼	1	7N	51E
60	Locate Creek tributary near Locate	SW¼SE¼	23	8N	52E
61	East Fork Little Powder River tributary near Hammond	NW¼SE¼	22	6S	54E
62	Powder River tributary near Powderville	NE¼NE¼	25	1N	53E
63	Cherry Creek tributary near Terry	NE¼SW¼	25	13N	50E
64	O'Fallon Creek near Ismay	East line	30	8N	56E
65	O'Fallon Creek tributary near Ismay	SE¼	29	8N	56E
66	Spring Creek tributary near Fallon	NE¼NE¼	13	12N	53E
67	Yellowstone River tributary No. 4 near Fallon	SW¼	23	13N	52E
68	Yellowstone River tributary No. 5 near Marsh	SW¼	21	14N	54E
69	Timber Fork Creek tributary near Lindsay	SW¼SW¼	36	17N	51E
70	Thirteenmile Creek tributary near Bloomfield	SE¼SE¼	9	19N	54E
71	Fox Creek tributary near Lambert	NW¼SW¼	24	22N	55E
72	First Hay Creek near Sidney	SE¼	16	24N	58E
73	Griffith Creek tributary near Glendive	NE¼NW¼	35	16N	56E
74	Yellowstone River tributary No. 6 near Glendive	NW¼SE¼	8	16N	56E
75	Alkali Creek tributary near Sidney	SW¼NE¼	7	20N	60E
76	Krug Creek tributary No. 2 near Wibaux	NW¼NW¼	6	14N	59E
77	South Fork Horse Creek tributary near Wibaux	SW¼SE¼	11	12N	58E
78	Pennel Creek near Baker	South line	36	9N	59E
79	Deep Creek near Baker	SW¼	2	6N	59E
80	Lame Jones Creek tributary near Willard	SE¼SE¼	11	5N	57E
81	Wolf Creek near Hammond	SE¼	5	8S	57E
82	North Creek near Alzada	SE¼NW¼	7	9S	59E

Crest-Stage Stations (cont'd)

Map number	Name	Location	Section	Town-ship	Range
83	Little Missouri River tributary near Albion	SW¼NW¼	21	7S	61E
84	Box Elder Creek tributary near Albion	SE¼	19	5S	59E
85	Coal Creek near Mill Iron	NW¼SW¼	26	2N	59E
86	North Fork Coal Bank Creek near Mill Iron	SW¼	12	2N	61E
87	Soda Creek tributary near Webster	NE¼	23	3N	61E

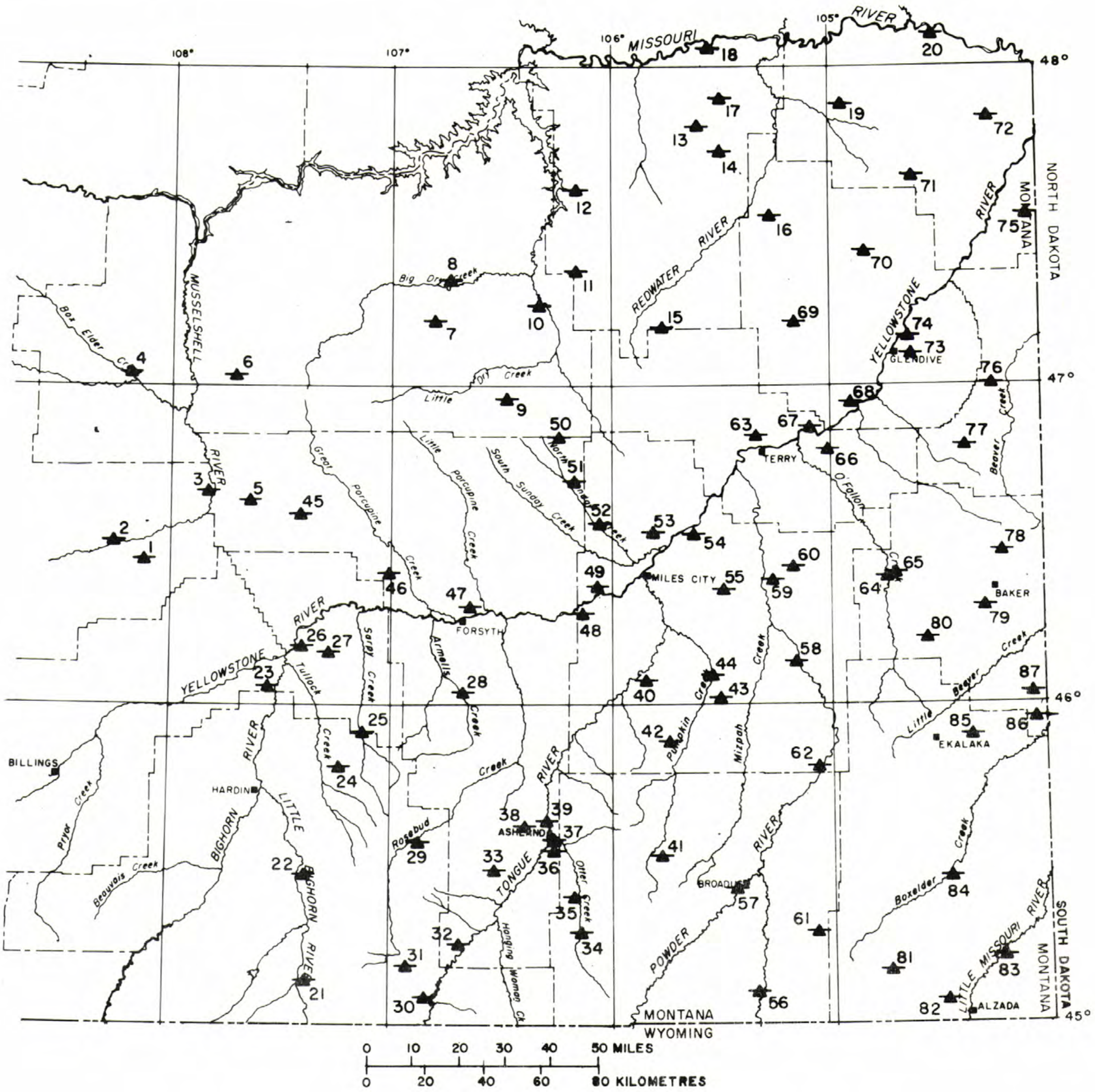


Figure 16.--Crest-stage stations.

INTERPRETIVE STUDIES

Availability of Water from the Madison Aquifer

Scattered and incomplete data indicate that the Madison aquifer (carbonates of the Madison Group and associated Paleozoic rocks) may yield as much as 2,200 gallons per minute (140 litres per second) to wells. However, the existing data are inadequate to predict the quantity and quality of water the aquifer will yield and the effects of development on the system.

The purpose of this study is to evaluate existing data and techniques and develop a plan for a comprehensive investigation of the Madison. The following approach is planned:

I. Evaluate the existing conceptual model.

A. List the constraints of the model and the possible consequences if the system is stressed.

B. Determine the reliability of the constraints by comparing different types of data and placing various hypothetical stresses on the system.

C. Refine and modify the model to fit the available data.

II. Evaluate selected techniques that may be useful hydrologic tools in a comprehensive study of the Madison aquifer.

A. Examine surface geophysical methods as to their application in extending point data in space and relative costs and manpower needs. The main emphasis will be on seismic methods.

B. Examine borehole geophysical methods as to types and uses. Mainly, determine which set of logs give optimum information.

C. Determine the possible relation between structure, geologic history, and various geohydrologic parameters.

D. Examine sedimentary petrology as a tool to relate porosity and permeability to the hydrologic system, to determine the factors that control permeability, and to determine the parameters that define the flow system.

E. Examine the use of geochemical techniques to describe the aquifer system and to develop a geochemical model.

III. Combine the conceptual model with the most promising techniques and plan a comprehensive study of the Madison aquifer.

A. Select test-hole locations, outline the geohydrologic tests to be made and, concurrently, prepare test-drilling specifications and a drilling contract.

B. Specify additional field and interpretive work necessary to extrapolate point data and further refine the conceptual model.

C. Outline continuing studies necessary to define the system and to predict water quality, quantity, and consequences of development.

Cooperating agency: Old West Regional Commission
Montana Bureau of Mines and Geology

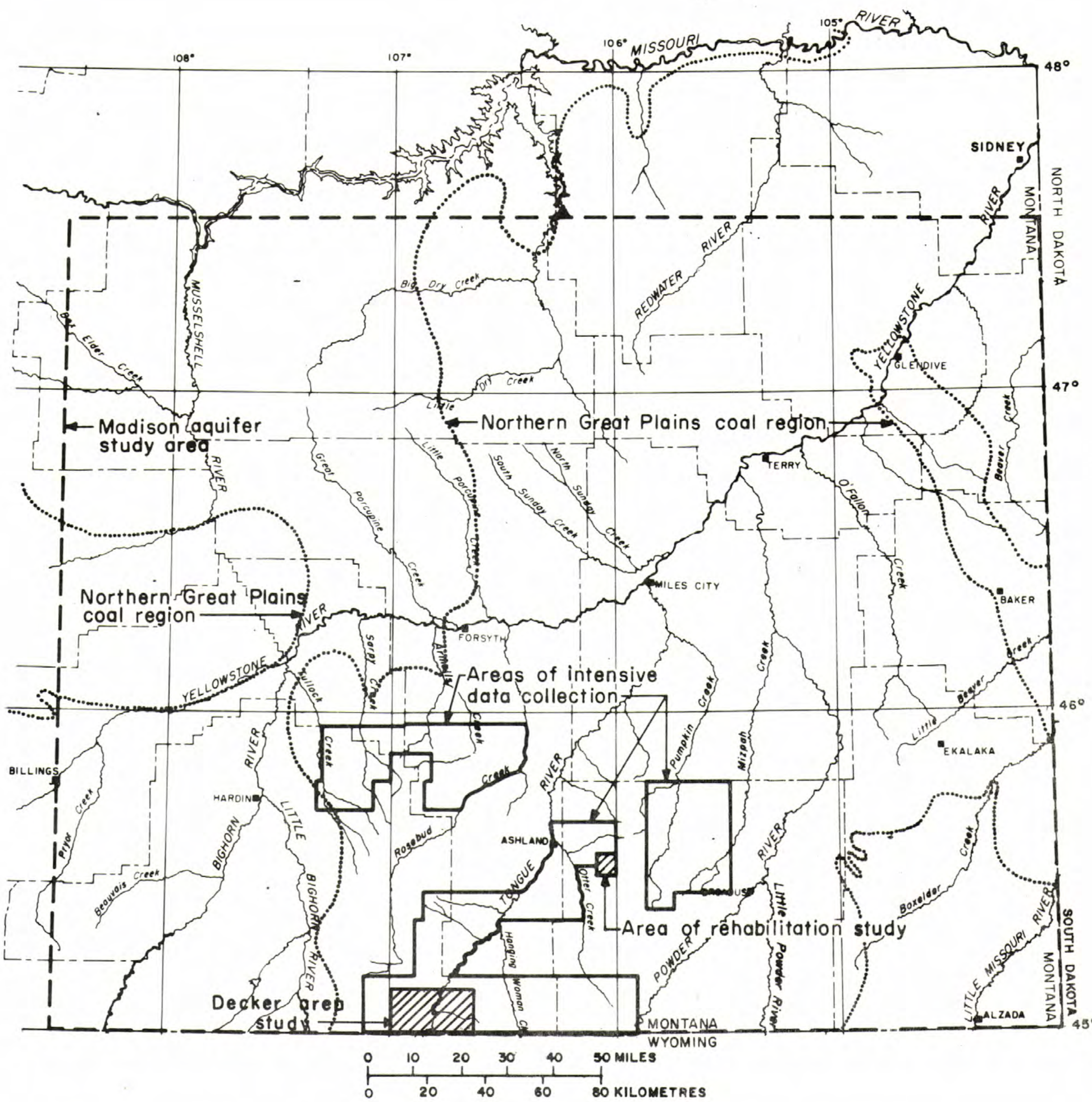


Figure 17 .--Ground-water interpretive-study areas.

Effects of Mining and Related Activities on the Shallow Ground-Water System

Strip mining and the related aspects of coal development can be expected to cause ground-water levels and ground-water quality to change near the area of development in the shallow aquifers in eastern Montana. The shallow aquifers are principally alluvium along stream valleys and relatively thin discontinuous sandstone and coal beds separated by shale overlying the Pierre Shale of Late Cretaceous age. Ground-water supplies are fairly evenly distributed, but small in amount, and are developed mostly for domestic and stock use. Data, data interpretation, and prediction of the effects of mining and related activities on the shallow ground-water system are needed by the public, industry, and government to aid in the wise development of the coal and water resources.

Areas underlain by the best quality coal in greatest amounts are of immediate importance to leasing for mining; these areas coincide with the areas shown on figure 17 for intensive data collection. The overall study area, whose boundaries may require adjustment in the future, is in general bounded on the north by the Yellowstone River, on the east by the Powder and Little Powder Rivers, on the south by Wyoming, and on the west by the Bighorn and Little Bighorn Rivers.

