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Peak Stages from Backwater Conditions at Streamflow-Gaging Stations in and near South Dakota through Water Year 2001

Open-File Report 2006-1395

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

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DIRK KEMPTHORNE, Secretary

U.S. Geological Survey
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Contents

Abstract....1
Introduction....1
Peak Stages due to Backwater Conditions....1
References Cited....5
Supplemental Information....7
Section A. Information for Gaging Stations....8
Section B. Plots of Annual Peak Stage and Stage at Peak Discharge....24

Figures

1. Gaging stations in and near South Dakota for which peak-stage data are presented....2
2. Relative frequency of backwater peak stages....3
3. Percent of backwater peak stages exceeding established flood stage....4
A1. Plots of annual peak stage and stage at peak discharge....25

Table

A1. Information for gaging stations with annual peak stages from backwater conditions, through water year 2001....9

Conversion Factors

Multiply	By	To obtain
	Length	
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
	Flow rate	
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

Horizontal coordinate information is referenced to the North American Datum of 1983 (NAD 83).

A water year is the 12-month period, October 1 through September 30, and is designated by the calendar year in which it ends. Thus, the water year ending September 30, 2001, is called the "2001 water year."

Peak Stages from Backwater Conditions at Streamflow-Gaging Stations in and near South Dakota through Water Year 2001

By Ryan F. Thompson

Abstract

Stream stages associated with the annual peak discharge are presented for 182 streamflow-gaging stations in and near South Dakota. The peak stage at a station can occur as the result of the annual maximum discharge, but also as the result of backwater conditions. Backwater, often caused by ice, can produce a peak stage higher than the stage coincident with annual maximum discharge. The U.S. Geological Survey has cooperated with the South Dakota Department of Transportation to prepare this report, which provides a summary of peak-stage data through water year 2001 for gaging stations in and near South Dakota where annual peak stages resulting from backwater conditions have exceeded stages associated with annual peak discharge by as much as several feet. Where applicable, data summaries include the flood stage that is assigned by the National Weather Service.

Introduction

The U.S. Geological Survey (USGS) collected peak-flow and stage data for many years at numerous streamflow-gaging stations in and near South Dakota. Backwater conditions are conditions that temporarily impede the flow of water in the channel. Backwater, often caused by ice, can produce a peak stage higher than the stage coincident with annual maximum discharge. Many of the reported annual peak stages have resulted from backwater conditions in the vicinity of gaging stations, and such stages have exceeded stages associated with annual peak discharges by as much as several feet at some gaging stations.

Annual maximum instantaneous (peak) discharges and stages for continuous-record and partial-record streamflow gaging stations in and near the State historically have been reported in a series of annual statewide "Water Resources Data" reports for South Dakota for water years 1966–2001 (U.S. Geological Survey, 1967–2002). For water years 1961–1965, streamflow records for South Dakota were included in joint annual reports for North Dakota and South Dakota (U.S. Geological Survey, 1962–1966). Prior to water year 1961, streamflow records for South Dakota were published in a series of USGS Water-Supply Papers that contained streamflow records for the Missouri River Basin (U.S. Geological Survey, 1959, 1964).

The South Dakota Department of Transportation (SDDOT) uses peak-flow data for many purposes, and more detailed knowledge of the effects of backwater conditions at gaging stations could have utility for various applications. For example, if a bridge is to be placed over a stream that is known to commonly have backwater-influenced peak stages that are much higher than stages associated with peak flow, the bridge may be designed with countermeasures to help prevent ice jams on piers, or additional freeboard to low steel. The USGS, in cooperation with SDDOT, prepared this report to provide a summary of peak-stage data through water year 2001 for gaging stations in and near South Dakota where annual peak stages resulting from backwater conditions have exceeded stages associated with annual peak discharge.

Peak Stages due to Backwater Conditions

For purposes of USGS streamflow gaging, backwater typically refers to any condition that temporarily impedes the flow of water in a channel, and subsequently results in temporary influence of the stage-discharge relation at a gaging station. Peak stage can exceed the stage associated with annual peak discharge within the same year at any given gaging station for several reasons. The most common reason is backwater. Although there are conditions other than backwater that can cause a stage within a given water year to exceed the stage associated with peak discharge, these conditions are rather uncommon. These uncommon conditions can occur when there is a change in control at a gaging station, or when dikes are built, rebuilt, or raised. For the purposes of this report, annual peak stages greater than the stage at annual peak discharge were assumed to be influenced by backwater conditions.

Stages associated with annual peak discharge were exceeded within the same year by higher stages resulting from backwater conditions at 182 streamflow-gaging stations in and near South Dakota (fig. 1). Selected data regarding peak stages for these gaging stations through water year 2001 are summarized in table A1 in the Supplemental Information section of this report. One of the columns in this table provides the percentage of peak stages from backwater conditions that have exceeded stages associated with annual peak discharge for each gaging station. These percentages are shown in figure 2.

Plots showing annual peak stages and stages associated with annual peak discharge are presented in Section B of the Supplemental Information section. Although annual peak-flow data are compiled by water year, which runs from October 1 through September 30, the plots are shown by calendar year. These plots show that annual peak stages from backwater conditions can exceed stages associated with annual peak discharge by as little as a few hundredths of a foot to as much as several feet for some gaging stations. Where applicable, these plots also show the flood stage for the site assigned by the National Weather Service. Additional details regarding flood stages and percentages of backwater peaks that exceed flood stages are provided in table 1, and the percentages are shown in figure 3.

Burr and Korkow (1996) provided tables of peak discharge and stage data for 250 gaging stations in South Dakota with 10 or more years of record through water year 1994, which included many of the gaging stations that are considered in this report. These tables provide specific dates and other details regarding annual peak discharges and associated stages, smaller peak discharges that comprise a "partial-duration flood series," and annual peak stages that exceed stage associated with annual peak discharge. Current data regarding annual peak discharges and associated stages can be obtained by accessing the Web interface for the USGS National Water Information System (NWISWeb) at *http://nwis.waterdata.usgs.gov/sd/nwis/peak*. Data sets provided include only data regarding annual peak discharges and associated stages for gaging stations in and near South Dakota. Additional details can be obtained upon request by contacting the USGS South Dakota Water Science Center.

Backwater conditions can be caused by a variety of factors including ice formation, ice jams or debris jams, sediment or leaf deposition, beaver dams, plant growth, or tributary

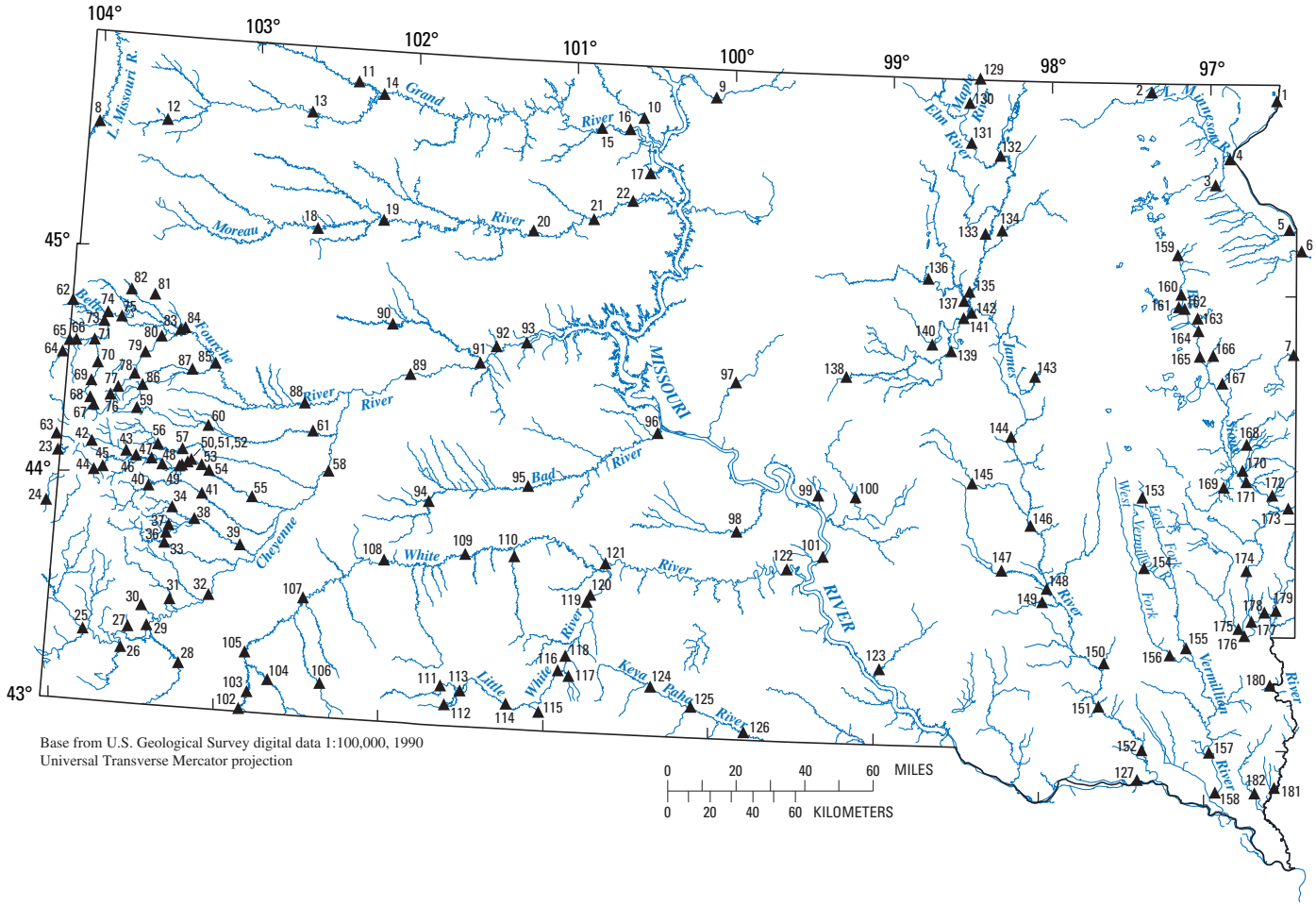

Figure 1. Gaging stations in and near South Dakota for which peak-stage data are presented.

inflows within a reach. Some of these factors may have negligible effects during high-flow conditions; however, notation of backwater conditions is independent of the magnitude of a flow event, and annual peak discharges for many years at many locations in South Dakota may be zero-flow or very low flow. Backwater conditions can be widespread throughout a reach of a river or very localized and restricted to the immediate vicinity of a gaging station. For example, ice jamming can be widespread within a reach, or can be restricted to a bridge in the vicinity of a gaging station. More detailed information regarding backwater conditions at specific gaging stations generally can be obtained from examination of data provided in the annual statewide "Water Resources Data" reports for South Dakota described previously.

Various procedures related to database handling or coding of peak-flow data also have potential to affect the data sets that are presented in this report. The following paragraphs include brief examples of the peak-flow data sets for several of the gaging stations and associated streams addressed within this report, with a purpose of providing a brief overview of some of the factors that affect backwater conditions at gaging stations in and near South Dakota and factors that have affected reporting of backwater conditions. Examples are presented according to the downstream ordering system used by USGS, which determines the ordering of stations in table A1 and the plots in Supplemental Information Section B.