The objectives of this study are several:

1. Define the regional hydrologic system of the aquifers above the Pierre Shale, including the interrelations between the most extensive aquifers, hydrologic characteristics, extent and boundaries of aquifers, water-quality variations, aquifer recharge and discharge, and streamflow. Definition of the system will initially be in areas planned for intensive data collection, followed by definition for the overall study area.

2. Obtain a detailed quantitative understanding of the flow system in relatively small areas of 10-20 square miles (26-52 square kilometres) in terms of ground-water recharge, movement, discharge, boundaries, and aquifer parameters. This information will form a conceptual model that will be the basis for predictive models.

3. Develop and test predictive models to assess the effects of several different levels of energy development and mining plans on regional and small-area flow systems.

4. Develop water-quality models to predict the rate and direction of leachate migration from spoil banks.

5. Utilize the predictive models to evaluate and improve the data-collection program.

Cooperating agencies:

1. U.S. Bureau of Land Management

2. Montana Bureau of Mines and Geology

3. Montana Department of Natural Resources and Conservation

Grants under consideration or in effect with:

1. Montana Bureau of Mines and Geology--selected test drilling and aquifer testing.

2. Montana Department of Intergovernmental Relations--development of format and software systems to make data collected by State agencies compatible with U.S. Geological Survey and STORET computer systems.

3. Montana State University--geochemistry, mineralogy, microorganisms, and chemical reactions that occur in spoils and aquifers.

Site Study to Assess the Ground-Water Problems That May Affect Restoration of Mined Lands

Problems of mined-land reclamation and possible solutions must be known before areas underlain by Federally owned coal will be recommended for leasing. These problems range from what type of surface treatment is best to what will be the effect of surface mining on the water resources.

The principal objective of the study is to provide the data and interpretations necessary to predict the potential water-resources problems related to mining and rehabilitation and to suggest alternative solutions to the problems. Concurrently, a monitoring system is needed to define baseline conditions and to document changes in ground-water flow and quality caused by mining and rehabilitation (see fig. 17).

The study will utilize the contributions of the following groups:

1. U.S. Bureau of Land Management -- land classification.

2. U.S. Bureau of Reclamation -- drill and core test holes, make physiochemical analyses of cores, perform leaching experiments, and perform engineering and soils tests.

3. U.S. Geological Survey -- obtain geophysical logs of test holes and correlate with cores, determine hydrologic characteristics of aquifer, install recorders for monitoring water levels, collect water samples for chemical analysis, collect related surface-water and sedimentation data, analyze all data and determine potential problems, and develop alternatives for management of the resource.

See page 104 for a description of work on this same tract having to do with erosion potential, soils, vegetation identification, and sediment-source mapping.

Yellowstone River Temperature Study

The purpose of the study is to determine the effect of possible reduction in streamflow on the temperature of the Yellowstone River from Billings to Sidney. A computer model of the energy budget for the stream system is being developed to predict temperature changes in the river as a result of preselected withdrawal rates at any point within the reach. The lack of detailed meteorological data (such as solar radiation) has necessitated the use of closed ponds to estimate equilibrium temperatures. Pond data are being collected at three sites near the river. River temperatures are being collected at the following sites:

Map number (fig.15)	Name
11	Yellowstone River at Billings
21	Bighorn River at Bighorn
33	Tongue River at Miles City
34	Yellowstone River at Miles City
38	Powder River near Locate
39	Yellowstone River near Sidney

NORTH DAKOTA

The work done by the Water Resources Division in North Dakota is listed in the following pages by sequential project identification number. Some of the projects (ND-001, 002, 003, and 004) are primarily concerned with data collection. Others (ND-018 and ensuing numbers) involve interpretation in addition to data collection. The results of all projects are made available to the public in various forms of publication.

Most of the work is done in cooperation with or at the funded request of other agencies as listed in the project descriptions in the following pages. Some work is funded entirely by the Geological Survey.

DATA-COLLECTION ACTIVITIES

SURFACE-WATER STATIONS

ND-001

Objectives

(A) To collect surface-water data sufficient to satisfy needs for current-purpose uses, such as (1) assessment of water resources, (2) operation of reservoirs or industries, (3) forecasting, (4) disposal of wastes and pollution controls, (5) discharge data to accompany water-quality measurements, (6) compact and legal requirements, and (7) research or analytical studies. (B) To collect data necessary for analytical studies to define for any location the statistical properties of, and trends in, the occurrence of water in streams, lakes, estuaries, etc., for use in planning and design.

Cooperators

Agency name	Abbreviation[1]
North Dakota State Water Commission	SWC
Oliver County	OC
U.S. Army Corps of Engineers - Omaha District	CE-O
U.S. Army Corps of Engineers - St. Paul District	CE-S
U.S. Bureau of Land Management	BLM
U.S. Bureau of Sport Fisheries and Wildlife	FWL
U.S. Dept. of the Interior - Missouri River Basin Program	MRB
U.S. Dept. of State - Waterways Treaty Program	WWT
U.S. Geological Survey - Federal Program	FED
U.S. Geological Survey - National Water Quality Accounting Network	NASQAN

Reports

Data are published in the annual series "Water Resources Data for North Dakota, Part I - Surface-Water Records."

[1]Abbreviations used for cooperators in the following summary of activities.

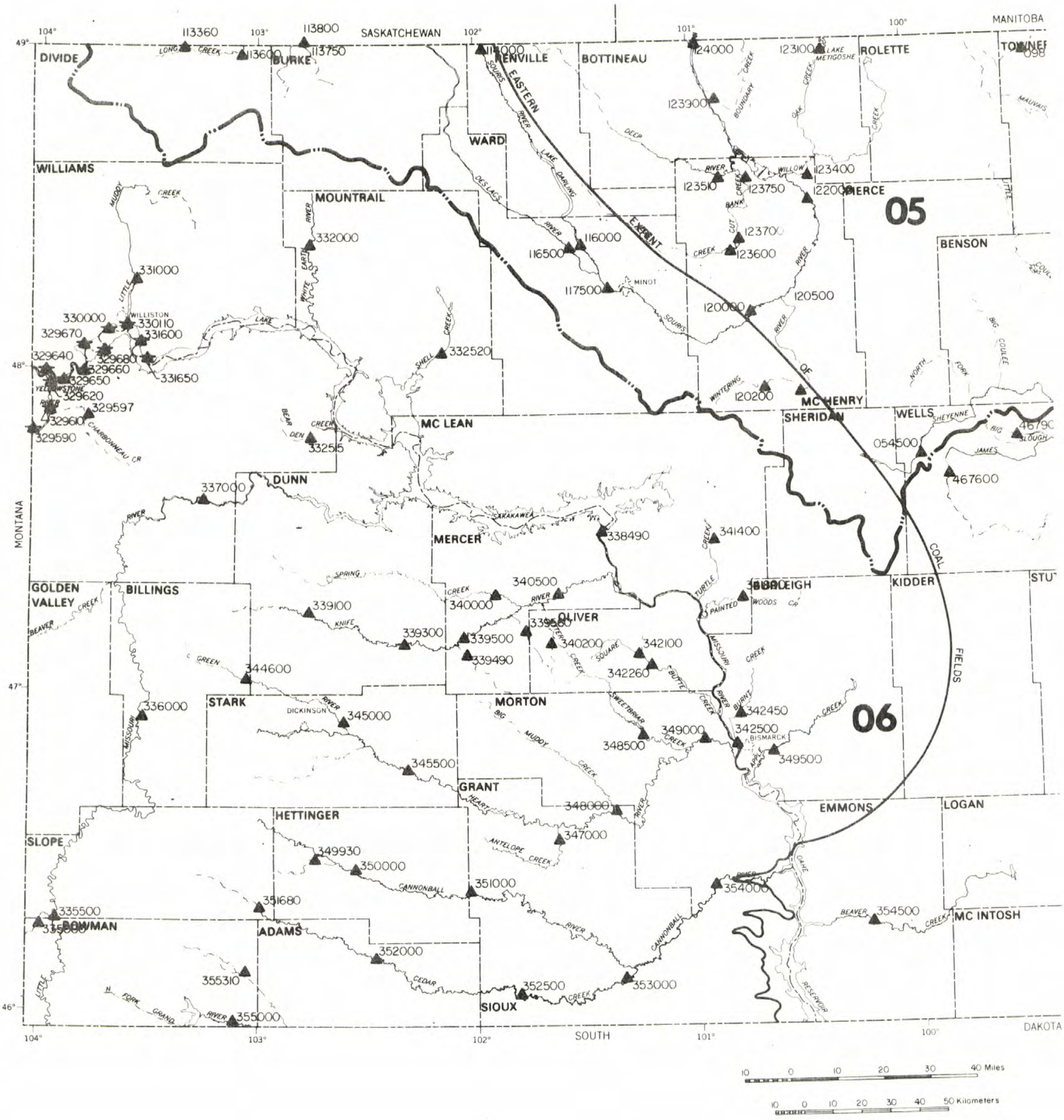


Figure 18.--Locations of streamflow stations.

Streamflow Stations

Station number[2]	Station name	Cooperator
Part 5		
113600	Long C. nr Noonan	WWT
114000	Souris R. nr Sherwood	WWT
116000	Souris R. nr Foxholm	SWC, FWL
116500	Des Lacs R. at Foxholm	SWC
117500	Souris R. at Minot	SWC
120200	Wintering R. nr Bergen	MRB
Part 6		
329597	Charbonneau C. nr Charbonneau	SWC
331000	L. Muddy C. bl Cow C. nr Williston	SWC
332000	White Earth R. nr White Earth	SWC
332515	Bear Den C. nr Mandaree	FED
332520	Shell C. nr Parshall	SWC
335000	L. Beaver C. nr Marmarth	CE-O, SWC
335500	L. Missouri R. at Marmarth	CE-O, SWC
336000	L. Missouri R. at Medora	CE-O
337000	L. Missouri R. nr Watford City	CE-O, FED
338490	Missouri R. at Garrison Dam	CE-O
339100	Knife R. at Manning	SWC
339300	Knife R. at Marshall	SWC
339490	Elm C. nr Golden Valley	SWC
339500	Knife R. nr Golden Valley	FED
339560	Brush C. nr Beulah	BLM
340000	Spring C. at Zap	SWC
340200	W. Br. Otter C. nr Beulah	SWC
340500	Knife R. at Hazen	SWC, CE-O
341400	Turtle C. nr Turtle Lake	MRB
341800	Painted Woods C. nr Wilton	MRB
342100	Square Butte C. trib. #2 nr Center	OC
342260	Square Butte C. bl. Center	OC
342450	Burnt C. nr Bismarck	SWC
342500	Missouri R. at Bismarck	FED, CE-O
344600	Green R. nr New Hradec	SWC
345000	Green R. nr Gladstone	SWC
345500	Heart R. nr Richardton	SWC
347000	Antelope C. nr Carson	SWC
348000	Heart R. nr Lark	CE-O
348500	Sweetbriar C. nr Judson	SWC, CE-O

[2] The station numbers used in this report are abbreviated station numbers. The complete number includes the part number. Part 5 is the Hudson Bay and Upper Mississippi River basins and Part 6 is the Missouri River basin.

Streamflow Stations, Cont.

Station number	Station name	Cooperator
Part 6, Cont.		
349000	Heart R. nr Mandan	SWC, CE-O
349500	Apple C. nr Menoken	SWC
349930	Coal Bank C. nr Havelock	BLM
350000	Cannonball R. nr Regent	CE-O
351000	Cannonball R. bl Bentley	SWC
351680	White Butte Fk. Cedar C. nr Scranton	SWC
352000	Cedar C. nr Haynes	SWC
352500	Cedar C. nr Pretty Rock	SWC
353000	Cedar C. nr Raleigh	SWC
354000	Cannonball R. at Breien	FED, CE-O
355000	N. Fk. Grand R. at Haley	SWC
355310	Buffalo C. Trib. nr Gascoyne	BLM

River-Stage Stations

Cooperator

U.S. Army Corps of Engineers.

Station number	Station name	Frequency
Part 6		
185600	Missouri R. No. 4 nr Nohly	Seasonal, March-October
185650	Missouri R. No. 5 nr Nohly	Do.
329590	Yellowstone R. No. 1 nr Fairview	Do.
329610	Yellowstone R. No. 2 nr Cartwright	Do.
329620	Yellowstone R. No. 3 nr Buford	Do.
329640	Missouri R. No. 5A at Buford	Do.
329650	Missouri R. No. 6 at Buford	Do.
329660	Missouri R. No. 7 nr Trenton	Do.
329680	Missouri R. No. 8 nr Trenton	Do.
330000	Missouri R. nr Williston	Continuous
330110	Missouri R. No. 9 at Williston	Seasonal, March-October
331600	Missouri R. No. 10 nr Williston	Do.
331650	Missouri R. No. 11 nr Williston	Do.
339000	Missouri R. bl. Garrison Dam	Continuous
340700	Missouri R. nr Stanton	Do.
340900	Missouri R. nr Hensler	Do.
341000	Missouri R. at Washburn	Do.
342020	Missouri R. at Price	Do.
349070	Missouri R. bl Mandan	Do.
349700	Missouri R. nr Schmidt	Do.

Reservoir and Lake Stations

Station number	Station name	Cooperator
Part 5		
113750	E. Br. Short C. Res. nr Columbus	WWT
115500	Lk. Darling nr Foxholm	SWC-FWL
Part 6		
343500	E. A. Patterson Lk. nr Dickinson	MRB
348490	Sweetbriar Res. nr Judson	SWC

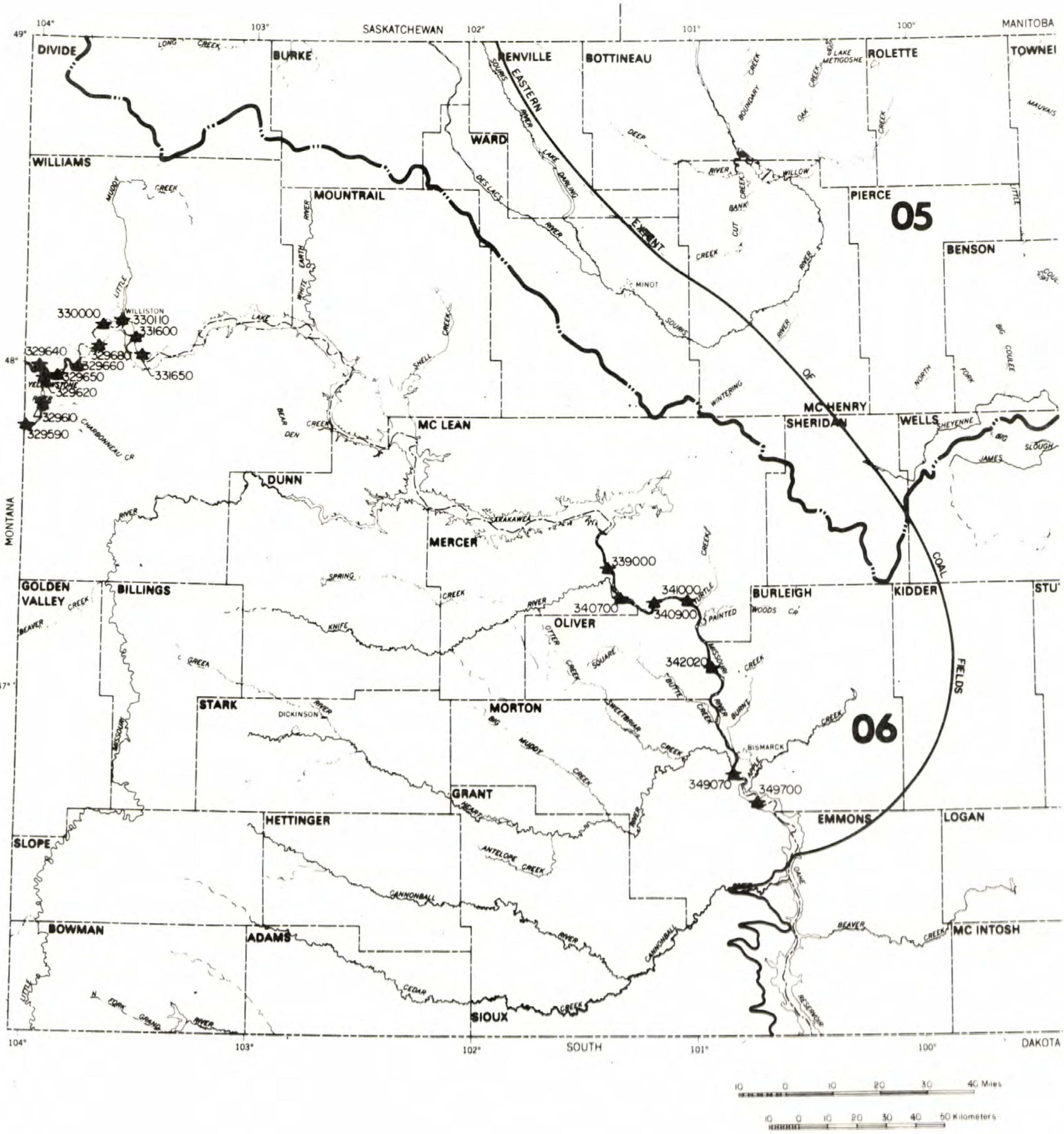


Figure 19.--Locations of river-stage stations.

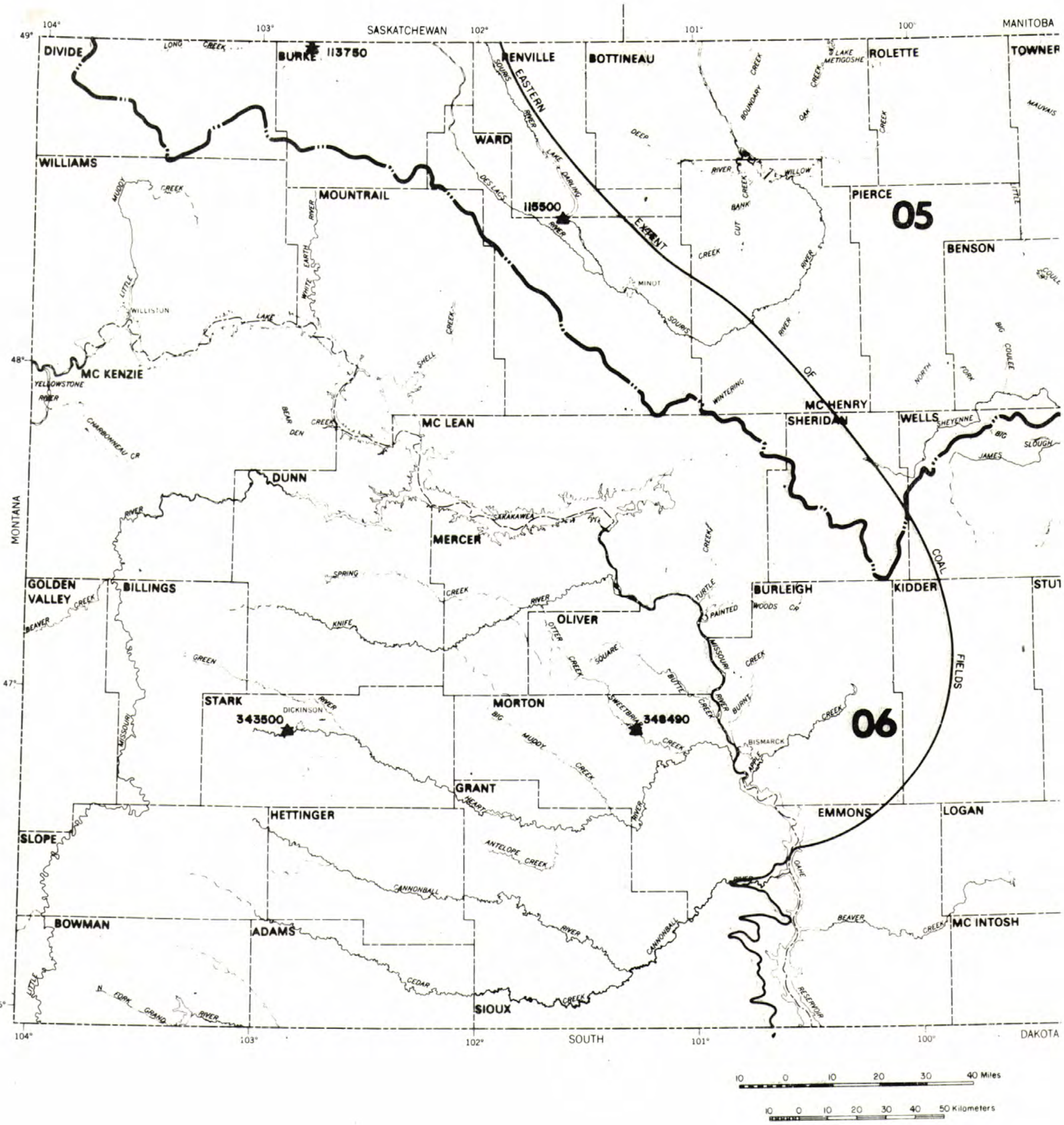


Figure 20.-- Locations of reservoir and lake stations.

Crest-Stage Stations

Cooperator

North Dakota State Highway Department.

Station number	Station name
1134.5	Long Creek tributary No. 2 near Crosby
1135.2	Long Creek tributary near Crosby
1161	Souris River tributary near Burlington
1162	Des Lacs River tributary near Donnybrook
1165.5	Fuller Coulee at Foxholm
1172	Souris River tributary No. 2 near Burlington
3297	Painted Woods Creek tributary near Williston
3298	Painted Woods Creek near Williston
3299	Painted Woods Creek tributary No. 2 nr Williston
3301	Sand Creek at Williston
3319	White Earth River tributary near Tioga
3321.5	White Earth River tributary near White Earth
3357	Deep Creek near Bowman
3361	Sheep Creek tributary near Medora
3362	Sheep Creek tributary No. 2 near Medora
3363	Little Missouri River tributary near Medora
3364	Jules Creek near Medora
3369.8	Little Missouri River tributary nr Watford City
3371	Spring Creek near Watford City
3376	East Branch Douglas Creek tributary nr Garrison
3379	Snake Creek tributary near Garrison
3402	West Branch Otter Creek near Beulah
3403	Otter Creek near Hannover
3420.5	Square Butte Creek at Center
3421.5	Square Butte Creek tributary near Center
3422.5	Square Butte Creek tributary No. 3 near Center
3432	Heart River tributary near South Heart
3442	Heart River tributary near Dickinson
3451	Antelope Creek near Dickinson
3452	Antelope Creek tributary near New England
3453	Antelope Creek tributary (Site No. 2) near New England
3457	Government Creek near Richardton
3471	Wilson Creek near Glen Ullin

Station number	Station name
3472	Hailstone Creek near Blue Grass
3516.5	Middle Fork Cedar Creek near Buffalo Springs
3516.8	White Butte Fork Cedar Creek near Scranton
3536	Louise Creek tributary near Brisbane
3537	Louise Creek tributary near Lark
3538	Louise Creek tributary No. 2 near Lark
3539	Louise Creek above Flasher
3548.85	North Fork Grand River tributary near Bowman
3549	Spring Creek near Bowman
3549.85	Alkali Creek near Bowman
3549.5	Spring Creek tributary near Bowman
3552	Buffalo Creek tributary near Buffalo Springs

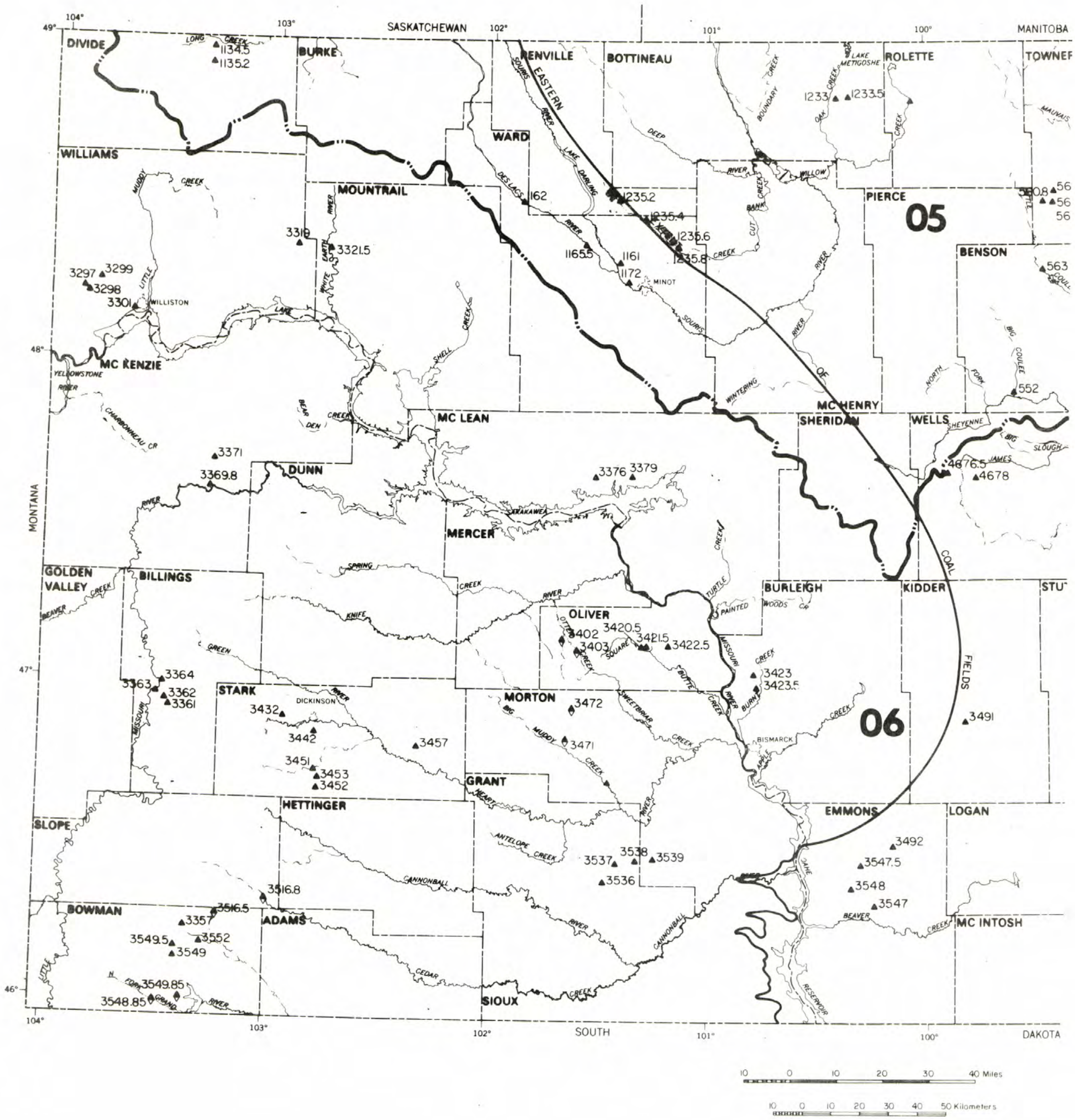


Figure 21.--Locations of crest-stage stations.