The first gaging station considered is station 05050000 (Bois de Sioux River near White Rock), which is located in northeastern South Dakota (fig. 1, map number 1). Table A1 indicates that peak annual stages from backwater conditions have exceeded peak stages associated with annual peak discharge for 15 of 59 years of record, or 25.4 percent of the

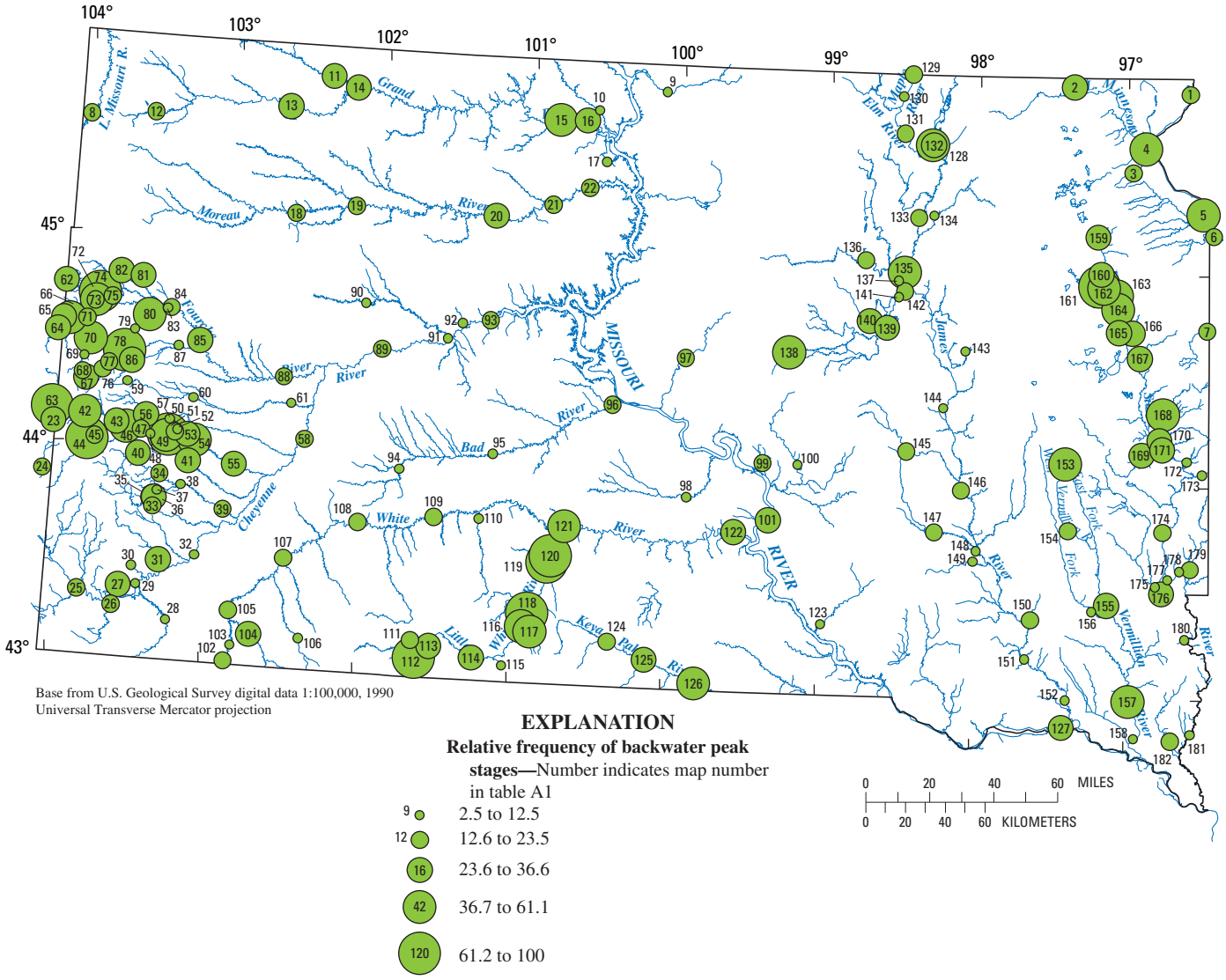

Figure 2. Relative frequency of backwater peak stages.

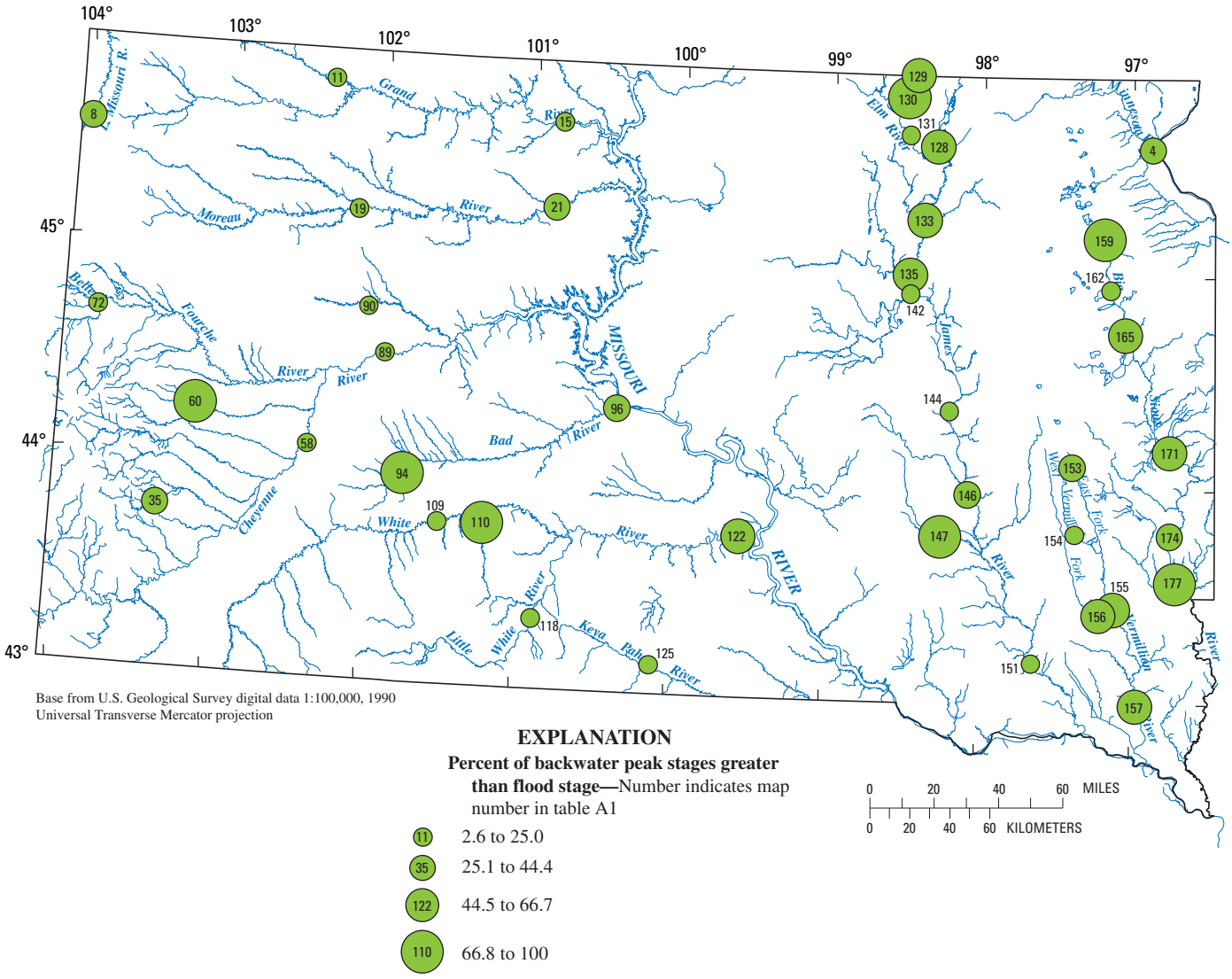

Figure 3. Percent of backwater peak stages exceeding established flood stage.

time. None of these backwater peak stages have exceeded the flood stage of 15 feet assigned for this site by the National Weather Service. The plot of annual peak stages for this site (Supplemental Information Section B) illustrates a relatively infrequent circumstance where peak annual stage is documented, but the smaller stage associated with annual peak discharge is not populated in the USGS peak-flow database. This is fairly common when the associated hydrographs are very flat and maximum instantaneous discharge approximates average daily discharge, as was documented for water years 1996 and 1998 in the "Water Resources Data" reports for South Dakota for these water years (U.S. Geological Survey, 1997, 1999). A similar circumstance can occur when the annual peak discharge is coded as an estimate and the stage at peak discharge is undocumented, as was done for station 05290000 (Little Minnesota River near Peever) for 1950 (Burr and Korkow, 1996). A fairly unique example is water year 1976 for station 06355500 (North Fork Grand River near White Butte), where an annual peak discharge is noted as a maximum daily average (Burr and Korkow, 1996); however, an annual peak stage associated with the maximum daily average discharge is not documented.

The data shown in the plots in Supplemental Information Section B are for the period of available peak-stage record for each gaging station, through water year 2001. Additional years of peak-discharge record are available for some stations, most typically for older records. An example is station 06356500 (South Fork Grand River near Cash), which has additional peak-discharge record for water years 1946–1966. Some years without a recorded peak stage can result from a lack of documented flow (annual peak discharge equal to zero) for a year, or minimal flow, which are not uncommon for some stations. Station 06408500 (Spring Creek near Hermosa) provides such an example for water years 1989 and 1990. This station also has peak-flow data for water years 1950–1972. Additional peak-discharge records for such stations typically can be found by accessing the NWISWeb link that was referenced earlier.

Ice conditions are the predominant cause of backwater conditions in South Dakota. Annual peak stages at some stations were caused by ice accumulating during winter months within stream or river channels. Station 06436180 (Whitewood Creek above Whitewood) is a good example of such a station, with many backwater peak stages occurring during December through February (Burr and Korkow, 1996). Backwater conditions resulting from ice jams during ice-out is a common occurrence in many rivers and streams that can cause very large increases in stage at some locations. An excellent example is station 06452000 (White River near Oacoma), which is a location where flood stages have frequently been exceeded because of backwater effects. This site also illustrates that annual peak stages associated with annual peak discharge can have very large effects from backwater. An example is 1978, when a peak stage of 23.59 feet resulted from backwater conditions on March 14, in association with the annual peak discharge of 25,000 cubic feet per second (ft^3/s) (Burr and Korkow, 1996). A secondary peak of 23,100 ft^3/s occurred on March 20 of that year, but reached a stage of only 12.77 feet, which is well below flood stage.

Some very unique backwater conditions can occur along upstream reaches of the James River in northeastern South Dakota, where the channel gradient is very low. Large flows in several major tributaries can cause backwater for many miles upstream in the main stem of the James River, and can cause "reverse flow" at some gaging stations. Station 06471000 (James River at Columbia) frequently experiences backwater conditions from the Elm River, which enters the James River about 0.3 mile downstream. The minimum daily mean flow recorded at this site is reverse flow of 2,400 ft^3/s on March 30, 1997. Peak stages at this station can occur at zero flow, which occurs at the transition between reverse flow and flow downstream. This circumstance occurred in association with the annual peak stage of 16.93 feet for water year 1989, as documented in the "Water Resources Data" report for South Dakota for this year (U.S. Geological Survey, 1990). Station 06473000 (James River at Ashton) experiences backwater conditions from the Snake River, which enters the James River about 6.1 miles downstream. The minimum daily mean flow recorded at this site is reverse flow of 8,400 ft^3/s on March 31, 1997. In comparison, the maximum instantaneous peak discharge and maximum daily mean discharge recorded at this site are 9,150 and 9,100 ft^3/s, respectively, on April 23, 1997.

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Supplemental Information

Section A. Information for Gaging Stations

Table A1. Information for gaging stations with annual peak stages from backwater conditions, through water year 2001.

[NWS, National Weather Service; --, not applicable]

Station number	Map number	Station name	Total number of years with a peak stage[1]	Number of years with backwater peak stages	Relative frequency of backwater peak stage (in percent)	Number of backwater peak stages greater than flood stage	Percent of backwater peak stages greater than flood stage	NWS flood stage[2] (in feet)	NWS flood stage local effect[2] (where available)
05050000	1	Bois de Sioux River near White Rock, SD	59	15	25.4	0	0	15	Flooding begins downstream of the White Rock Dam on the Bois de Sioux River.
05051650	2	La Belle Creek near Veblen, SD	14	4	28.6	--	--	--	--
05289985	3	Big Coulee Creek near Peever, SD	14	3	21.4	0	0	10	At 9.5 feet the water reaches the bottom of the bridge just southwest of the gage. At 10.5 feet the water reaches the bottom of the bridge 1 mile northeast of the gage, and the bridge just southwest of the gage is overtopped.
05290000	4	Little Minnesota River near Peever, SD	54	26	48.1	8	30.8	9	At 10.0 feet low-lying wooded pasture land begins flooding on the right bank of the river.
05291000	5	Whetstone River near Big Stone City, SD	72	27	37.5	0	0	12	The road 2 miles west and 1 mile south of the gage floods.
05292704	6	North Fork Yellow Bank River near Odessa, MN	11	2	18.2	--	--	--	--
05299700	7	Cobb Creek near Gary, SD	10	2	20.0	0	0	15	--
06334500	8	Little Missouri River at Camp Crook, SD	47	11	23.4	4	36.4	12	Overflows east bank onto first terrace of levee.
06354860	9	Spring Creek near Herried, SD	30	1	3.3	--	--	--	--
06354882	10	Oak Creek near Wakpala, SD	17	2	11.8	0	0	10	At 18.0 feet water reaches the bottom of the bridge just northwest of the gage.
06355500	11	North Fork Grand River near White Butte, SD	55	14	25.5	1	7.1	12	--

Table A1. Information for gaging stations with annual peak stages from backwater conditions, through water year 2001.—Continued

[NWS, National Weather Service; --, not applicable]

Station number	Map number	Station name	Total number of years with a peak stage[1]	Number of years with backwater peak stages	Relative frequency of backwater peak stage (in percent)	Number of backwater peak stages greater than flood stage	Percent of backwater peak stages greater than flood stage	NWS flood stage[2] (in feet)	NWS flood stage local effect[2] (where available)
06356000	12	South Fork Grand River at Buffalo, SD	40	9	22.5	--	--	--	--
06356500	13	South Fork Grand River near Cash, SD	32	11	34.4	0	0	12	--
06357500	14	Grand River at Shadehill, SD	28	8	28.6	--	--	--	--
06357800	15	Grand River at Little Eagle, SD	31	14	45.2	2	14.3	15	Low-lying pasture and hay land along the river begins to flood.
06358000	16	Grand River near Wakpala, SD	4	1	25.0	--	--	--	--
06358520	17	Deadman Creek tributary near Mobridge, SD	25	1	4.0	--	--	--	--
06359000	18	Moreau River at Bixby, SD	20	4	20.0	--	--	--	--
06359500	19	Moreau River near Faith, SD	58	11	19.0	2	18.2	16	Right bank overflows and lowland flooding begins.
06360000	20	Moreau River near Eagle Butte, SD	15	4	26.7	0	0	21	--
06360500	21	Moreau River near Whitehorse, SD	48	9	18.8	3	33.3	21	Low-lying pasture lands along the river begin to flood.
06361000	22	Moreau River at Promise, SD	30	4	13.3	--	--	--	--
06392900	23	Beaver Creek at Mallo Camp near Four Corners, WY	17	6	35.3	--	--	--	--
06392950	24	Stockade Beaver Creek near Newcastle, WY	17	3	17.6	--	--	--	--

Table A1. Information for gaging stations with annual peak stages from backwater conditions, through water year 2001.—Continued

[NWS, National Weather Service; --, not applicable]

Station number	Map number	Station name	Total number of years with a peak stage[1]	Number of years with backwater peak stages	Relative frequency of backwater peak stage (in percent)	Number of backwater peak stages greater than flood stage	Percent of backwater peak stages greater than flood stage	NWS flood stage[2] (in feet)	NWS flood stage local effect[2] (where available)
06395000	25	Cheyenne River at Edgemont, SD	61	8	13.1	0	0	11	At 8.0 feet the left bank begins to overflow. At 13.5 feet flooding begins in the Dudley, SD, community.
06400000	26	Hat Creek near Edgemont, SD	26	4	15.4	0	0	13	At 9.0 feet the left bank will overflow. At 10.0 feet the right bank will overflow.
06400497	27	Cascade Springs near Hot Springs, SD	8	2	25.0	--	--	--	--
06400875	28	Horsehead Creek at Olerichs, SD	18	1	5.6	0	0	17	--
06401500	29	Cheyenne River below Angostura Dam, SD	46	4	8.7	0	0	--	--
06402000	30	Fall River at Hot Springs, SD	63	1	1.6	0	0	13	At 4.5 feet banks begin to overflow causing minor flooding along North River Street. At 16.0 feet there is extensive flooding to buildings along the river.
06402500	31	Beaver Creek near Buffalo Gap, SD	63	21	33.3	0	0	6.5	At 6.0 feet the right bank begins to overflow.
06402600	32	Cheyenne River near Buffalo Gap, SD	11	1	9.1	--	--	--	--
06403300	33	French Creek above Fairburn, SD	20	3	15.0	--	--	--	--
06404000	34	Battle Creek near Keystone, SD	30	5	16.7	0	0	6.5	--
06404998	35	Grace Coolidge Creek near Game Lodge near Custer, SD	25	8	32.0	3	37.5	9.5	At 10.8 feet cabins along Grace Coolidge Creek are threatened.
06405000	36	Grace Coolidge Creek near Custer, SD	10	3	30.0	--	--	--	--

Table A1. Information for gaging stations with annual peak stages from backwater conditions, through water year 2001.—Continued

[NWS, National Weather Service; --, not applicable]

Station number	Map number	Station name	Total number of years with a peak stage[1]	Number of years with backwater peak stages	Relative frequency of backwater peak stage (in percent)	Number of backwater peak stages greater than flood stage	Percent of backwater peak stages greater than flood stage	NWS flood stage[2] (in feet)	NWS flood stage local effect[2] (where available)
06405800	37	Bear Gulch near Hayward, SD	13	1	7.7	--	--	--	--
06406000	38	Battle Creek at Hermosa, SD	40	1	2.5	0	0	8	Pasture and farm lands begin flooding.
06406500	39	Battle Creek below Hermosa, SD	13	2	15.4	0	0	9	--
06406920	40	Spring Creek above Sheridan Lake near Keystone, SD	11	3	27.3	--	--	--	--
06408500	41	Spring Creek near Hermosa, SD	27	9	33.3	0	0	8	The right bank will begin to overflow.
06408700	42	Rhoads Fork near Rochford, SD	18	7	38.9	--	--	--	--
06408860	43	Rapid Creek near Rochford, SD	6	2	33.3	--	--	--	--
06409000	44	Castle Creek above Deerfield Reservoir near Hill City, SD	53	43	81.1	0	0	6.5	--
06410000	45	Castle Creek below Deerfield Dam, SD	18	3	16.7	0	0	--	--
06410500	46	Rapid Creek above Pactola Reservoir at Silver City, SD	48	21	43.8	0	0	13	Flooding of roads begins.
06411500	47	Rapid Creek below Pactola Dam, SD	39	9	23.1	--	--	--	--
06412000	48	Rapid Creek at Big Bend near Rapid City, SD	13	1	7.7	0	0	7	Flooding begins on roads in Dark Canyon.

Table A1. Information for gaging stations with annual peak stages from backwater conditions, through water year 2001.—Continued

[NWS, National Weather Service; --, not applicable]

Station number	Map number	Station name	Total number of years with a peak stage[1]	Number of years with backwater peak stages	Relative frequency of backwater peak stage (in percent)	Number of backwater peak stages greater than flood stage	Percent of backwater peak stages greater than flood stage	NWS flood stage[2] (in feet)	NWS flood stage local effect[2] (where available)
06412500	49	Rapid Creek above Canyon Lake near Rapid City, SD	54	21	38.9	0	0	15	--
06412800	50	Cleghorn Springs north channel at Fish Hatchery at Rapid City, SD	1	1	100	--	--	--	--
06413700	51	Rapid Creek above water treatment plant at Rapid City, SD	5	1	20.0	--	--	--	--
06414000	52	Rapid Creek at Rapid City, SD	30	3	10.0	0	0	11	Parks in Rapid City and low-lying areas in Rapid Valley begin flooding.
06416000	53	Rapid Creek below Hawthorn Ditch at Rapid City, SD	11	3	27.3	--	--	--	--
06418500	54	Rapid Creek below Little Giant Ditch near Rapid City, SD	5	3	60.0	--	--	--	--
06421500	55	Rapid Creek near Farmingdale, SD	53	13	24.5	0	0	11	The creek overflows the Farmingdale-Folsom road.
06422500	56	Boxelder Creek near Nemo, SD	32	9	28.1	0	0	6	At 6.5 feet the right bank begins overflowing.
06423010	57	Boxelder Creek near Rapid City, SD	13	1	7.7	0	0	33.5	Basements begin to flood.
06423500	58	Cheyenne River near Wasta, SD	74	14	18.9	1	7.1	14	The right bank begins to overflow and affect agricultural land.
06424000	59	Elk Creek near Roubaix, SD	18	1	5.6	0	0	11	Water will flood roads near Elk Creek, including Forestry Road 151.
06425100	60	Elk Creek near Rapid City, SD	21	1	4.8	1	100	9	Banks will begin to overflow.

Table A1. Information for gaging stations with annual peak stages from backwater conditions, through water year 2001.—Continued

[NWS, National Weather Service; --, not applicable]

Station number	Map number	Station name	Total number of years with a peak stage[1]	Number of years with backwater peak stages	Relative frequency of backwater peak stage (in percent)	Number of backwater peak stages greater than flood stage	Percent of backwater peak stages greater than flood stage	NWS flood stage[2] (in feet)	NWS flood stage local effect[2] (where available)
06425500	61	Elk Creek near Elm Springs, SD	35	2	5.7	0	0	12	Flooding of agricultural land begins.
06428500	62	Belle Fourche River at Wyoming-South Dakota State line	55	14	25.5	0	0	15	Minor lowland flooding begins.
06429500	63	Cold Springs Creek at Buckhorn, WY	8	7	87.5	--	--	--	--
06429905	64	Sand Creek near Ranch A near Beulah, WY	16	4	25.0	--	--	--	--
06430500	65	Redwater Creek at Wyoming-South Dakota State line	47	16	34.0	0	0	12	Flooding of nearby roads begins.
06430532	66	Crow Creek near Beulah, WY	10	4	40.0	--	--	--	--
06430770	67	Spearfish Creek near Lead, SD	13	4	30.8	0	0	9	At 11.2 feet banks begin overflowing. At 11.7 feet water will begin affecting nearby roads, including Highway 14A.
06430800	68	Annie Creek near Lead, SD	13	2	15.4	0	0	10	At 9.7 feet the creek overflows its banks and runs down a ditch on Highway 14A.
06430898	69	Squaw Creek near Spearfish, SD	13	1	7.7	--	--	--	--
06431500	70	Spearfish Creek at Spearfish, SD	55	23	41.8	0	0	9	At 9.5 feet the right bank begins overflowing.
06432020	71	Spearfish Creek below Spearfish, SD	13	2	15.4	--	--	--	--
06433000	72	Redwater River above Belle Fourche, SD	55	28	50.9	3	10.7	10	Banks begin overflowing.

Table A1. Information for gaging stations with annual peak stages from backwater conditions, through water year 2001.—Continued

[NWS, National Weather Service; --, not applicable]

Station number	Map number	Station name	Total number of years with a peak stage[1]	Number of years with backwater peak stages	Relative frequency of backwater peak stage (in percent)	Number of backwater peak stages greater than flood stage	Percent of backwater peak stages greater than flood stage	NWS flood stage[2] (in feet)	NWS flood stage local effect[2] (where available)
06433500	73	Hay Creek at Belle Fourche, SD	43	9	20.9	--	--	--	--
06434500	74	Inlet Canal near Belle Fourche, SD	1	1	100	--	--	--	--
06436000	75	Belle Fourche River near Fruitdale, SD	52	7	13.5	0	0	12	The right bank is subject to overflow and flooding of lowlands begins.
06436156	76	Whitetail Creek at Lead, SD	13	3	23.1	--	--	--	--
06436170	77	Whitewood Creek at Deadwood, SD	14	3	21.4	--	--	--	--
06436180	78	Whitewood Creek above Whitewood, SD	19	14	73.7	0	0	10	At 11.5 feet the left bank will overflow.
06436190	79	Whitewood Creek near Whitewood, SD	20	1	5.0	--	--	--	--
06436198	80	Whitewood Creek above Vale, SD	19	8	42.1	--	--	--	--
06436500	81	Horse Creek near Newell, SD	8	2	25.0	--	--	--	--
06436700	82	Indian Creek near Arpan, SD	20	6	30.0	--	--	--	--
06436760	83	Horse Creek above Vale, SD	21	1	4.8	0	0	17	At 7.0 feet the right bank begins to overflow.
06436800	84	Horse Creek near Vale, SD	19	3	15.8	--	--	--	--
06437000	85	Belle Fourche River near Sturgis, SD	56	14	25.0	0	0	15	Flooding of agricultural land begins.
06437200	86	Bear Butte Creek near Galena, SD	3	1	33.3	0	0	6.5	Gravel roads near the creek begin flooding.

Table A1. Information for gaging stations with annual peak stages from backwater conditions, through water year 2001.—Continued

[NWS, National Weather Service; --, not applicable]

Station number	Map number	Station name	Total number of years with a peak stage[1]	Number of years with backwater peak stages	Relative frequency of backwater peak stage (in percent)	Number of backwater peak stages greater than flood stage	Percent of backwater peak stages greater than flood stage	NWS flood stage[2] (in feet)	NWS flood stage local effect[2] (where available)
06437500	87	Bear Butte Creek near Sturgis, SD	20	1	5.0	--	--	--	--
06438000	88	Belle Fourche River near Elm Springs, SD	73	15	20.5	0	0	15	Flooding of agricultural land begins.
06438500	89	Cheyenne River near Plainview, SD	40	8	20.0	1	12.5	16	--
06439000	90	Cherry Creek near Plainview, SD	55	4	7.3	1	25.0	17	--
06439300	91	Cheyenne River at Cherry Creek, SD	34	3	8.8	--	--	--	--
06439430	92	Cottonwood Creek near Cherry Creek, SD	16	2	12.5	--	--	--	--
06439500	93	Cheyenne River near Eagle Butte, SD	41	8	19.5	--	--	--	--
06440200	94	South Fork Bad River near Cottonwood, SD	13	1	7.7	1	100	12	Flooding of agricultural land begins.
06441000	95	Bad River near Midland, SD	35	1	2.9	0	0	21	Flooding of agricultural land begins.
06441500	96	Bad River near Fort Pierre, SD	76	12	15.8	4	33.3	21	Bad River Road begins flooding about 7 miles upstream of the gage.
06442000	97	Medicine Knoll Creek near Blunt, SD	43	8	18.6	--	--	--	--
06442500	98	Medicine Creek at Kennebec, SD	43	3	7.0	--	--	--	--
06442718	99	Campbell Creek near Lee's Corner, SD	14	2	14.3	0	0	15	Lowland flooding begins.