GROUND-WATER STATIONS

ND-002

Objectives

(A) To collect water-level data sufficient to provide a minimum long-term data base so that the general response of the hydrologic system to natural climatic variations and induced stresses is known and potential problems can be defined early enough to allow proper planning and management. (B) To provide a data base against which the short-term records acquired in areal studies can be analyzed. This analysis must (1) provide an assessment of the ground-water resource, (2) allow prediction of future conditions, (3) detect and define pollution and supply problems, and (4) provide the data base necessary for management of the resource.

Cooperators

North Dakota State Water Commission and U.S. Army Corps of Engineers, Omaha District.

Reports

Selected data are published at 5-year intervals in U.S. Geological Survey Water-Supply Papers. Open-file data available from the U.S. Geological Survey, Bismarck, ND.

Ground-Water Stations

County	Total recorders	Weekly	Monthly	Quarterly	Annual	Total
Adams					9	9
Bowman	4		7		11	22
Burke	1				6	7
Burleigh	3		12	7	5	27
Divide				1	8	9
Grant				2	21	23
Hettinger				1	5	6
McLean	4		7	3	22	36
Mercer				9	3	12
Morton		1	1		1	3
Mountrail	-		1		11	12
Oliver				1	3	4
Renville				1	9	10
Sioux				2	11	13
Stark				3	9	12
Ward	3			9	20	32
Williams	3		12	11	11	37
Totals	18	1	40	50	165	274

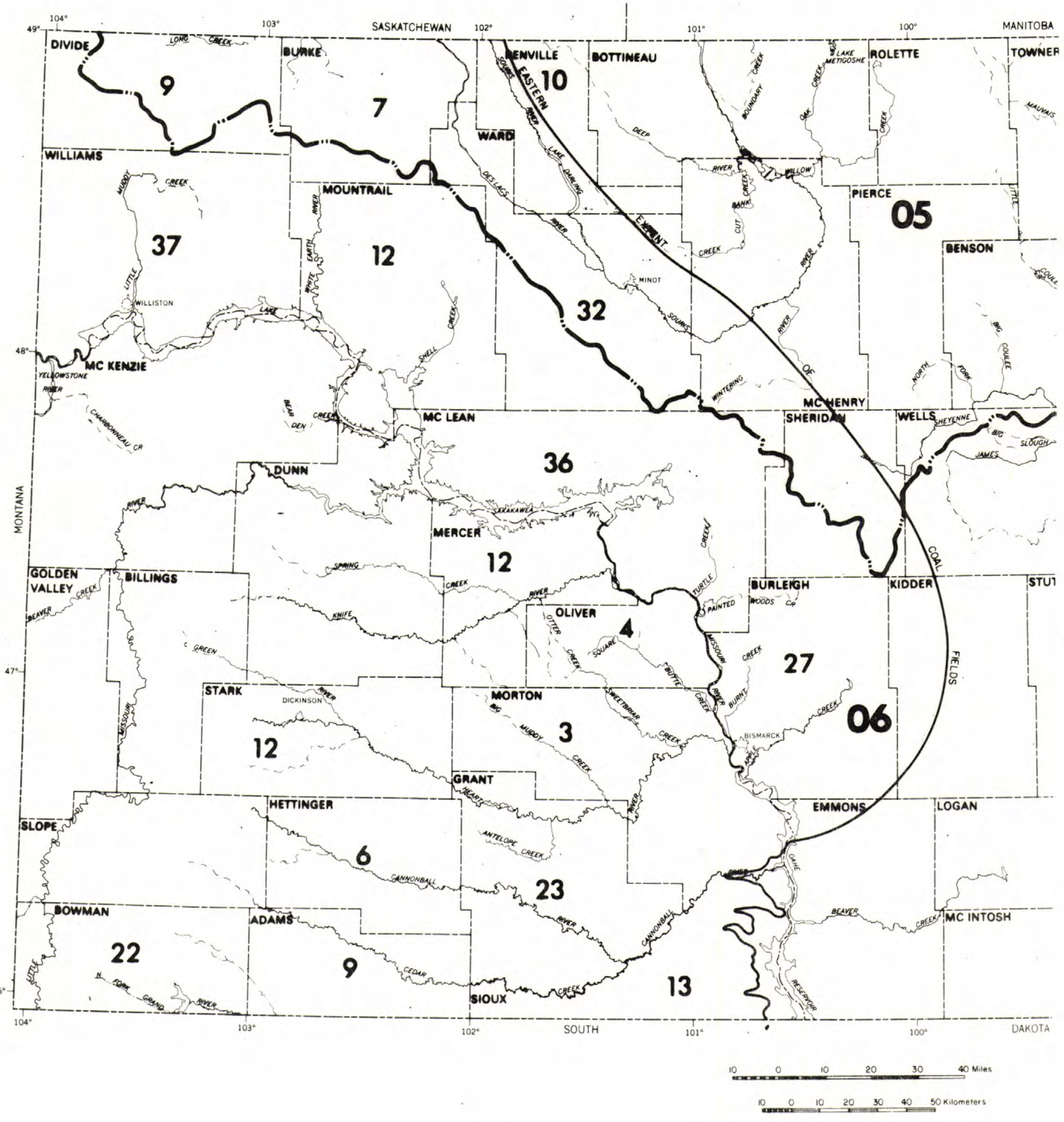


Figure 22.--Number of ground-water stations, by county.

WATER-QUALITY STATIONS

ND-003

Objectives

To provide a national bank of water-quality data for broad Federal planning and action programs and to provide data for Federal management of interstate and international waters.

Cooperators

U.S. Bureau of Land Management, U.S. Army Corps of Engineers, Environmental Protection Agency, and North Dakota State Water Commission.

Reports

Data are published in the annual series, "Water Resources Data for North Dakota, Part 2 - Water-Quality Records" and in the Water-Supply Paper series "Quality of Surface Waters of the United States" (parts 5 and 6).

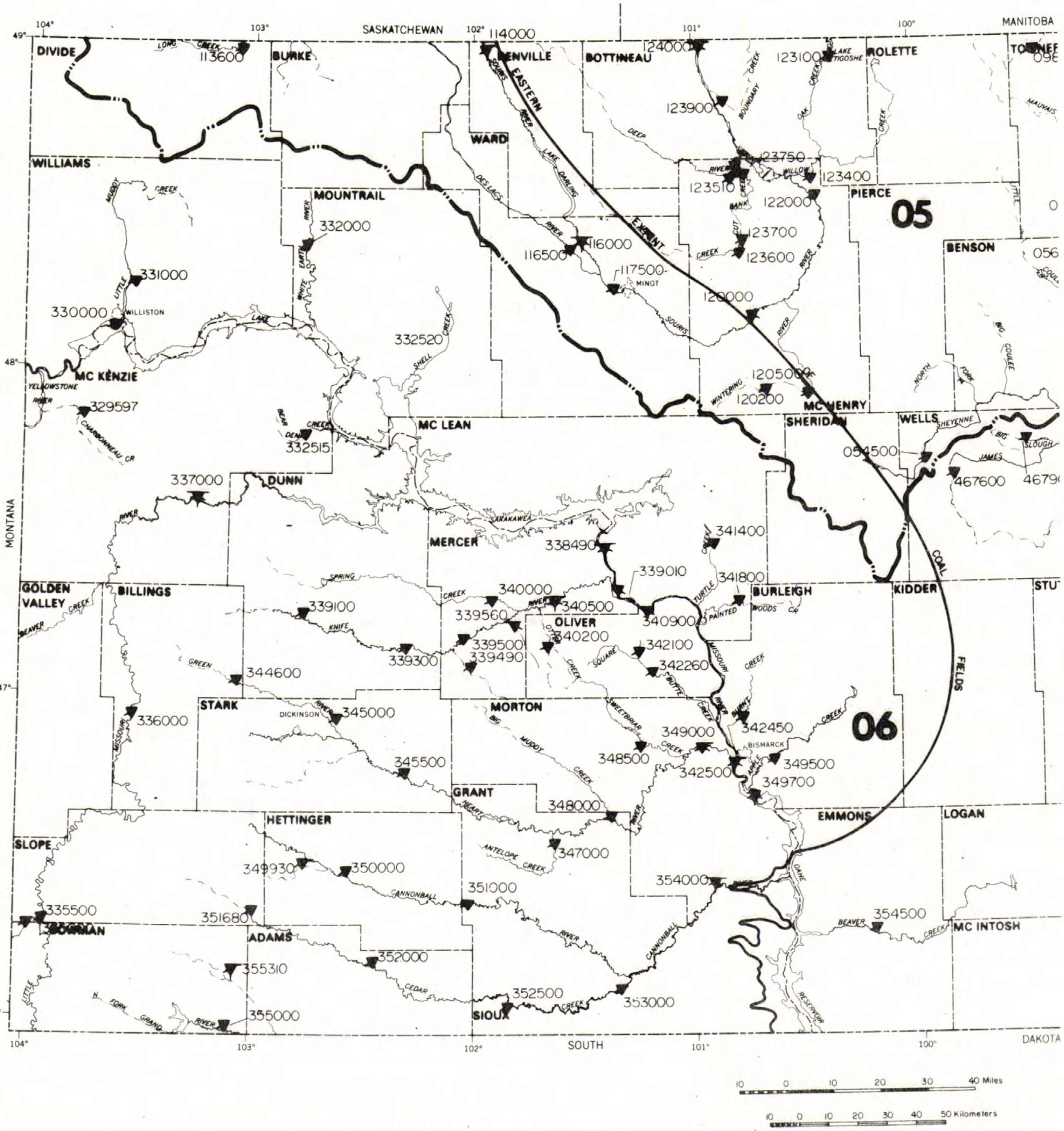


Figure 23.--Locations of water-quality stations.

Environmental Protection Agency

(National Water-Quality Surveillance System)

Station number	Station name
05114000	Souris R. nr Sherwood, N.D., NW¼SE¼NE¼ sec. 33, T. 164 N., R. 87 W.
06342500	Missouri R. at Bismarck, N.D., SE¼NW¼SE¼ sec. 31, T. 139 N., R. 80 W.
06349700	Missouri R. nr Schmidt, N.D., SW¼NE¼ sec. 26, T. 137 N., R. 80 W.

Sampling Schedule and Parameters

Field Measurements
(Biweekly)

00010 [3]	Temperature	00095	Specific conductance
00400	pH	00300	Dissolved oxygen
31501	Total coliform	31616	Fecal coliform

Lab Measurements
(Biweekly)

00340	Chemical oxygen demand	00610	Nitrogen NH_4 TOT
00070	Turbidity	00630	Nitrate + Nitrite, TOT
70300	Residue, dis. 180°C	00665	Phosphorus, TOT
70299	Residue, susp. 110°C	00680	Organic carbon, TOT
00625	Nitrogen, TOT KJD		

(Quarterly)

00915	Calcium, dis.	00445	Carbonate
00925	Magnesium, dis.	00400	Bicarbonate
00930	Sodium, dis.	00945	Sulfate, dis.
00935	Potassium, dis.	00955	Silica, dis.
00940	Chloride, dis.		

In addition the following samples are sent to EPA's Lab in Denver.

06342500 & 06349700: monthly metals (total)
05114000 : Quarterly metals (total) & seasonal pesticides

[3] U.S. Geological Survey parameter code.

Environmental Protection Agency

(Baseline Water-Quality Data)

Station number	Station name
06330000	Missouri R. nr Williston, N.D., sec. 6, T. 153 N., R. 101 W.
06338490	Missouri R. at Garrison Dam, N.D., S½ sec. 31, T. 147 N., R. 84 W.
06340000	Spring C. at Zap, N.D., SW¼ sec. 14, T. 144 N., R. 89 W.
06340500	Knife R. at Hazen, N.D., SE¼ sec. 18, T. 144 N., R. 86 W.

Sampling Schedule and Parameters

Field Measurements (Monthly)

00010	Temperature	00400	pH
00095	Specific conductance	00300	Oxygen, dis.

Lab Measurements (Monthly)

00915	Calcium, dis.	00940	Chloride, dis.
00925	Magnesium, dis.	00955	Silica, dis.
00930	Sodium, dis.	70299	Residue, susp. 110°C
00935	Potassium, dis.	00625	Nitrogen, TOT KJD
00445	Carbonate	00665	Phosphorus, TOT.
00440	Bicarbonate	00610	Nitrogen NH_4, TOT.
00945	Sulfate, dis.	00630	Nitrate + Nitrite, Tot.
		00310	Biochemical Oxygen Demand

(Quarterly)

Dissolved	Total		Dissolved	Total	
01106	01105	Aluminum	01049	01051	Lead
01020	01022	Boron	01090	01092	Zinc
01040	01042	Copper	01145	01147	Selenium
00950	00951	Fluoride	71890	71900	Mercury

Nelson Lake Study

(Located Upstream from 06342260)

Eight sites--four on the lake, Ash pond, two tributaries, and one downstream--were selected for sampling and analysis for trace-element composition of aqueous effluents from coal-fired powerplants to surface waters. Two suites of samples were collected in May and September 1974. Analysis consisted of the following:

Parameters

Dissolved	Total		Dissolved	Total	
01106	01105	Aluminum	01060	01062	Molybdenum
01005	01007	Barium	01065	01067	Nickel
01010	01012	Beryllium	01075	01077	Silver
01015	01017	Bismuth	01080	01082	Strontium
01020	01022	Boron	01100	01102	Tin
01025	01027	Cadmium	01150	01152	Titanium
01030	01034	Chromium	01085	01087	Vanadium
01035	01037	Cobalt	01090	01092	Zinc
01040	01042	Copper	01160	01162	Zirconium
01120	01122	Gallium	09511	--	Radium
01025	01127	Germanium	80020	--	Uranium
01046	01045	Iron	01000	01002	Arsenic
01049	01051	Lead	00950	00951	Fluoride
01130	01132	Lithium	71890	71900	Mercury
01056	01055	Manganese	01145	01147	Selenium

U.S. Geological Survey

(Benchmark Stations)

Station number	Station name
06332515	Bear Den C. nr Mandaree, N.D., NW¼ sec. 30, T. 150 N., R. 94 W.

Sampling Schedule and Parameters

Field Measurements
(Monthly)

00095	Specific conductance	31501	Total coliform
00010	Temperature, °C	31616	Fecal coliform
00400	pH	31679	Fecal streptococci
00300	Dissolved oxygen		

Lab Measurements
(Monthly)

00955	Silica, dis.	00950	Fluoride, dis.
00915	Calcium, dis.	70300	Dissolved solids
00925	Magnesium, dis.		
00930	Sodium, dis.		
00935	Potassium, dis.	00900	Total hardness
00440	Bicarbonate	00630	Nitrate + Nitrite as N, total
00445	Carbonate	00665	Phosphorus as P, total
00945	Sulfate, dis.	80154	Suspended sediment concentration
00940	Chloride, dis.		

(Semi-Annual)

01045	Iron, TOT	01077	Silver, TOT
01002	Arsenic, TOT	01092	Zinc, TOT
01027	Cadmium, TOT	00720	Cyanide
01034	Chromium, TOT	01007	Barium, TOT
01042	Copper, TOT	01147	Selenium, TOT
01051	Lead, TOT	01055	Manganese, TOT
71900	Mercury, TOT		

Lab Measurements, Continued

Pesticides of Whole Water
(Annual)

39360	DDD	39350	Chlordane
39365	DDE	39540	Parathion
39330	Aldrin	39600	Methyl Parathion
39370	DDT	39530	Malathion
39380	Dieldrin	39570	Diazinon
39390	Endrin	39730	2, 4-D
39410	Heptachlor	39740	2, 4, 5-T
39420	Heptachlor, Epox.	39760	Silvex
39340	Lindane		

Pesticides of Bed Materials
(Annual)

39363	DDD	39393	Endrin
39368	DDE	39413	Heptachlor
39333	Aldrin	39423	Heptachlor, Epox.
39373	DDT	39343	Lindane
39383	Dieldrin	39351	Chlordane

Radiochemical (Whole-Water)
(Annual)

80030	Gross Alpha, dis.	80060	Gross Beta, susp.
80050	Gross Beta, dis.	09511	Radium
80040	Gross Alpha, susp.	-	Uranium

U.S. Geological Survey

(Missouri River Basin)

Station number	Station name
06338490[1]	Missouri R. at Garrison Dam, N.D., S½ sec. 31, T. 147 N., R. 84 W.
06339010[2]	Missouri R. ab. Stanton, N.D., E½ sec. 22, T. 145 N., R. 84 W.
06340900[2]	Missouri R. nr Hensler, N.D., SW¼ sec. 22, T. 144 N., R. 83 W.
06341800	Painted Woods C. nr Wilton, N.D.

[1]Daily temperature and specific conductance.

[2]Continuous temperature recorder only.

Sampling Schedule and Parameters

Field Measurements (Monthly)

00400	pH	00095	Specific conductance
00010	Temperature		

Lab Measurements (Monthly)

00440	Bicarbonate	00925	Magnesium, dis.
01020	Boron, dis.	00935	Potassium, dis.
00915	Calcium, dis.	00955	Silica, dis.
00445	Carbonate, dis.	00930	Sodium, dis.
00940	Chloride, dis.	00945	Sulfate, dis.
00080	Color	00070	Turbidity (JTU)
70300	Residue, dis. 180°C	00666	Phosphorus, dis.
00950	Fluoride, dis.	00631	Nitrate + Nitrite, dis.

(Semi-annually)

01106	Aluminum, dis.	01056	Manganese, dis.
01000	Arsenic, dis.	71890	Mercury, dis.
01005	Barium, dis.	01065	Nickel, dis.
01030	Chromium, dis.	01080	Strontium, dis.
01035	Cobalt, dis.	01090	Zinc, dis.
01040	Copper, dis.	01025	Cadmium, dis.
00720	Cyanide	01145	Selenium, dis.
01046	Iron, dis.	01060	Molybdenum, dis.
01049	Lead, dis.	01085	Vanadium, dis.
01130	Lithium, dis.		

U.S. Geological Survey

(National Water Quality Accounting Network)

Station number	Station name
06337000[1,2]	Lt. Missouri R. nr Watford City, N.D., NW¼SE¼SE¼ sec. 35, T T. 148 N., R. 99 W.
06338490[2]	Missouri R. at Garrison Dam, N.D., S½ sec. 31, T. 147 N., R. 84 W.
06340500[2]	Knife R. at Hazen, N.D., SE¼ sec. 18, T. 144 N., R. 86 W.
06354000[2]	Cannonball R. at Breien, N.D., sec. 36, T. 134 N., R. 82 W.

[1]National Pesticide Network stations include quarterly determination of pesticides from whole-water sample and semi-annual determination of pesticides from bed material.

[2]Daily collected sample for temperature and specific conductance.

Sampling Schedule and Parameters

Field Measurements (Monthly)

00010	Temperature	31616	Coliform, fecal
00095	Conductivity	31679	Streptococci, fecal
00400	pH		

Lab Measurements (Monthly)

00955	Silica, dis.	00070	Turbidity, JTU
00915	Calcium, dis.	00950	Fluoride, dis.
00925	Magnesium, dis.	00665	Phosphorus, total
00930	Sodium, dis.	00630	Nitrate + nitrite as N, Tot.
00935	Potassium, dis.	00625	Total Kjeldahl as N
00440	Bicarbonate	00680	Organic carbon, Tot.
00445	Carbonate		Phytoplankton, (3-codominants genera) (Total count)
00945	Sulfate, dis.		
00940	Chloride, dis.	80154	Suspended sediments
70300	Dissolved solids at 180°C	70331	Suspended sediments, sieve diameter, % finer than 0.062 mm.
00900	Total hardness as $CaCO_3$		
00902	Non-carbonate hardness		

U.S. Geological Survey (National Water Quality Accounting Network), Continued

Lab Measurements (Quarterly)

Dissolved	Total		Dissolved	Total	
01002	01000	Arsenic	01051	01049	Lead
01027	01025	Cadmium	01055	01056	Manganese
01034	01030	Chromium	71900	71890	Mercury
01037	01035	Cobalt	01147	01145	Selenium
01042	01040	Copper	01092	01090	Zinc
01045	01046	Iron			

Periphyton (3-codominants genera, Biomass-dry and ash weights)

32228 Chlorophyll a, periphyton
32226 Chlorophyll b, periphyton

Station number	Station name
05113600	Long C. nr Noonan, N. D. NE¼ sec. 1, T. 163 N., R. 96 W.
05114000	Souris R. nr Sherwood, N. D. NW¼SE¼NE¼ sec. 33, T. 164 N., R. 87 W.
05120500	Wintering R. nr Karlsruhe, N. D. on line between secs. 10 & 11, T. 154 N., R. 77 W.
06335000	Lt. Beaver C. nr Marmarth, N. D. NE¼ sec. 7, T. 132 N., R. 106 W.
06339300	Knife R. at Marshall, N. D. NW¼ sec. 10, T. 142 N., R. 82 W.
06342500[1]	Missouri R. at Bismarck, N. D. SE¼NW¼SE¼ sec. 31, T. 139 N., R. 80 W.
06349500	Apple C. nr Menoken, N. D. NW¼NE¼ sec. 9, T. 138 N., R. 79 W.
06349700[1]	Missouri R. nr Schmidt, N. D. SW¼NE¼ sec. 26, T. 137 N., R. 80 W.

[1]Continuous temperature recorder only.

Sampling Schedule and Parameters

Field Measurements
(Monthly)

00400	pH	00095	Specific conductance
00010	Temperature		

Lab Measurements
(Monthly)

00440	Bicarbonate	00935	Potassium, dis.
01020	Boron, dis.	00955	Silica, dis.
00915	Calcium, dis.	00930	Sodium, dis.
00445	Carbonate	00945	Sulfate, dis.
00940	Chloride, dis.	00660	Phosphate, dis.
70300	Residue, dis. 180°C	71851	Nitrate, dis.
00950	Fluoride, dis.	01046	Iron, dis.
00925	Magnesium, dis.	01056	Manganese, dis.

North Dakota State Water Commission

(Specific Conductance Network)

Station number	Station name
05116500	Des Lacs R. at Foxholm, N. D. NW¼NE¼NW¼ sec. 2, T. 156 N., R. 85 W.
05117500	Souris R. ab. Minot, N. D. NW¼NW¼SE¼ sec. 17, T. 155 N., R. 83 W.
05120200	Wintering R. nr Bergen, N. D. on west line of sec. 4, T. 151 N., R. 78 W.
06329597	Charbonneau C. nr Charbonneau, N. D. SW¼ sec. 31, T. 151 N., R. 102 W.
06331000	Lt. Muddy C. bl. Cow C. nr Williston, N. D.
06332000	White Earth R. at White Earth, N. D.
06332520	Shell C. nr Parshall, N. D. SE¼NE¼ sec. 29, T. 153 N., R. 89 W.
06335500	Lt. Missouri R. at Marmarth, N. D. SW¼ sec. 30, T. 133 N., R. 105 W.
06336000	Lt. Missouri R. at Medora, N. D. NE¼ sec. 27, T. 140 N., R. 102 W.
06339100	Knife R. at Manning, N. D. SE¼NW¼ sec. 6, T. 143 N., R. 95 W.
06339490	Elm C. nr Golden Valley, N. D. SE¼NW¼ sec. 23, T. 142 N., R. 90 W.
06339500	Knife R. nr Golden Valley, N. D. SE¼ sec. 34, T. 143 N., R. 90 W.
06340200	W. B. Otter C. nr Beulah, N. D. NW¼NW¼SW¼ sec. 12, T. 142 N., R. 87 W.
06341400	Turtle C. nr Turtle Lake, N. D. N. line of sec. 19, T. 146 N., R. 80 W.
06342100	Square Butte C. Tr. 2 nr Center, N. D. NE¼NE¼ sec. 24, T. 142 N., R. 84 W.
06342260	Square Butte C. bl. Center, N. D. SE¼ sec. 4, T. 141 N., R. 83 W.