Table A1. Information for gaging stations with annual peak stages from backwater conditions, through water year 2001.—Continued

[NWS, National Weather Service; --, not applicable]

Station number	Map number	Station name	Total number of years with a peak stage[1]	Number of years with backwater peak stages	Relative frequency of backwater peak stage (in percent)	Number of backwater peak stages greater than flood stage	Percent of backwater peak stages greater than flood stage	NWS flood stage[2] (in feet)	NWS flood stage local effect[2] (where available)
06442900	100	Elm Creek near Gann Valley, SD	11	1	9.1	--	--	--	--
06443000	101	Missouri River at Chamberlain, SD	12	3	25.0	0	0	60	American Creek Marina just upstream of the gage will begin flooding.
06445685	102	White River near Nebraska-South Dakota State line	14	2	14.3	0	0	18	Flooding of agricultural land begins.
06445700	103	White River at Slim Butte, SD	17	2	11.8	--	--	--	--
06445980	104	White Clay Creek near Oglala, SD	29	10	34.4	--	--	--	--
06446000	105	White River near Oglala, SD	58	10	17.2	--	--	--	--
06446100	106	Wounded Knee Creek at Wounded Knee, SD	9	1	11.1	--	--	--	--
06446200	107	White River near Rockyford, SD	9	2	22.2	--	--	--	--
06446500	108	White River near Interior, SD	14	3	21.4	--	--	--	--
06447000	109	White River near Kadoka, SD	46	8	17.4	2	25.0	13	Minor lowland flooding begins.
06447230	110	Blackpipe Creek near Belvidere, SD	9	1	11.1	1	100	14	At 13.5 feet the left bank will overflow.
06447500	111	Little White River near Martin, SD	44	9	20.4	0	0	10	Flooding of agricultural land begins.
06448000	112	Lake Creek above Refuge near Tuthill, SD	24	17	70.8	0	0	4.5	Water overflows the culverts.

Table A1. Information for gaging stations with annual peak stages from backwater conditions, through water year 2001.—Continued

[NWS, National Weather Service; --, not applicable]

Station number	Map number	Station name	Total number of years with a peak stage[1]	Number of years with backwater peak stages	Relative frequency of backwater peak stage (in percent)	Number of backwater peak stages greater than flood stage	Percent of backwater peak stages greater than flood stage	NWS flood stage[2] (in feet)	NWS flood stage local effect[2] (where available)
06449000	113	Lake Creek below Refuge near Tuthill, SD	42	11	26.2	--	--	--	--
06449100	114	Little White River near Vetal, SD	41	13	31.7	0	0	11	At 9.7 feet the right bank will overflow and affect agricultural land. At 11.0 feet the left bank will overflow.
06449250	115	Spring Creek near St. Francis, SD	15	1	6.7	--	--	--	--
06449300	116	Little White River above Rosebud, SD	18	11	61.1	--	--	--	--
06449400	117	Rosebud Creek at Rosebud, SD	23	9	39.1	--	--	--	--
06449500	118	Little White River near Rosebud, SD	58	38	65.5	1	2.6	12	At 6.0 feet the left band will overflow into the floodplain.
06450000	119	Little White River at White River, SD	2	2	100	--	--	--	--
06450500	120	Little White River below White River, SD	32	26	81.3	0	0	13	Banks overflow extensively causing agricultural flooding.
06451500	121	Little White River at Westover, SD	6	3	50.0	--	--	--	--
06452000	122	White River near Oacoma, SD	41	15	36.6	7	46.7	15	Flooding of residences near the White River begins.
06452320	123	Platte Creek near Platte, SD	13	1	7.7	--	--	--	--
06464000	124	Keya Paha River near Hidden Timber, SD	5	1	20.0	--	--	--	--

Table A1. Information for gaging stations with annual peak stages from backwater conditions, through water year 2001.—Continued

[NWS, National Weather Service; --, not applicable]

Station number	Map number	Station name	Total number of years with a peak stage[1]	Number of years with backwater peak stages	Relative frequency of backwater peak stage (in percent)	Number of backwater peak stages greater than flood stage	Percent of backwater peak stages greater than flood stage	NWS flood stage[2] (in feet)	NWS flood stage local effect[2] (where available)
06464100	125	Keya Paha River near Keyapaha, SD	20	6	30.0	1	16.7	10	At 5.5 feet the right bank will overflow. At 9.0 feet the left bank will overflow.
06464500	126	Keya Paha River at Wewela, SD	46	19	41.3	0	0	11	Begins affecting agricultural land.
06467500	127	Missouri River at Yankton, SD	65	23	35.4	18	78.3	20	--
06471000	128	James River at Columbia, SD	54	29	53.7	19	65.5	13	Flooding of the lower-lying agricultural areas begins.
06471200	129	Maple River at North Dakota-South Dakota State line	38	7	18.4	4	57.1	10	--
06471350	130	Maple River at Frederick, SD	13	1	7.7	1	100	10	At 10.5 feet the bridge 2 miles north of the gage is overtopped.
06471500	131	Elm River at Westport, SD	54	9	16.7	2	22.2	14	The county road east of Westport becomes impassable.
06471550	132	James River below Columbia, SD	6	2	33.3	--	--	--	--
06472000	133	James River near Stratford, SD	23	3	13.0	2	66.7	14	Significant amounts of agricultural land begin flooding.
06472500	134	Mud Creek near Stratford, SD	10	1	10.0	--	--	--	--
06473000	135	James River at Ashton, SD	42	18	42.9	9	50.0	13	Flooding begins to affect some cropland along with moderate flooding of pasture and low-lying areas.
06473500	136	South Fork Snake Creek near Athol, SD	20	3	15.0	--	--	--	--
06473700	137	Snake Creek near Ashton, SD	22	2	9.1	--	--	--	--

Table A1. Information for gaging stations with annual peak stages from backwater conditions, through water year 2001.—Continued

[NWS, National Weather Service; --, not applicable]

Station number	Map number	Station name	Total number of years with a peak stage[1]	Number of years with backwater peak stages	Relative frequency of backwater peak stage (in percent)	Number of backwater peak stages greater than flood stage	Percent of backwater peak stages greater than flood stage	NWS flood stage[2] (in feet)	NWS flood stage local effect[2] (where available)
06473750	138	Wolf Creek near Ree Heights, SD	18	7	38.9	--	--	--	--
06474000	139	Turtle Creek near Tulare, SD	31	8	25.8	--	--	--	--
06474300	140	Medicine Creek near Zell, SD	27	7	25.9	--	--	--	--
06474500	141	Turtle Creek at Redfield, SD	10	1	10.0	0	0	7	The water reaches the bottom of the bridge on the east side of Redfield. Moderate flooding of agricultural land outside of Redfield begins on the right side of Turtle Creek.
06475000	142	James River near Redfield, SD	51	12	23.5	2	16.7	20	Flooding of low-lying agricultural and pasture land begins.
06475850	143	Foster Creek tributary near Carpenter, SD	12	1	8.3	--	--	--	--
06476000	144	James River at Huron, SD	60	6	10.0	1	16.7	11	Significant amounts of rural areas will experience some flooding.
06476500	145	Sand Creek near Alpena, SD	46	7	15.2	--	--	--	--
06477000	146	James River near Forestburg, SD	54	7	13.0	3	42.9	12	The left bank flooding begins and some of the gravel roads along the river begin to flood.
06477500	147	Firesteel Creek near Mitchell, SD	46	6	13.0	5	83.3	8	--
06478000	148	James River near Mitchell, SD	9	1	11.1	--	--	--	--
06478052	149	Enemy Creek near Mitchell, SD	24	3	12.5	0	0	17	Lower banks overflow.
06478390	150	Wolf Creek near Clayton, SD	24	4	16.7	--	--	--	--

Table A1. Information for gaging stations with annual peak stages from backwater conditions, through water year 2001.—Continued

[NWS, National Weather Service; --, not applicable]

Station number	Map number	Station name	Total number of years with a peak stage[1]	Number of years with backwater peak stages	Relative frequency of backwater peak stage (in percent)	Number of backwater peak stages greater than flood stage	Percent of backwater peak stages greater than flood stage	NWS flood stage[2] (in feet)	NWS flood stage local effect[2] (where available)
06478500	151	James River near Scotland, SD	73	9	12.3	1	11.1	13	Significant agricultural flooding begins.
06478513	152	James River near Yankton, SD	19	1	5.3	--	--	--	--
06478535	153	East Fork Vermillion River near Ramona, SD	9	5	55.6	2	40.0	7.5	The bridge 1 mile north of the gage is overtopped. Significant amount of agricultural land is flooded as both banks are overtopped.
06478540	154	Little Vermillion River near Salem, SD	31	4	12.9	1	25.0	6	At 8.0 feet the water reaches the bottom of the bridge at the gaging location as well as the 2 bridges 2 miles east of the gage.
06478600	155	East Fork Vermillion River near Parker, SD	6	2	33.3	1	50.0	12	At 13.0 feet the water reaches the bottom of the bridge 1 mile east and 1 mile south of the gage.
06478690	156	West Fork Vermillion River near Parker, SD	40	4	10.0	2	50.0	9	Minor flooding of agricultural land begins.
06479000	157	Vermillion River near Wakonda, SD	40	16	40.0	9	56.3	14	Minor flooding of low-lying areas begins if not leveed, and some agricultural land will flood if the levees fail.
06479010	158	Vermillion River near Vermillion, SD	18	1	5.6	0	0	21	The water reaches the bottom of the bridge 4.5 miles northeast of the gage. Significant agricultural flooding begins and a few farm houses are also affected by high water.
06479215	159	Big Sioux River near Florence, SD	18	5	27.8	4	80.0	8	At 8.5 feet the water reaches the bottom of the bridge 1 mile east and 1.5 miles north of the gage.
06479438	160	Big Sioux River near Watertown, SD	29	9	31.0	0	0	10	Significant amounts of pasture and cropland are flooded.

Table A1. Information for gaging stations with annual peak stages from backwater conditions, through water year 2001.—Continued

[NWS, National Weather Service; --, not applicable]

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06479450	161	Lake Kampeska (inlet/outlet) near Watertown, SD	7	6	85.7	--	--	--	--
06479500	162	Big Sioux River at Watertown, SD	30	12	40.0	2	16.7	8	--
06479515	163	Willow Creek near Watertown, SD	18	8	44.4	0	0	10	--
06479520	164	Big Sioux River below Watertown, SD	7	3	42.9	--	--	--	--
06479525	165	Big Sioux River near Castlewood, SD	25	6	24.0	3	50.0	11	Significant amounts of pasture and other agricultural lands will be flooded.
06479529	166	Stray Horse Creek near Castlewood, SD	17	6	35.3	--	--	--	--
06479640	167	Hidewood Creek near Estelline, SD	29	10	34.5	--	--	--	--
06479910	168	Sixmile Creek near Brookings, SD	10	4	40.0	--	--	--	--
06479928	169	Battle Creek near Nunda, SD	10	3	30.0	--	--	--	--
06479980	170	Medary Creek near Brookings, SD	21	6	28.6	--	--	--	--
06480000	171	Big Sioux River near Brookings, SD	40	11	27.5	6	54.5	9	Significant amounts of pasture and farm lands begin flooding on the left bank of the river.
06480400	172	Spring Creek near Flandreau, SD	11	1	9.1	--	--	--	--
06480650	173	Flandreau Creek above Flandreau, SD	20	2	10.0	--	--	--	--

Table A1. Information for gaging stations with annual peak stages from backwater conditions, through water year 2001.—Continued

[NWS, National Weather Service; --, not applicable]

Station number	Map number	Station name	Total number of years with a peak stage[1]	Number of years with backwater peak stages	Relative frequency of backwater peak stage (in percent)	Number of backwater peak stages greater than flood stage	Percent of backwater peak stages greater than flood stage	NWS flood stage[2] (in feet)	NWS flood stage local effect[2] (where available)
06481000	174	Big Sioux River near Dell Rapids, SD	40	9	22.5	4	44.4	12	Agricultural lands along the lower banks of the river begin to flood.
06481500	175	Skunk Creek at Sioux Falls, SD	17	2	11.8	0	0	11.5	Minor flooding of rural pasture land begins along with some flooding in the parks and fields in Sioux Falls.
06482000	176	Big Sioux River at Sioux Falls, SD	17	6	35.3	--	--	--	--
06482020	177	Big Sioux River at North Cliff Avenue at Sioux Falls, SD	31	1	3.2	1	100	16	Rural flooding downstream of Sioux Falls begins and the Glenwood Stable begins to flood.
06482100	178	Big Sioux River near Brandon, SD	13	1	7.7	--	--	--	--
06482610	179	Split Rock Creek at Corson, SD	32	5	15.6	--	--	--	--
06482848	180	Beaver Creek at Canton, SD	18	2	11.1	--	--	--	--
06485500	181	Big Sioux River at Akron, IA	40	5	12.5	2	40.0	16	Several farm levees are overtopped with significant flooding of agricultural lands.
06485696	182	Brule Creek near Elk Point, SD	12	2	16.7	--	--	--	--

[1]Includes years with a peak stage associated with peak flow and/or a peak stage associated with a backwater event.

[2]Information accessed Nov. 25, 2002, at *www.crh.noaa.gov/cgi-bin/ahps.cgi*

Section B. Plots of Annual Peak Stage and Stage at Peak Discharge

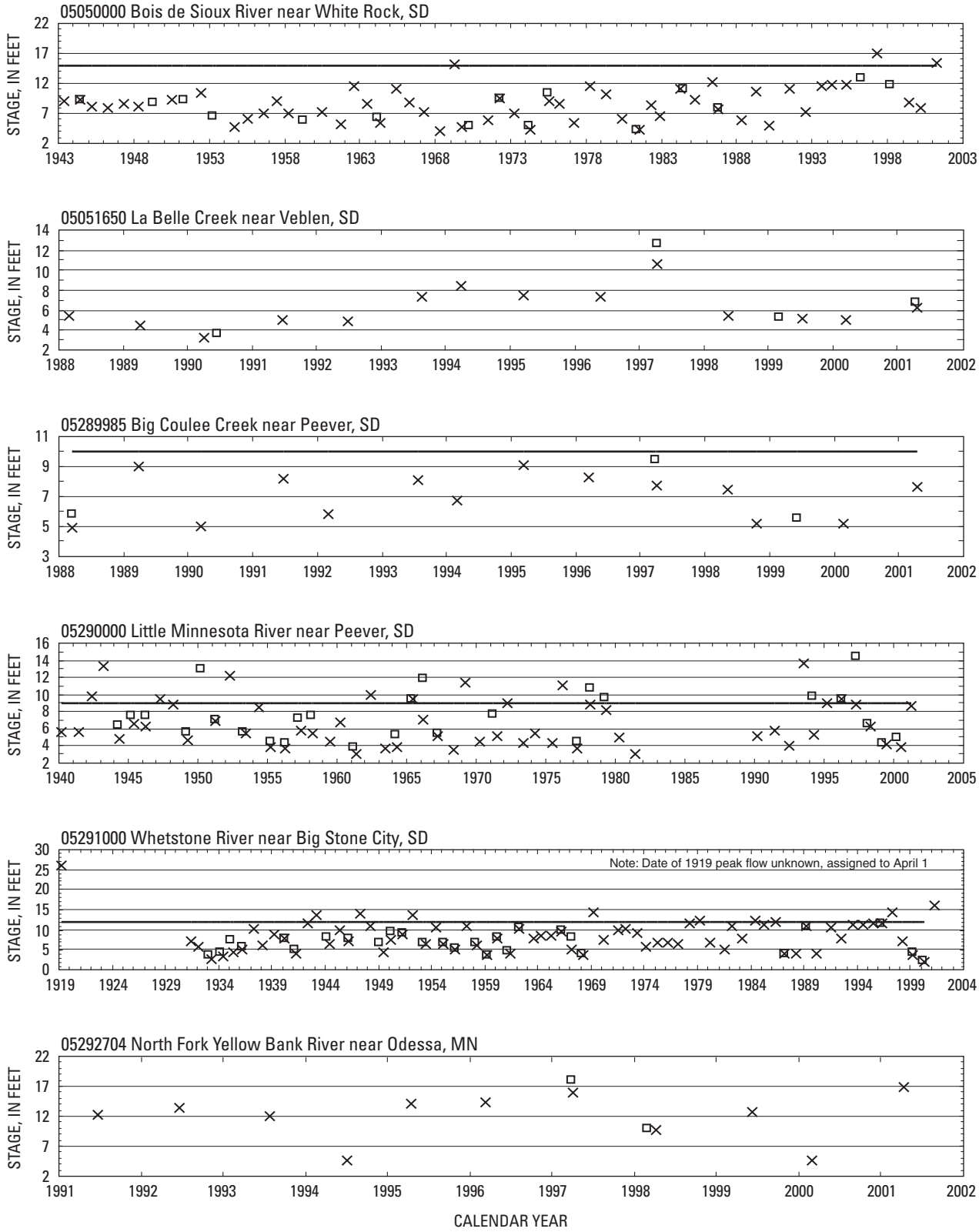


Figure A1. Plots of annual peak stage and stage at peak discharge.