North Dakota State Water Commission (Specific Conductance Network),

Continued

Station number	Station name
06342450	Burnt C. nr Bismarck, N. D. SW¼NW¼SW¼ sec. 29, T. 140 N., R. 80 W.
06344600	Green R. nr New Hradec, N. D. on line between sec. 13 & 14, T. 141 N., R. 98 W.
06345000	Green R. nr Gladstone, N. D. SW¼ sec. 36, T. 140 N., R. 95 W.
06345500	Heart R. nr Richardton, N. D. NE¼ sec. 29, T. 138 N., R. 92 W.
06347000	Antelope C. nr Carson, N. D. NW¼NE¼ sec. 8, T. 135 N., R. 87 W.
06348000	Heart R. nr Lark, N. D. NW¼NW¼SW¼ sec. 9, T. 136 N., R. 85 W.
06348500	Sweetbriar C. nr Judson, N. D. SW¼ sec. 14, T. 139 N., R. 84 W.
06349000[1]	Heart R. nr Mandan, N. D. NW¼NE¼ sec. 25, T. 139 N., R. 82 W.
06350000	Cannonball R. at Regent, N. D. NE¼NE¼ sec. 13, T. 134 N., R. 95 W.
06351000	Cannonball R. bl. Bentley, N. D. SW¼SW¼ sec. 6, T. 133 N., R. 90 W.
06351680	White Butte F. Cedar C. nr Scranton, N. D. NW¼ sec. 21, T. 133 N., R. 98 W.
06352000	Cedar C. nr Haynes, N. D. W½ sec. 20, T. 131 N., R. 94 W.
06352500	Cedar C. nr Pretty Rock, N. D. S½ sec. 33, T. 130 N., R. 89 W.
06353000	Cedar C. nr Raleigh, N. D. NE¼SE¼ sec. 8, T. 130 N., R. 85 W.

[1]"Daily" temperature and conductance.

North Dakota State Water Commission (Specific Conductance Network),

Continued

Sampling Schedule and Parameters

Field Measurements
(Monthly)

00010	Temperature	00095	Specific conductance

Lab Measurements
(semi-annually)

00440	Bicarbonate	00935	Potassium, dis.
01020	Boron, dis.	00955	Silica, dis.
00915	Calcium, dis.	00930	Sodium, dis.
00940	Chloride, dis.	00945	Sulfate, dis.
00445	Carbonate, dis.	00660	Phosphate, dis.
70300	Residue, dis. 180°C	71851	Nitrate, dis.
00950	Fluoride, dis.	01046	Iron, dis.
00925	Magnesium, dis.	01056	Manganese, dis.

U.S. Army Corps of Engineers - St. Paul

Station number	Station name
05116000	Souris R. nr Foxholm, N.D., SW¼SE¼ sec. 34, T. 157 N., R. 84 W.

Sampling Schedule and Parameters

Field Measurements (Monthly)

00010	Temperature	00300	Dissolved oxygen
00095	Conductivity, field	31616	Fecal coliform
00400	pH, field	31501	Total coliform

Lab Measurements (Monthly)

00440	Bicarbonate	00945	Sulfate, dis.
00915	Calcium, dis.	00310	Biochemical Oxygen Demand
00940	Chloride, dis.	00340	Chemical Oxygen Demand
70301	Dissolved solids	00070	Turbidity
00950	Fluoride, dis.	00080	Color
00900	Hardness	00608	Ammonium as N
01046	Iron, dis.	00625	Nitrogen, TOT. KJD
00925	Magnesium, dis.	00671	Phosphorus, dis.
01056	Manganese, dis.	00665	Phosphorus, total
00631	Nitrate + Nitrite, dis.	38260	Detergents (MBAS)
00660	Ortho Phosphate, dis.		Phytoplankton (3-codominant genera) (Total count)
00935	Potassium, dis.		
00955	Silica, dis.	80154	Concentration, susp. sed.
00930	Sodium, dis.	80155	Discharge, susp. sed.

Semi-annually suspended sediment and bed material are analyzed for particle size.

(Quarterly)

	Periphyton (3-codominant genera, Biomass-dry and ash weights)	01037	Cobalt, total
		01042	Copper, total
		00720	Cyanide, total
	Macronivertebrates (Identification, Diversity Index, Biomass-wet weights)	01045	Iron, total
		01051	Lead, total
		01132	Lithium, total
		01055	Manganese, total
00680	Organic carbon, total	71900	Mercury, total
00300	Dissolved oxygen	01062	Molybdenum, total
01105	Aluminum, total	01067	Nickel, total
01002	Arsenic, total	01147	Selenium, total
01007	Barium, total	01077	Silver, total
01012	Beryllium, total	01082	Strontium, total
01022	Boron, total	01087	Vanadium, total
01027	Cadmium, total	01092	Zinc, total
01034	Chromium, total		

Annually bed material is analyzed for minor elements as listed above.

<u>Pesticides of Whole Water</u>
(Semi-annual)

39360	DDD	39350	Chlordane
39365	DDE	39540	Parathion
39330	Aldrin	39600	Methyl Parathion
39370	DDT	39530	Malathion
39380	Dieldrin	39570	Diazinon
39390	Endrin	39730	2, 4-D
39410	Heptachlor	39740	2, 4, 5-T
39420	Heptachlor, Epox.	39760	Silvex
39340	Lindane		

<u>Pesticides of Bed Materials</u>
(Annual)

39363	DDD	39351	Chlordane
39368	DDE	39541	Parathion
39333	Aldrin	39601	Methyl Parathion
39373	DDT	39531	Malathion
39383	Dieldrin	39771	Diazinon
39393	Endrin	39731	2, 4-D
39413	Heptachlor	39741	2, 4, 5-T
39423	Heptachlor, Epox.	39761	Silvex
39343	Lindane		

U.S. Bureau of Land Management

Station number	Station name
06349930	Coal Bank C.nr Havelock, N.D., NW¼SW¼ sec. 34, T. 135 N., R. 96 W.
06355310	Buffalo C.trib. nr Gascoyne, N.D., SE¼NE¼ sec. 3, T. 130 N., R. 99 W.
06339560	Brush C. nr Beulah, N.D., NW¼SW¼NW¼ sec. 25, T. 143 N., R. 88 W.

Sampling Schedule and Parameters

Field Measurements
(Monthly)

00300	DO	00095	Conductance
00400	pH	00400	Bicarbonate
00010	Temp.	00445	Carbonate

Lab Measurements
(Monthly)

00915	Calcium, dis.	01020	Boron, dis.
00925	Magnesium, dis.	70300	Dissolved solids
00930	Sodium, dis.	00625	KGN, total
00935	Potassium, dis.	00610	NH_4, total
00955	Silica, dis.	00310	BOD
00940	Chloride, dis.	00070	Turbidity
00945	Sulfate, dis.	00681	Organic Carbon, dis.
00631	Nitrate-Nitrite, total	00689	Organic Carbon, susp.
00665	Phosphate, total		

(Quarterly)

Dissolved	Total		Dissolved	Total	
01000	01002	Arsenic	01056	01055	Manganese
01010	01012	Beryllium	71890	71900	Mercury
01025	01027	Cadmium	01060	01062	Molybdenum
01030	01034	Chromium	01066	01067	Nickel
01040	01042	Cooper	01145	01147	Selenium
01049	01051	Lead	01085	01087	Vanadium
01046	01045	Iron	01106	01105	Aluminum
01130	01132	Lithium	01090	01092	Zinc

U.S. Bureau of Land Management, Continued

Annual (Low Flow)

80030	Gross Alpha, dis.
80050	Gross Beta, dis.
80040	Gross Alpha, susp.
80060	Gross Beta, susp.
09511	Radium
	Uranium, flourmetric

SEDIMENT STATIONS

ND-004

Objectives

To provide a national bank of sediment data for use in broad Federal and State planning and action programs and to provide data for Federal management of interstate and international waters.

Cooperators

State International Commission, U.S. Army Corps of Engineers, and U.S. Bureau of Land Management.

Reports

Data are published in the annual series, "Water Resources Data for North Dakota, Part 2 - Water-Quality Records" and in the Water-Supply Paper series "Quality of Surface Waters of the United States" (parts 5 and 6).

Sediment Stations

Station number	Station name	Cooperator
Part 5		
114000	Souris R.nr Sherwood	WWT
116000	Souris R.nr Foxholm	CE-S
Part 6		
332515	Bear Den Creek near Mandaree (hydrologic benchmark station)	FED
337000	Little Missouri R.nr Watford City	NASQAN, CE-O
338490	Missouri R. at Garrison Dam	NASQAN
339560	Brush Creek near Beulah	BLM
340500	Knife R.at Hazen	NASQAN
342500	Missouri R.at Bismarck	CE-O
349000	Heart R.at Mandan	CE-O
349930	Coal Bank Creek nr Havelock	BLM
354000	Cannonball R.at Breien	NASQAN, CE-O
355310	Buffalo Creek trib. nr Gascoyne	BLM

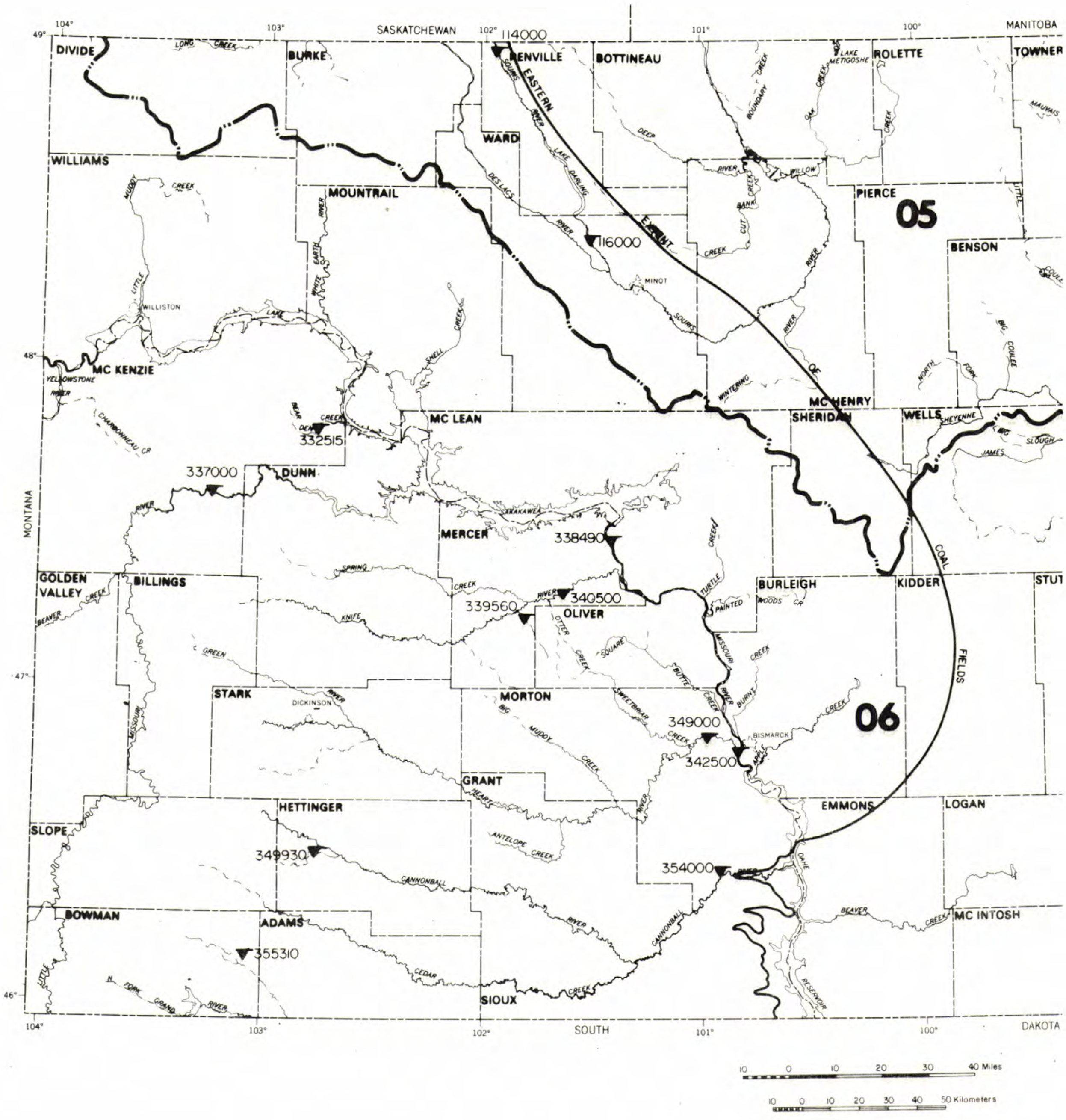


Figure 24.--Locations of sediment stations.

COUNTY GROUND-WATER STUDIES

ND-018-069

County ground-water studies are underway or have been completed in nearly all of the counties within the Fort Union coal region. The studies are made in cooperation with the North Dakota State Water Commission, North Dakota Geological Survey, the counties, and Federal agencies having responsibility for administrating any public lands that may be included in the counties. These agencies are primarily the U.S. Forest Service and the U.S. Park Service.

The purpose of the studies is to determine the quantity and quality of ground water available for domestic, municipal, industrial, and irrigation uses. The specific objectives of each project are to: (1) determine the location, extent, and nature of the major aquifers and confining beds, (2) evaluate the occurrence and movement of ground water, including the sources of recharge and discharge, (3) estimate the quantities of water stored in the aquifers, (4) estimate the potential yields of wells tapping the major aquifers, and (5) determine the chemical quality of ground water.

The results of each study are published in three reports, (1) geology, (2) ground-water basic data, and (3) ground-water resources.