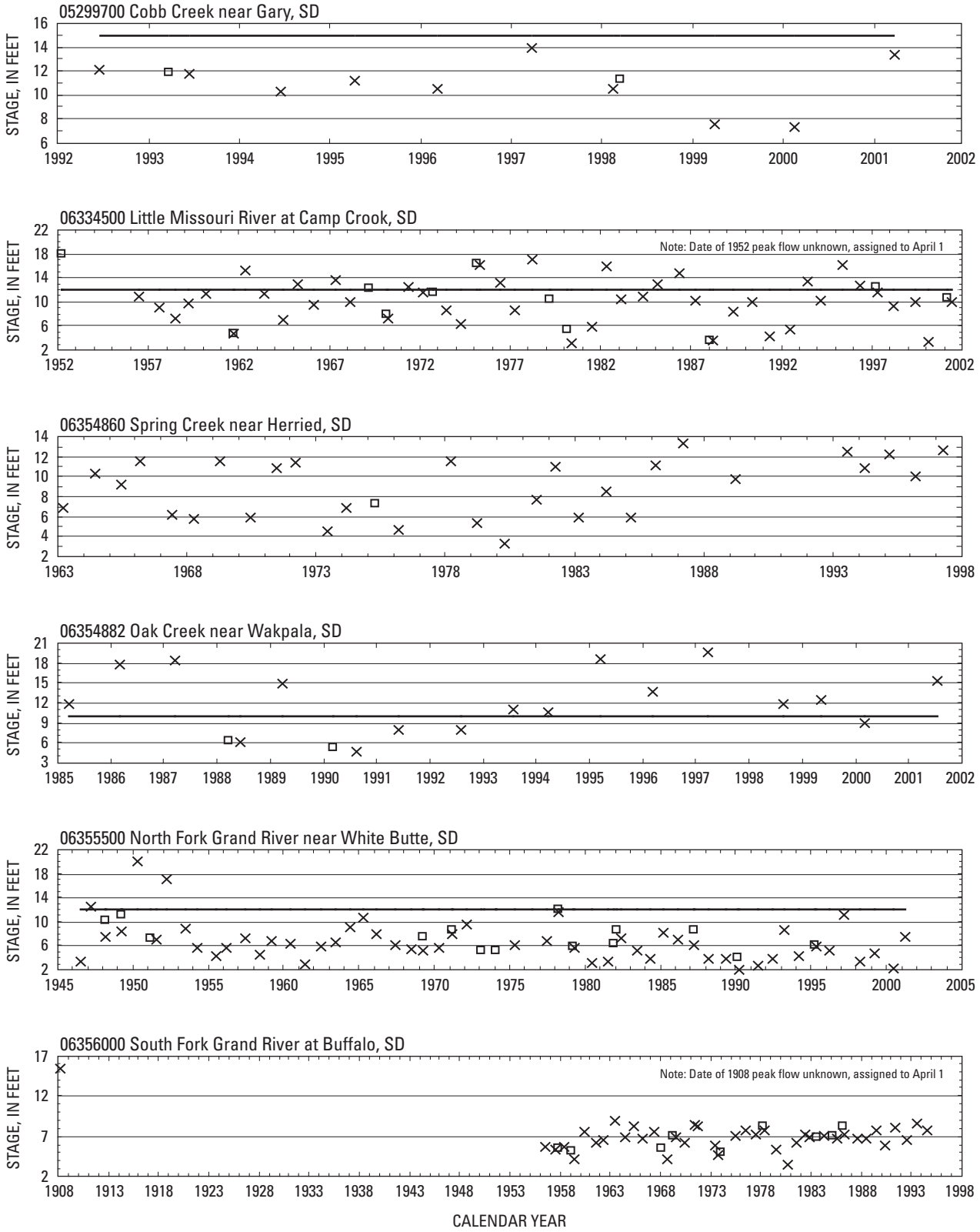


Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

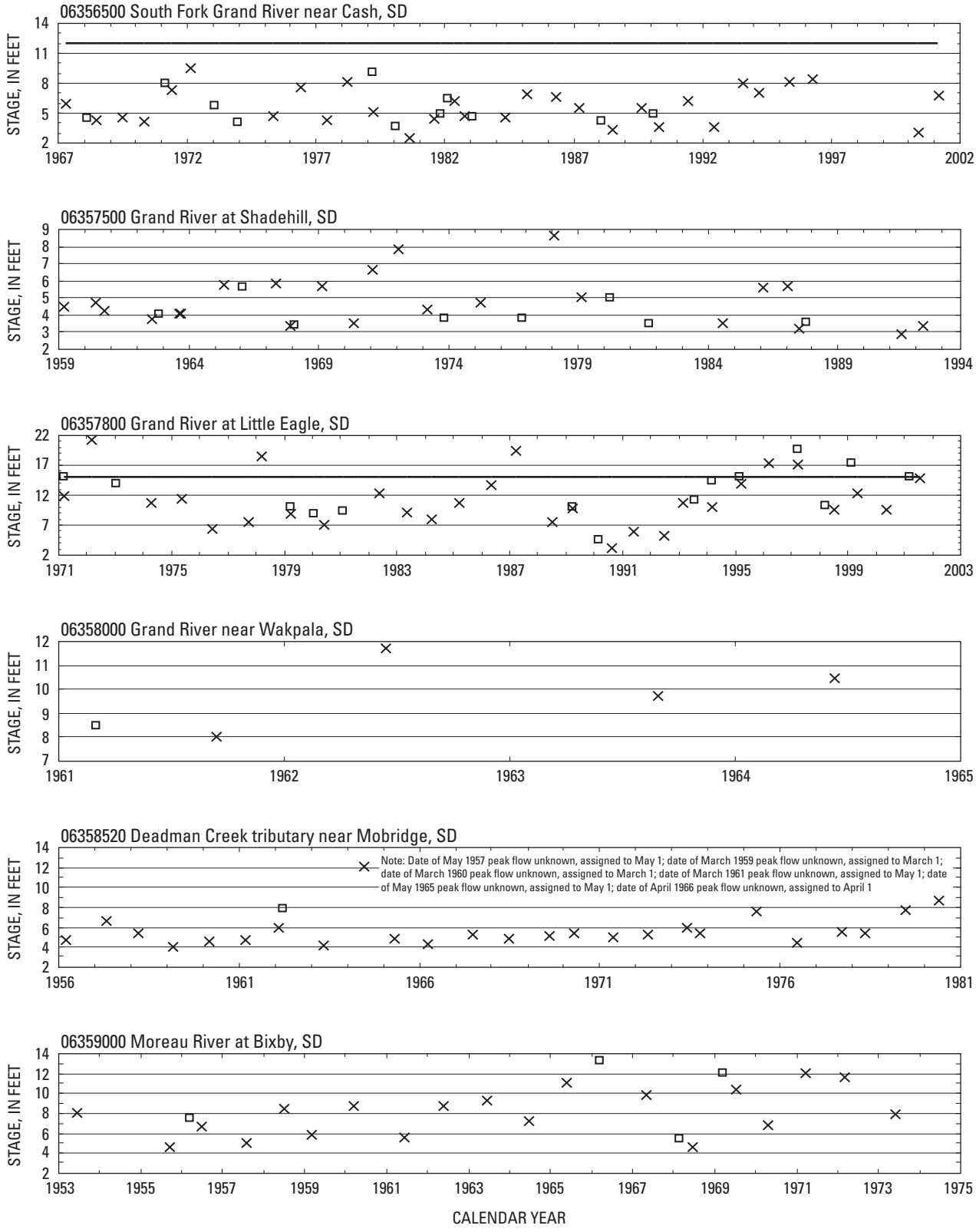


Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

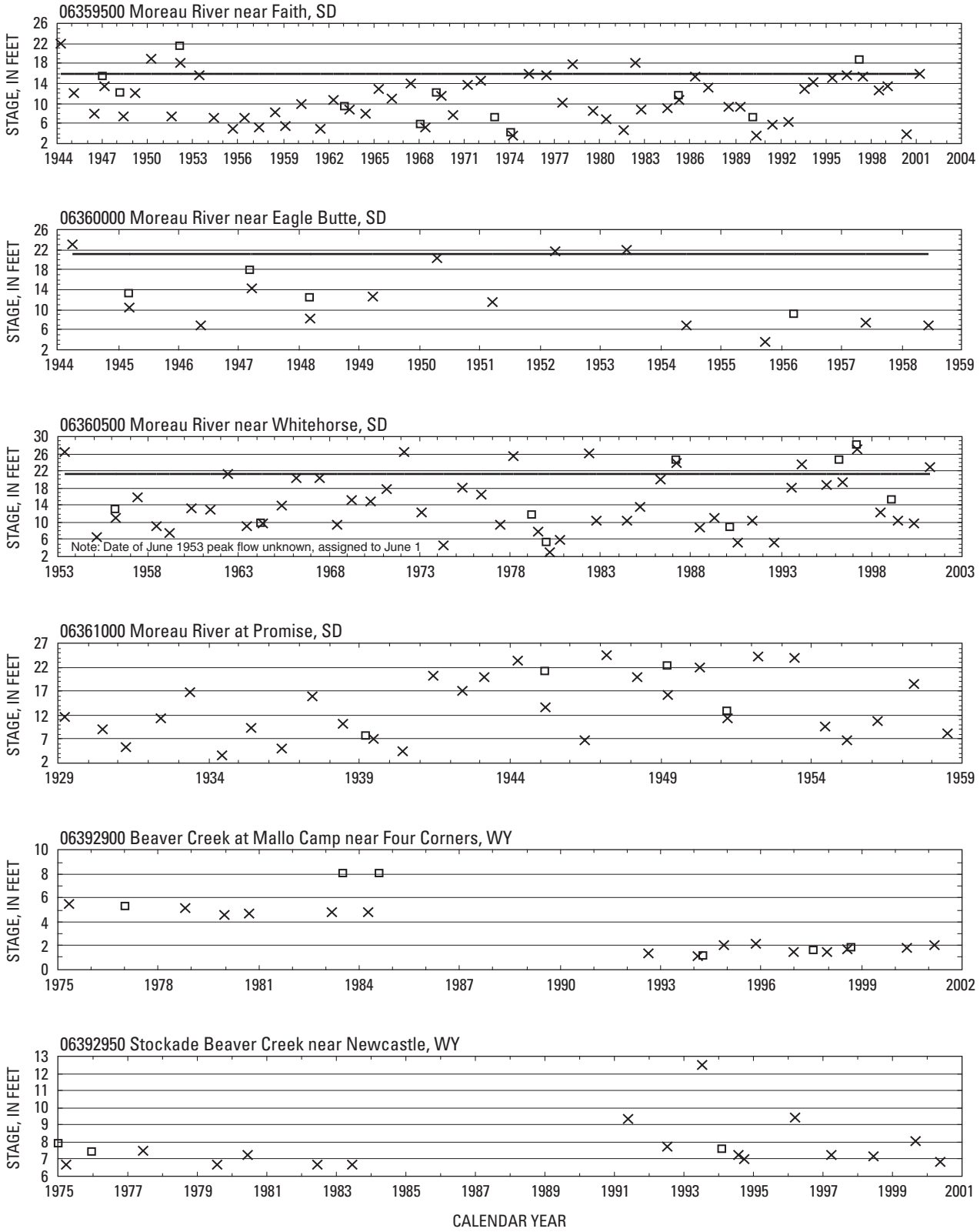


Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

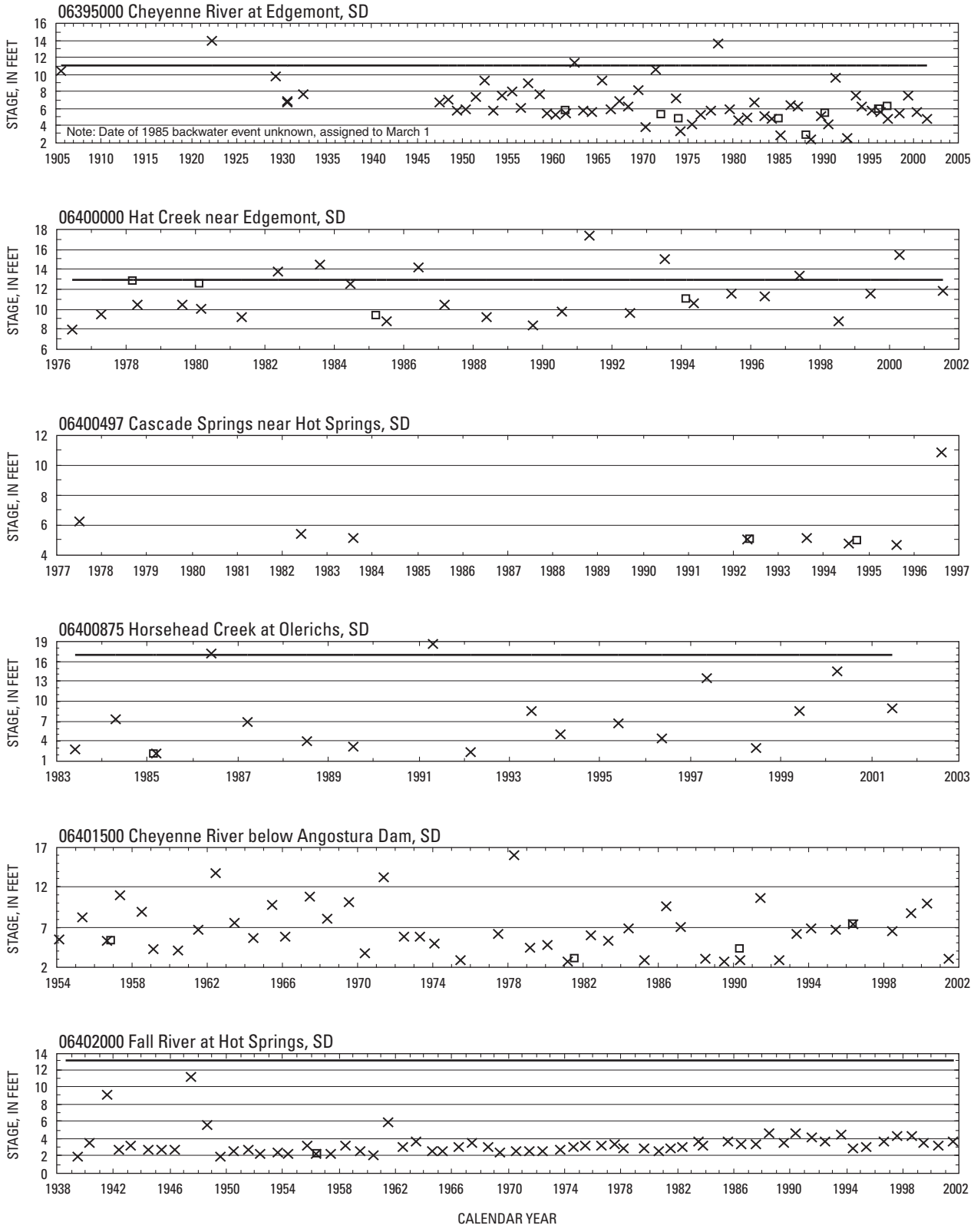


Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