The following counties and projects have been completed or are in progress.

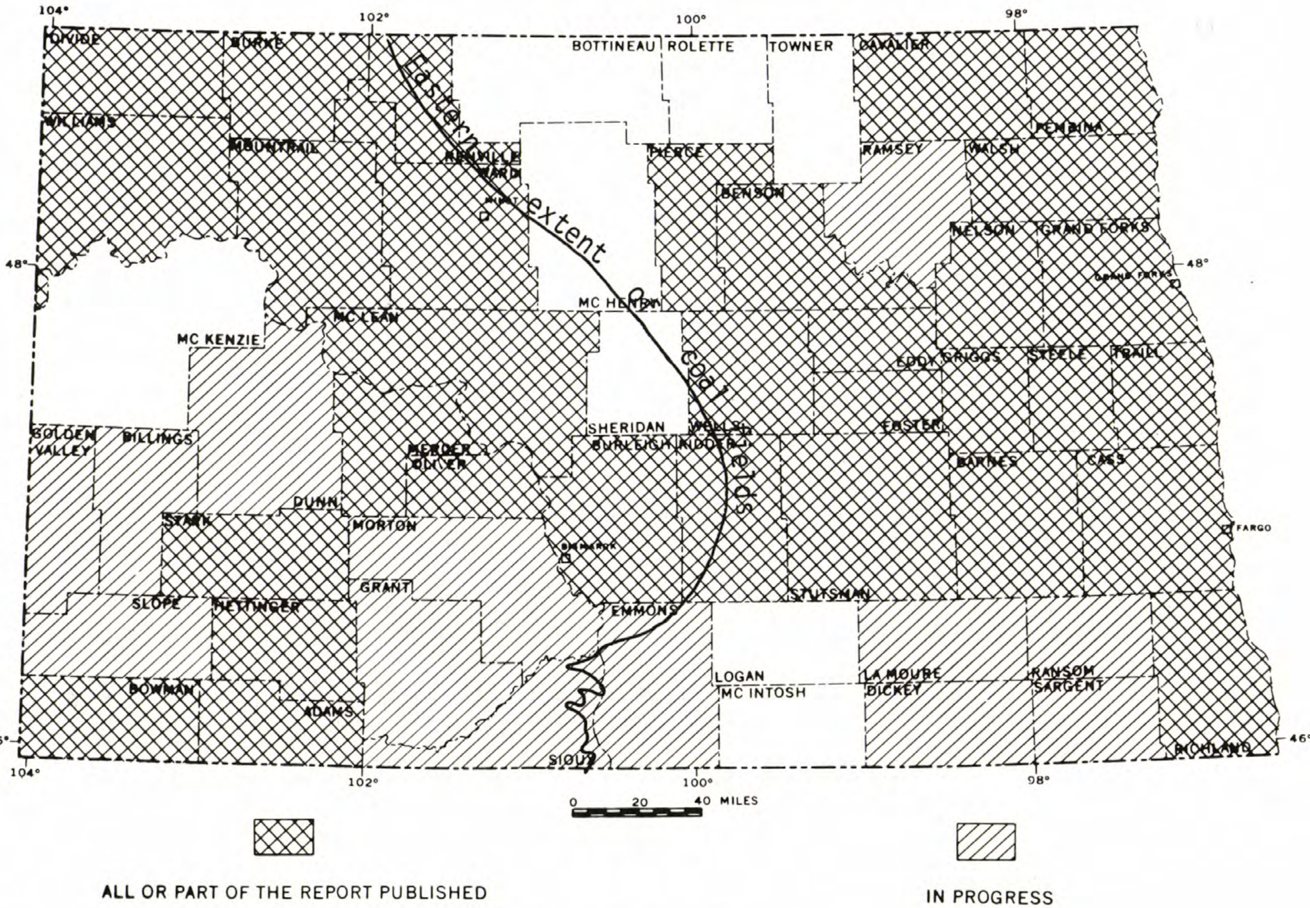


Figure 25.--Locations of county ground-water studies.

Project number	Counties	Reports published
ND-018[1]	Kidder	Parts 1, 2, and 3
ND-028[1]	Burleigh	Parts 1, 2, and 3
ND-032[1]	Divide	Parts 1, 2, and 3
ND-034[1]	Ward and Renville	Parts 2 and 3
ND-035[1]	Williams	Parts 1, 2, and 3
ND-041[1]	Burke and Mountrail	Parts 1, 2, and 3
ND-044[1]	McLean	Parts 1, 2, and 3
ND-045[1]	Mercer and Oliver	Parts 1, 2, and 3
ND-046	Hettinger and Stark	Part 2
ND-059	Dunn	None
ND-060	Emmons	None
ND-061	Grant and Sioux	None
ND-063	Morton	None
ND-069	Billings, Golden Valley, and Slope	None

[1]Completed, others are in progress.

SHALLOW GROUND-WATER STUDY (GASCOYNE LIGNITE MINE)

ND-040

This investigation is a study of the shallow aquifers and water quality at the Gascoyne lignite mine in Bowman County, North Dakota, to determine the effects of lignite mining upon the shallow ground-water aquifers. Twenty-three test holes ranging in depth from 75 to 450 feet have been drilled, and water samples have been collected for chemical analysis. The test wells are currently being monitored. Water samples have been collected from the mine lakes and the stream draining the mine area.

Cooperators

Northern Great Plains Resources Group and the U.S. Bureau of Land Management.

Reports

"Shallow Ground Water in Selected Areas in the Fort Union Coal Region," U.S. Geological Survey open-file report 74-371, 72 p.

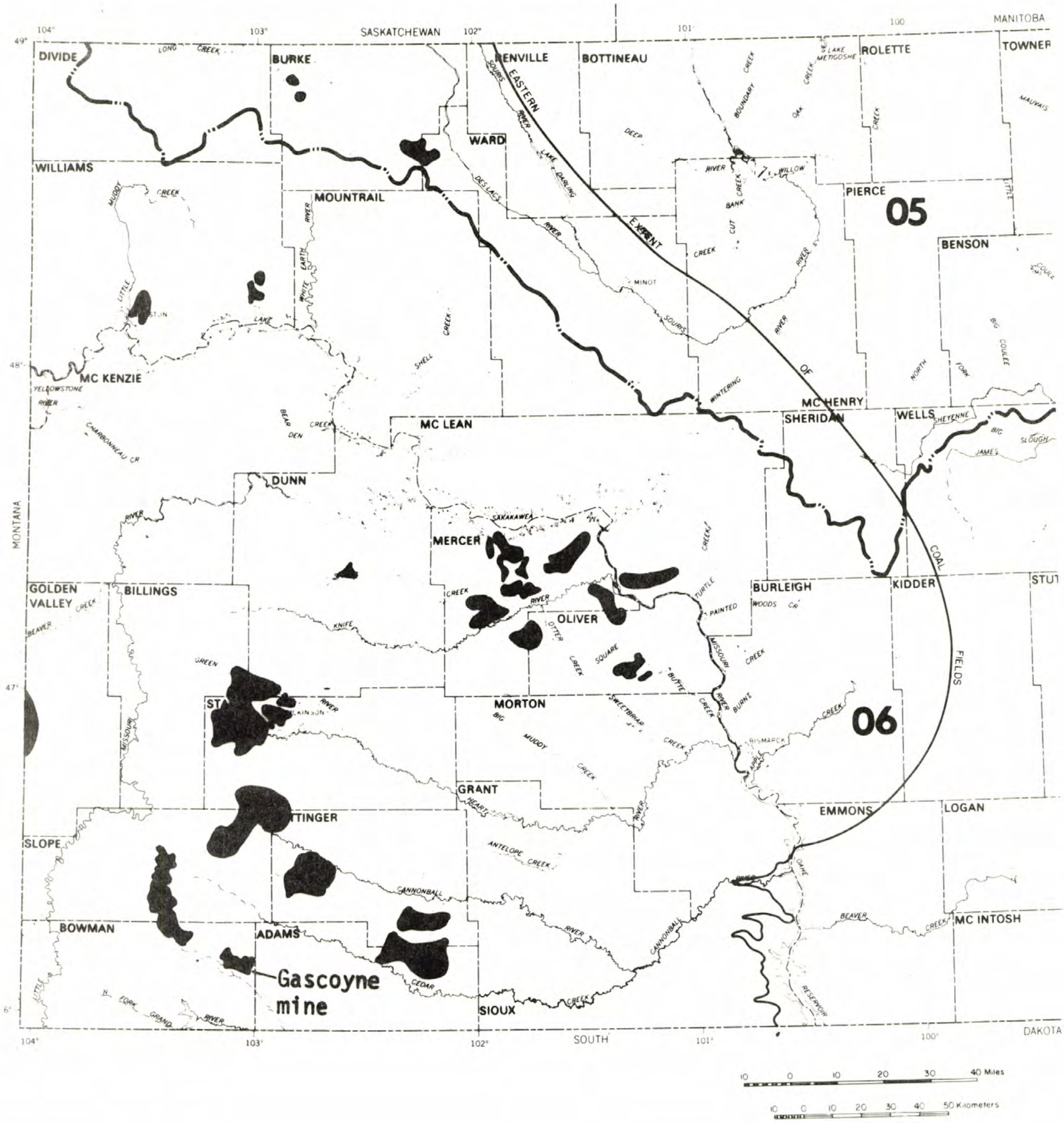


Figure 26.--Locations of major strippable lignite deposits and Gascoyne mine.

HYDROLOGIC CHANGES DUE TO LIGNITE MINING IN NORTH DAKOTA

PART 1 - RECONNAISSANCE OF STRIPPABLE LIGNITE DEPOSITS

ND-070

The objectives are to define for each strippable lignite deposit (as identified on the accompanying map) the following: (1) A summary of local geologic conditions, (2) description of the local ground-water flow system, (3) flow characteristics of streams, (4) chemical quality of water from streams, lakes, and aquifers, (5) stream sediment loads, and (6) recommendations for more intensive hydrologic studies in probable problem areas.

The project is funded by the U.S. Geological Survey.

AVAILABILITY OF GROUND WATER FROM THE CRETACEOUS AND TERTIARY AQUIFERS OF THE FORT UNION COAL REGION

ND-071

This investigation is a compilation of existing data from South Dakota, North Dakota, Montana, and Wyoming of the Tertiary rocks and aquifers overlying the Pierre Shale. The objectives of the investigation are: (1) to determine the location, extent, and nature of the aquifers and confining beds, (2) to evaluate the occurrence and movement of ground water, including the sources of recharge and discharge, and (3) to determine the chemical quality of the ground water.

The project is funded by the U.S. Geological Survey.

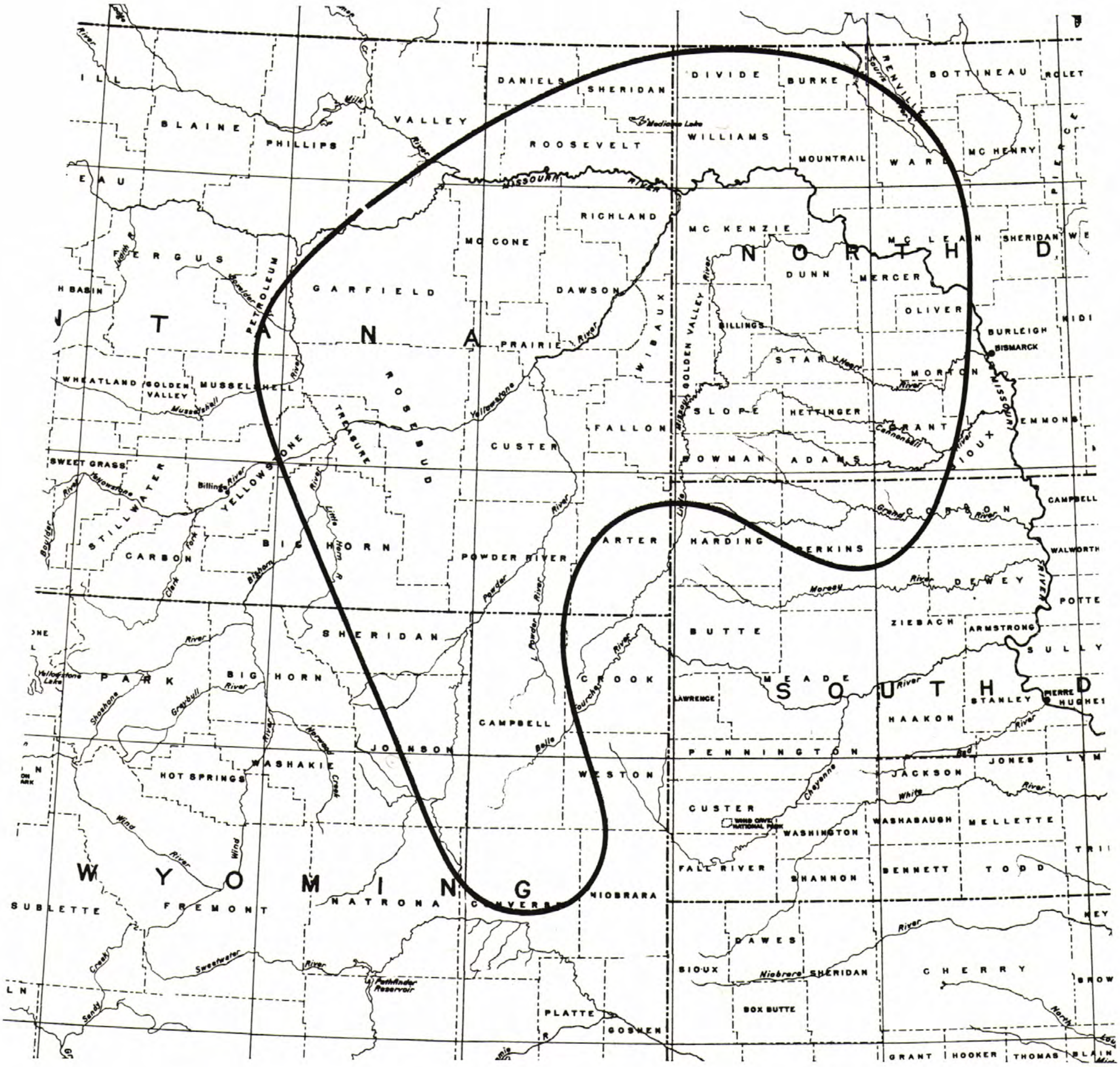


Figure 27 .--Location of study area for ND-071.

Deep Ground Water (Madison Limestone)

A plan of study is being prepared for a quantitative investigation of the Madison Limestone aquifer system and associated deep ground water beneath northeastern Wyoming, northwestern South Dakota, and southeastern Montana. Funds to develop the plan of study are provided by the Old West Regional Commission.

The quantitative investigations will include drilling and hydraulic testing. These activities will be expensive due to the relatively great depths involved. In order to minimize costs, geophysical data are being obtained and analyzed in an effort to gain some understanding of fracture and secondary permeability patterns in advance of drilling. Current efforts also include the construction of a digital model of the system to test relative sensitivities of the model components and to also guide data collection.

The plan of study is to be completed by summer 1975 and will be published.

Complementary parts of the investigation are described on pages 32 and 55 of this report.

Additional information may be obtained from:

Regional Hydrologist, Central Region   Telephone: (303) 234-3661
U.S. Geological Survey
Water Resources Division
Building 25, Denver Federal Center
Lakewood, Colorado 80225

MONTANA

Otter Creek EMRIA Study Site near Ashland, Montana

(Project CR75-104FI)

Funds: U.S. Geological Survey and

Bureau of Land Management

The Public Lands Hydrology Program is conducting studies on the 1,920-acre Otter Creek EMRIA Study Site near Ashland, Montana (see figure 17) to provide data for evaluating the reclamation potential of that area after surface mining for coal.

A map showing annual source-area sediment yields is being prepared and the relations of sediment yield to percent bare soil and average watershed slope will be described. Estimates will be made of the amount of sediment contributed by the study-site area to Otter Creek.

Estimates of peak flows with recurrence intervals of 2, 5, 10, 25, and 50 years were made for various ephemeral streams on and near the study site using channel width and depth measurements. The curves used for flow estimates were based on records from crest-stage gages in southeastern Montana. Several channel cross-sections downstream from the strippable coal deposits were surveyed and monumented. These will be resurveyed periodically when the area is mined, thus monitoring the effects of mining and subsequent rehabilitation on channel erosion and deposition.

A map of the vegetation-soil units on the site was prepared from aerial photographs and on site observations. Vegetation, mulch, and rock cover and percent bare soil were measured in each unit. Internal-water stress in the woody plants present was also measured.

Soil samples to the depth of active rooting were obtained in each vegetation-soil unit. The depth of rooting was used along with moisture-retention forces and bulk density of the soil to estimate the average annual soil-moisture storage under normal precipitation conditions. The weight of roots, the electrical conductivity, pH and relative erodibility were measured for each soil sample in the laboratory. Progress is being made in methods for estimating the moisture-retention capacity, the infiltration rate, and the bulk density of the disturbed soils after mining and regrading. These data will be useful in selecting suitable vegetation species for seeding the overburden topped with available soil and in determination of whether or not furrowing, pitting or terracing will be needed to enhance vegetation establishment and to minimize runoff and erosion.

Additional information on this study may be obtained from Richard F. Hadley, Lakewood, Colorado, Telephone No. (303) 234-4175.

Occurrence of Ground Water and Effects of Surface Mining of Coal on Shallow Aquifers in the Decker Area, Big Horn County, Montana

(Project CR74-093F)

Funds: U.S. Geological Survey

A study near Decker of general conditions of ground-water occurrence in shallow sandstone and coal aquifers in the Wasatch and Fort Union Formations is nearing completion. The study encompasses an area of about 150 square miles and extends about 9 miles on either side of the north-flowing Tongue River (see Figure 17). The area includes one active surface coal mine and two proposed surface mines. Objectives of the study are:

A. To complete a data inventory of existing wells and springs.
B. To establish baseline conditions from which to appraise changes in ground-water flow patterns and water quality as a result of mining and rehabilitation activities.
C. To show areas of ground-water recharge and discharge and direction of ground-water movement.
D. To show effects of geologic structure (faulting and fracturing) in ground-water movement.
E. To assess the hydrologic effects of mining to date.
F. To predict the probable hydrologic effects of mining at the two proposed mine sites.

Additional information on this study may be obtained from Richard F. Hadley, Lakewood, Colorado, Telephone No. (303) 234-4175.

Wyoming

Hanna Basin EMRIA Site

(Project CR75-104FI)

Funds: U.S. Geological Survey and

Bureau of Land Management

The Public Lands Hydrology Program is conducting studies in cooperation with the Bureau of Land Management on the 2,240-acre Hanna Basin EMRIA Study Site near Seminoe Reservoir in Wyoming (106°47'30" long., 42° lat.). This investigation is to provide data for evaluating the reclamation potential of lands that will be disturbed by surface mining for coal.

A map showing present annual source-area sediment yields was prepared and the relations of sediment-yield estimates to amount of bare soil and average land slope were developed. Estimates of the amount of sediment contributed from the study site to Seminoe Reservoir were also made. In addition, estimates of sediment yield that may occur from presumed overburden areas were made for three periods: (1) during mining, (2) during a 5-year rehabilitation period after the overburden has been graded to slopes less than 3:1 and seeded to perennial grasses, and (3) after the 5-year rehabilitation period. The conditions at a nearby surface mine where some rehabilitation work has been done was used as a basis for the conditions of the overburden during the above-mentioned periods.

A map of the vegetation-soil units on the site was prepared from aerial photographs and on-site observations. Vegetation, mulch, and rock cover and percent bare soil were measured in each unit. Internal-water stress in the woody plants present was also measured.

Soil samples to the depth of active rooting were obtained in each vegetation-soil unit. The depth of rooting was used along with moisture-retention forces and bulk density of the soil to estimate the average annual soil-moisture storage under normal precipitation conditions. The weight of roots, the electrical conductivity, pH and relative erodibility were measured for each soil sample in the laboratory. Progress is being made in methods for estimating the moisture-retention capacity, the infiltration rate, and the bulk density of the disturbed soils after mining and regrading. These data will be useful in selecting suitable vegetation species for seeding the overburden topped with available soil and in determination of whether or not furrowing, pitting or terracing will be needed to enhance vegetation establishment and to minimize runoff and erosion.

Observations of reclamation practices will continue during the mining and post-mining period and compared with the baseline data collected during the first year of studies.

Sediment Yield Estimates

(Project CR75-104FI)

Funds: U.S. Geological Survey and

Bureau of Land Management

The disturbance of land that will accompany the surface mining of coal in Campbell County, Wyoming will undoubtedly change the erosion and sediment yield patterns locally in the vicinity of mines. There are few suspended-sediment stations in this area (see Figure 8) and, therefore, little baseline information from which to assess possible changes. Using information gathered at small stock reservoirs of sediment deposition and observations of drainage basins characteristics a reconnaissance sediment-yield map is being made of the part of Campbell County shown on figure 8.

Simulation of rainfall on mining areas

(Project CR74-092FI)

Funds: U.S. Geological Survey and

Bureau of Land Management

During 1974 simulated rainfall was applied to revegetated spoils piles and nearby undisturbed natural ground at two mines in Wyoming. These were the Pacific Power and Light mine at Glenrock and the Bighorn mine near Sheridan. Runoff and erosion from the areas was compared and related to mean slope, percentage of clay in the top 10 cm, and amount of vegetation.

Occurrence of Ground Water in

Southeastern Campbell County, Wyoming

(Project CR74-093F)

Funds: U.S. Geological Survey

A study of general conditions of ground-water occurrence in shallow sandstone and coal aquifers in the Wasatch and Fort Union Formations in southeastern Campbell County is about 20 percent completed. The study, which encompasses an area of about 1,000 square miles, (figure 3) includes no active surface coal mines. The area does include several proposed mines, however, and should include a number of active mines in the next decade. Objectives of the study are:

A. To complete a data inventory of existing wells and springs.
B. To establish baseline conditions from which to appraise

changes in ground-water flow patterns and water quality as a result of mining and rehabilitation activities.

C. To show areas of ground-water recharge and discharge and direction of ground-water movement.

D. To show any existing areal patterns of water quality.

E. To predict the probable hydrologic effects of mining at proposed mine sites.

Additional information on this study may be obtained from Richard F. Hadley, Lakewood, Colorado, Telephone No. (303) 234-4175.

RESEARCH ACTIVITIES, WATER RESOURCES DIVISION, GEOLOGICAL SURVEY

AS DIRECTLY RELATED TO COAL AND OIL-SHALE MINING AND PROCESSING

Microbial controls on leaching

A grant to Montana State University is in effect to study the release of inorganic solutes in coal spoils as a result of microbial processes. Studies are being made of the microbial growth inhibiting or prompting properties of earth materials and the influence of micro-organisms on the breakdown and dissolution of earth materials.

Kenneth Temple, Department of Microbiology, Montana State University
Bozeman, Montana
Telephone: FTS (406) 587-4511 ask Oper. for 994-2901

Background geochemistry of Western energy resource areas

This project represents the aqueous phase of a total broad-brush geochemical background study. The work currently is on trace elements in the Northern Great Plains Region and will be extended to other areas of the Rocky Mountain Region by end of Fiscal '76. A standardized analytical schedule for water and sediment is being devised for recommendation to quality-of-water programs related to coal and oil-shale mining and processing.

Gerald L. Feder, Lakewood, Colorado
Telephone: FTS (303) 234-2404
(In association with Jon Connor, Lakewood, Colorado
Telephone: FTS (303) 234-3715)

Geochemistry interactions between coal and water

The reasons for sulfate loss when ground water moves through a coal seam will involve laboratory leaching experiments to investigate sulfate adsorption by coal. Current work is in the analysis of water samples collected from the Fort Union Formation for dissolved gases.

Donald W. Fisher, Reston, Virginia
Telephone: FTS (703) 860-6951

Borehole geophysics

This project is funded to develop hardware and data interpretation techniques, including computer programs, for downhole logging. A focused density tool has recently been developed, and work is under way on a computer program to determine the mineralogy, porosity, fluid, and strength characteristics for coal by geophysical methods. Future plans for geophysical logging will be in wells located near Gillette, Wyoming, that are completed in the Madison Limestone.

Scott Keys, Lakewood, Colorado
Telephone: FTS (303) 234-2617

Organic solutes in water

The development of new analytical methods which classify, characterize, and extract organic solutes dissolved in water has been developed. The methodology will be applied to surface and ground water in Western coal and oil-shale regions to quantify the dissolved organic material in advance of coal or oil-shale mining or processing. Research is also under way to characterize organics in bed sediments. The work will ultimately focus on waste management of organic residuals generated by retorting oil shale.

Jerry A. Leenheer, Lakewood, Colorado
Telephone: FTS (303) 234-2404

Residual-discharge modeling

A residual-discharge model is being developed for high BTU coal gasification, coal strip mines, and coal-fired steam generating plants planned for the Yampa River basin in Colorado. Planned research will concern modification of residual discharges by changing coal input quality and plant technology. The impact of residual discharges will be assessed by ecological modeling.

Nicholas C. Matalas, Reston, Virginia
Telephone: FTS (703) 860-6927

River bed forms as related to coal development

Beginning in Fiscal '76, a study will be made of sediment sources, sediment movement, and changes in river channels which occur before and after intensive coal development. The study will deal primarily with the Powder River area in Wyoming and Montana.

Robert H. Meade, Lakewood, Colorado
Telephone: FTS (303) 234-2320

Well drilling

Studies are being made and equipment developed to improve drilling, sampling, and testing techniques for wells in coal beds. The studies include design of packers, methods of QW sampling, and methods of head testing, with emphasis on wells to be completed in multiple aquifers. The work thus far has been in Montana and in Fiscal '76 will be expanded to Wyoming.

Eugene Shuter, Lakewood, Colorado
Telephone: FTS (303) 234-2615