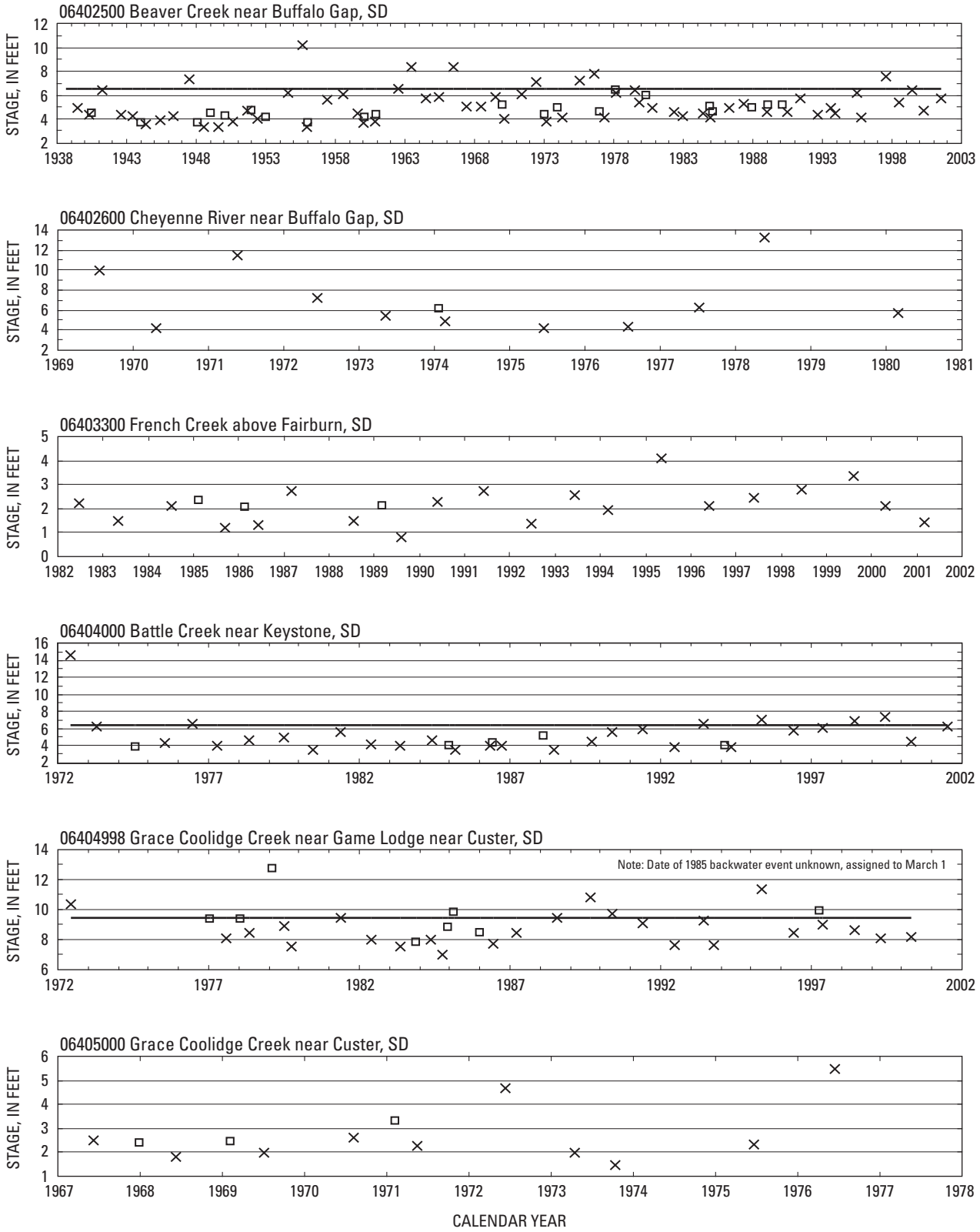


Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

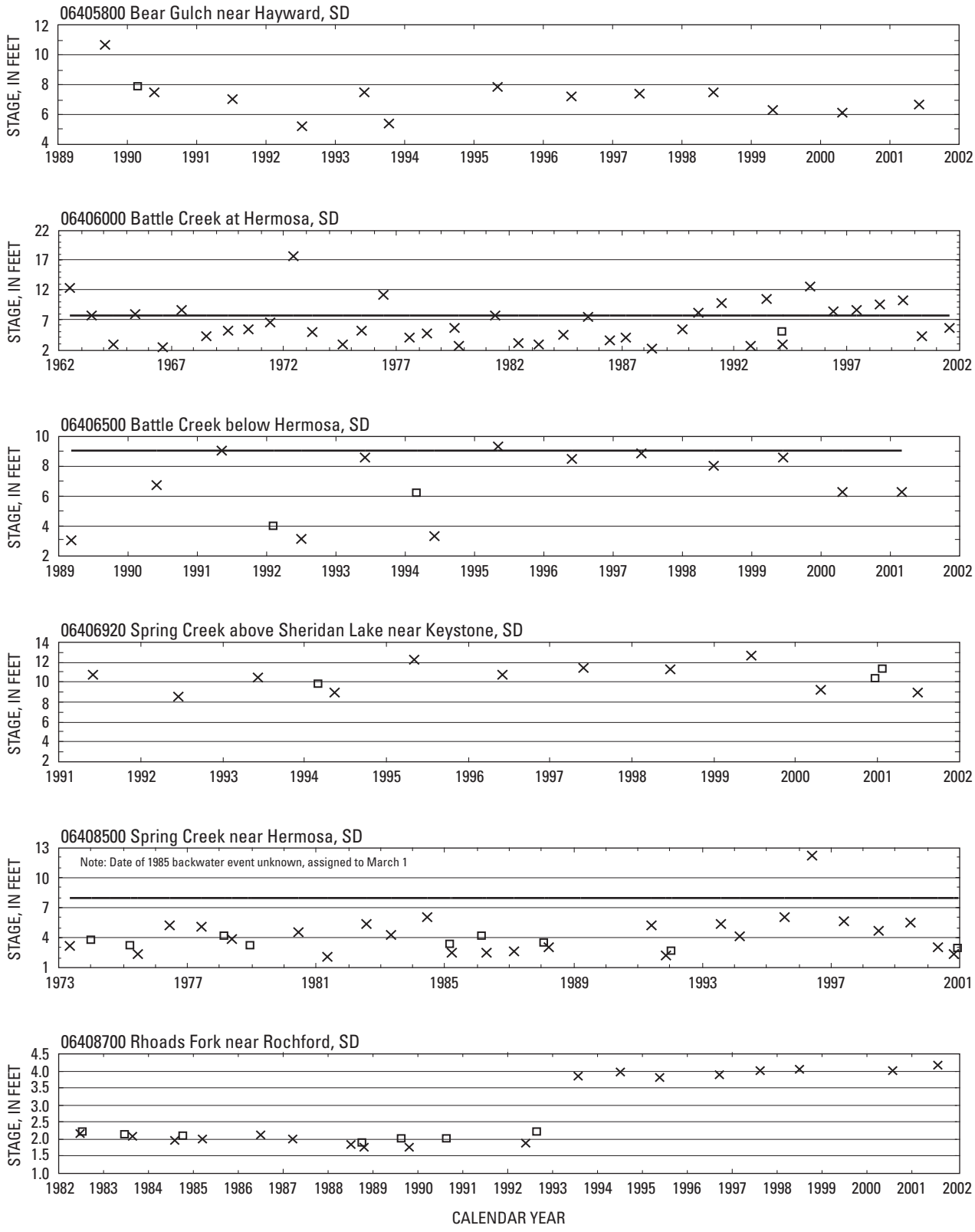


Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

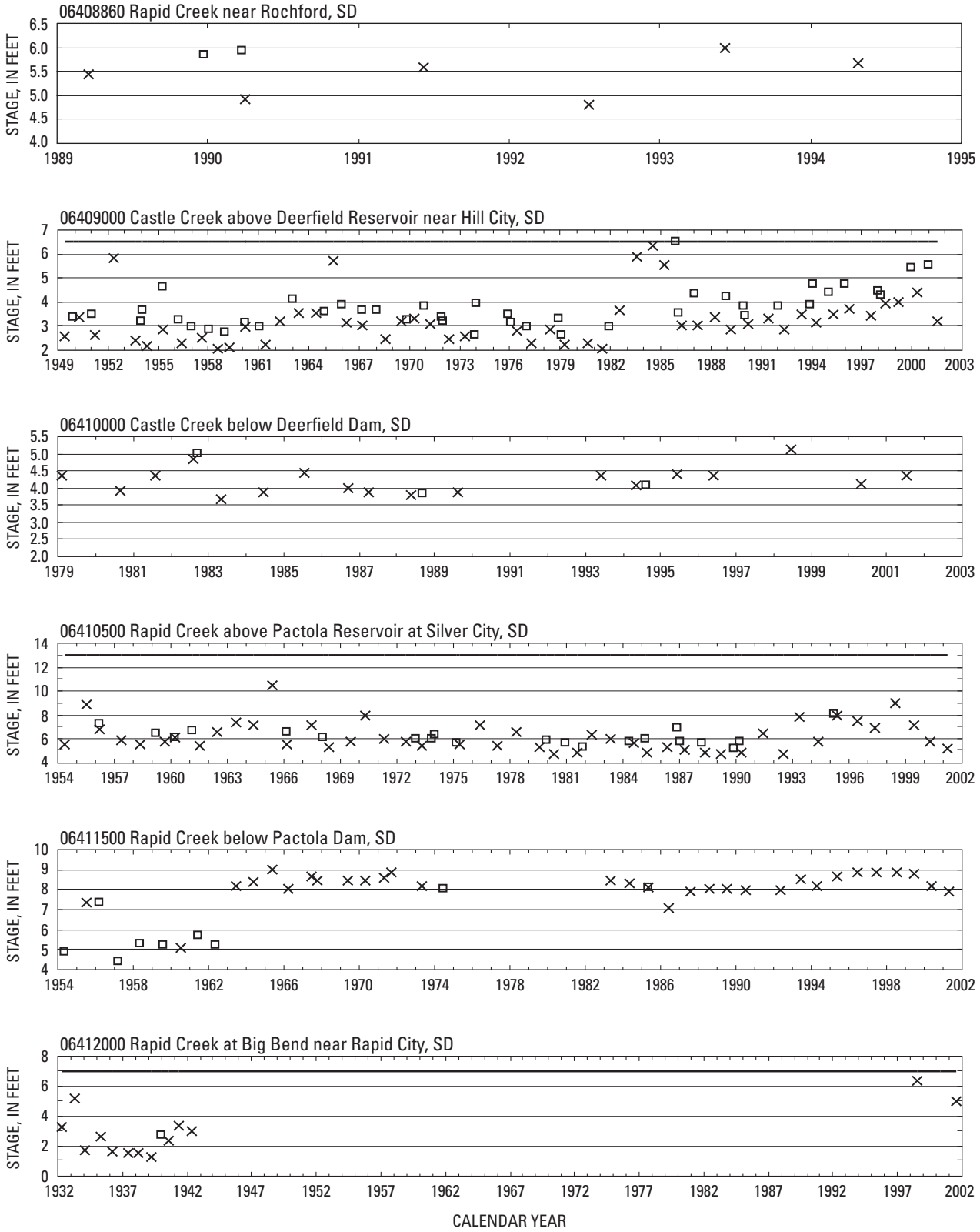


Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

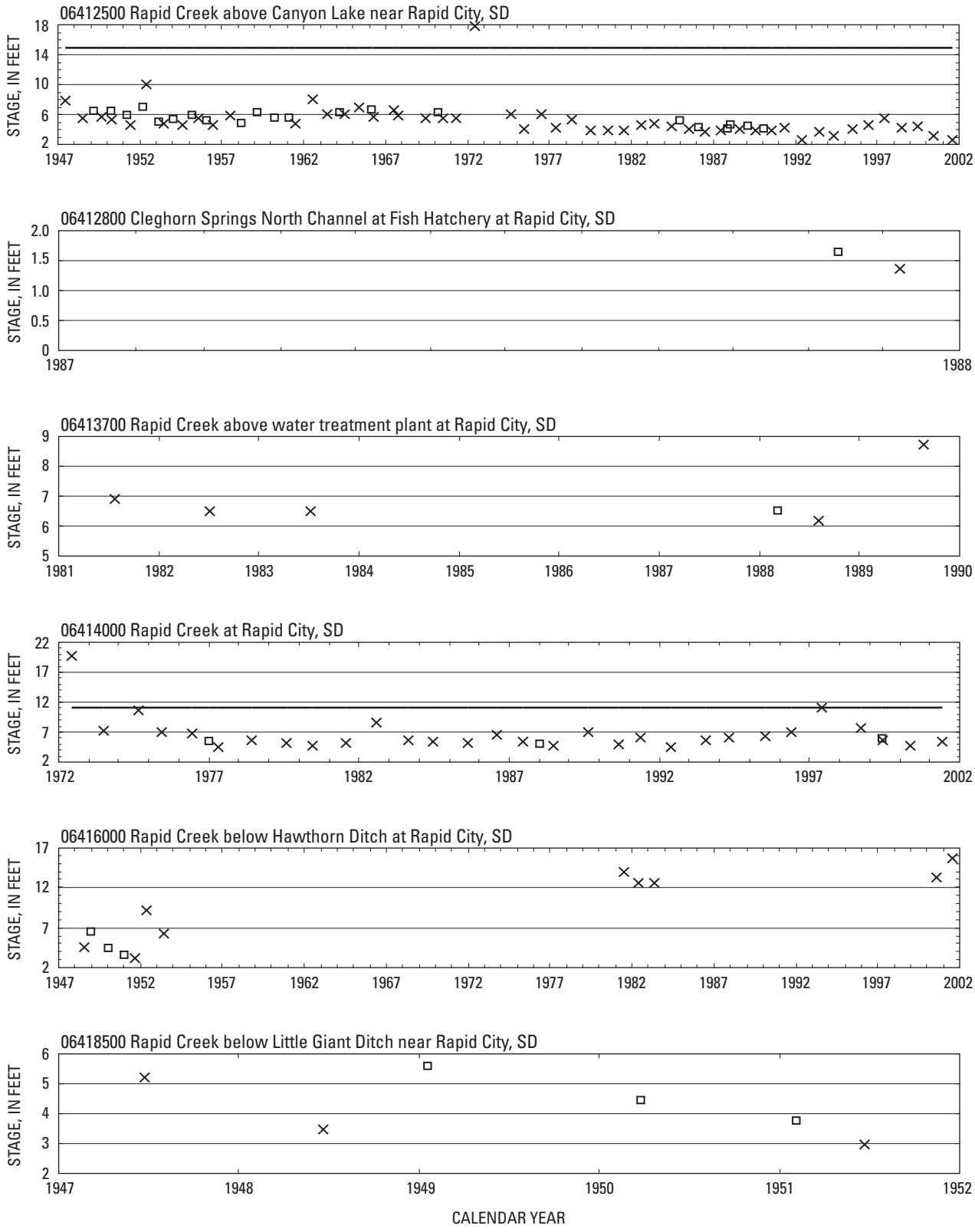
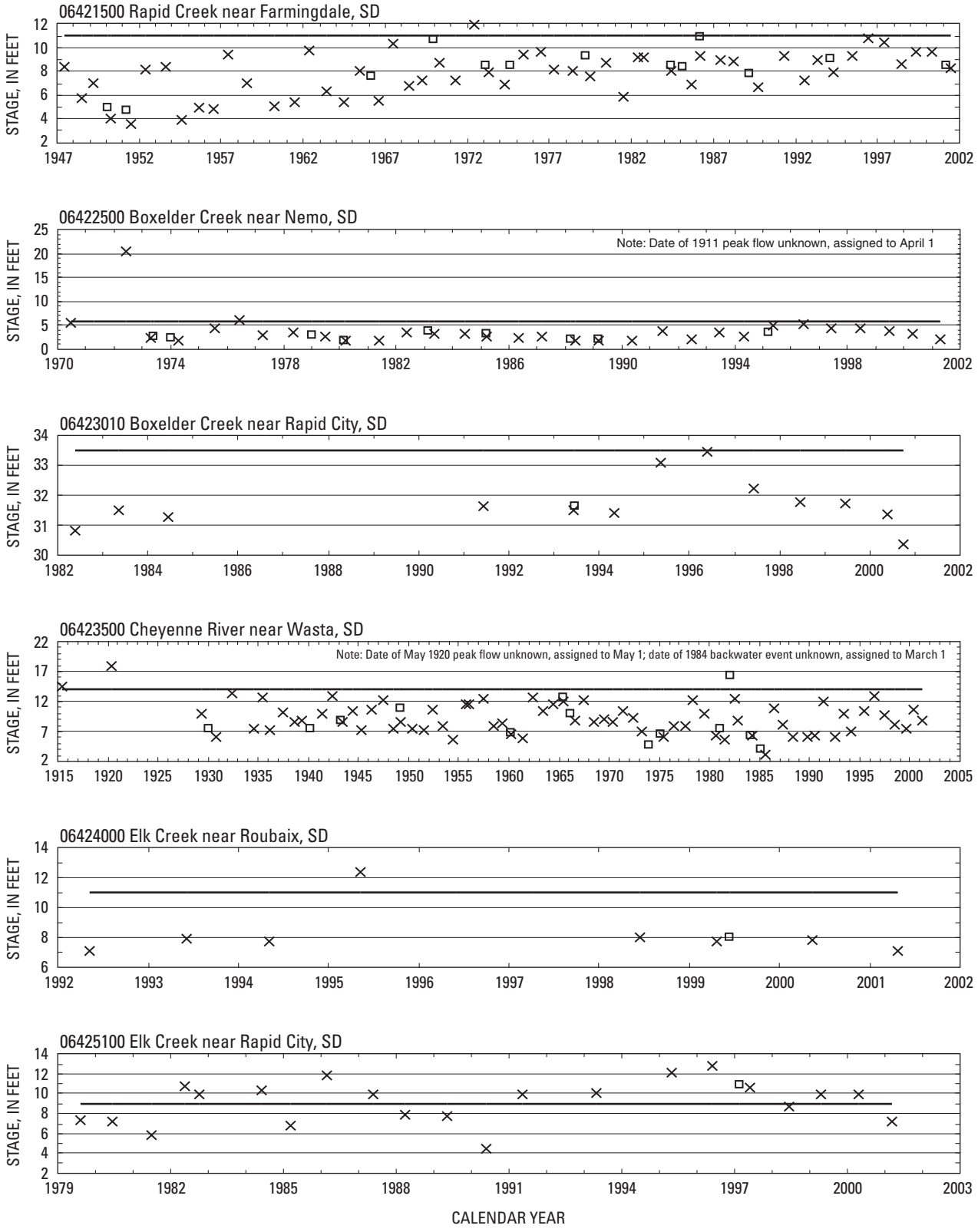


Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued



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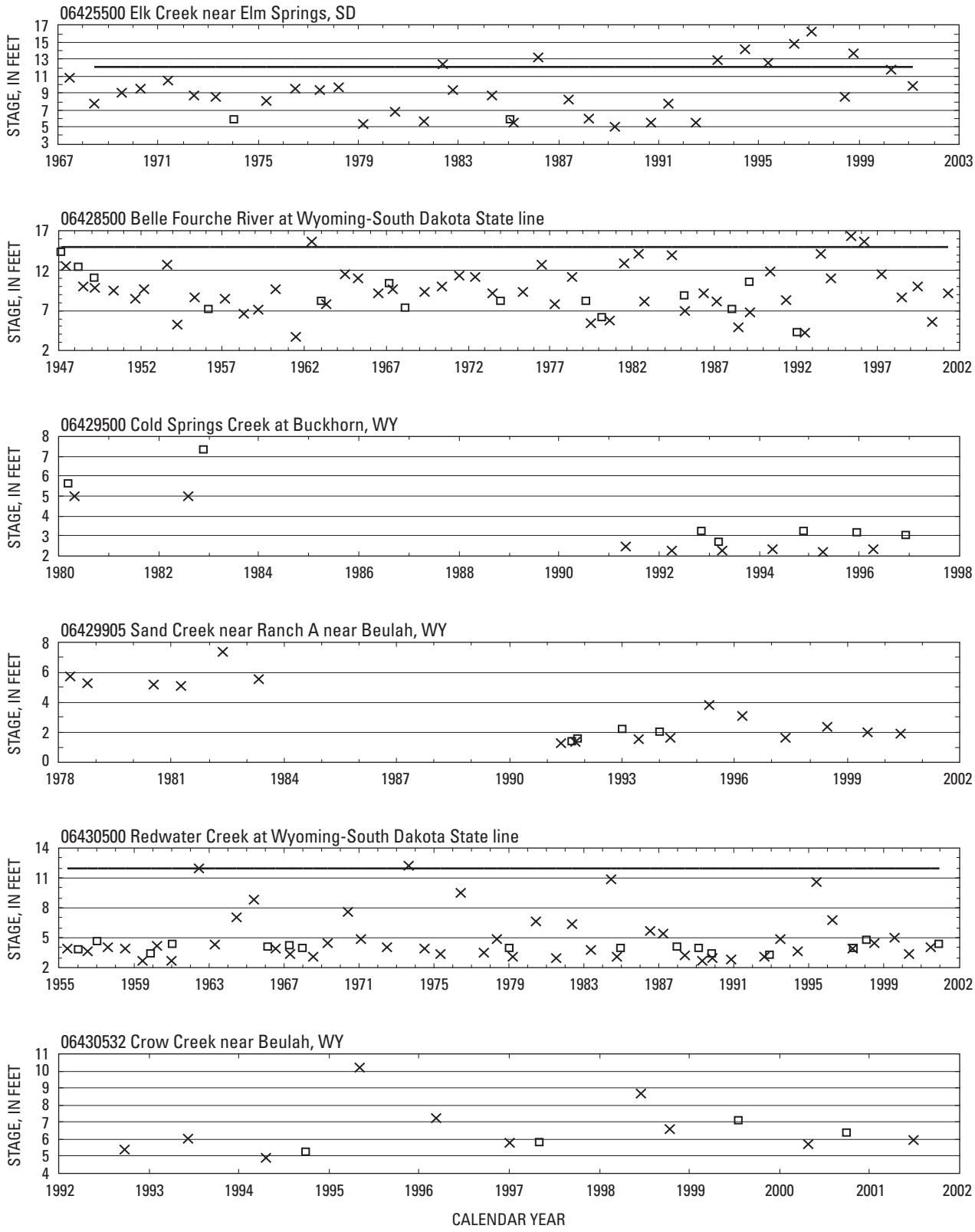


Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

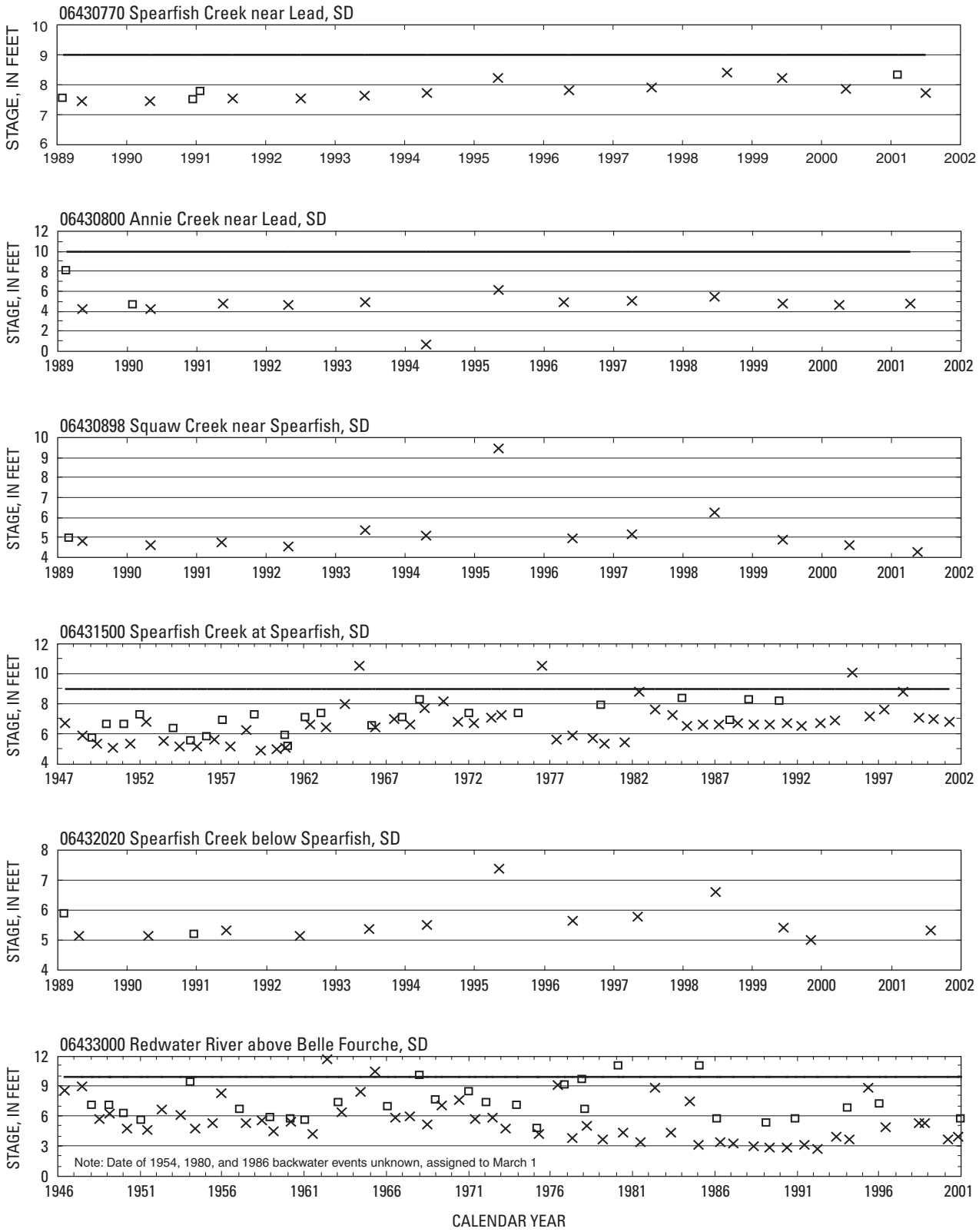


Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

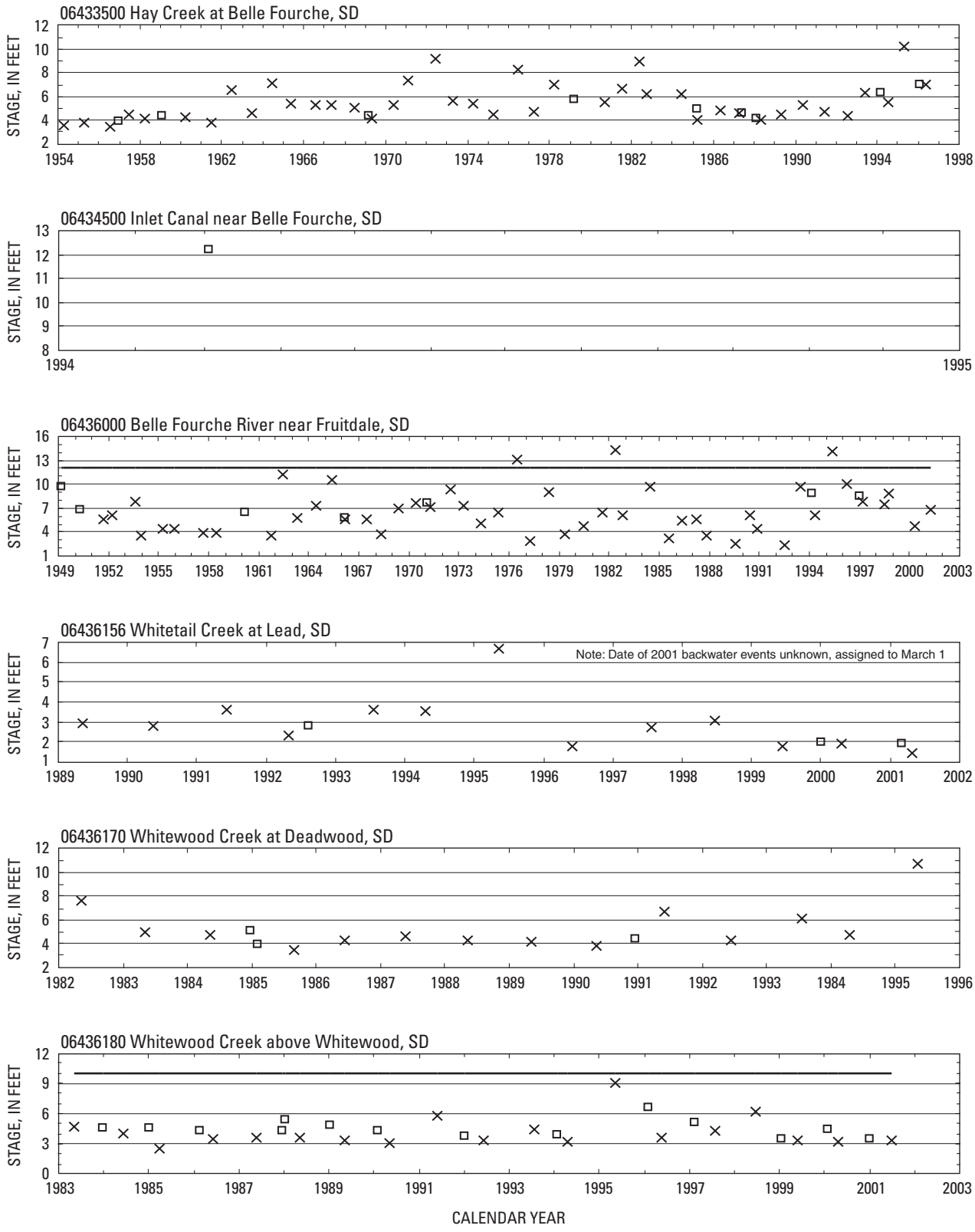
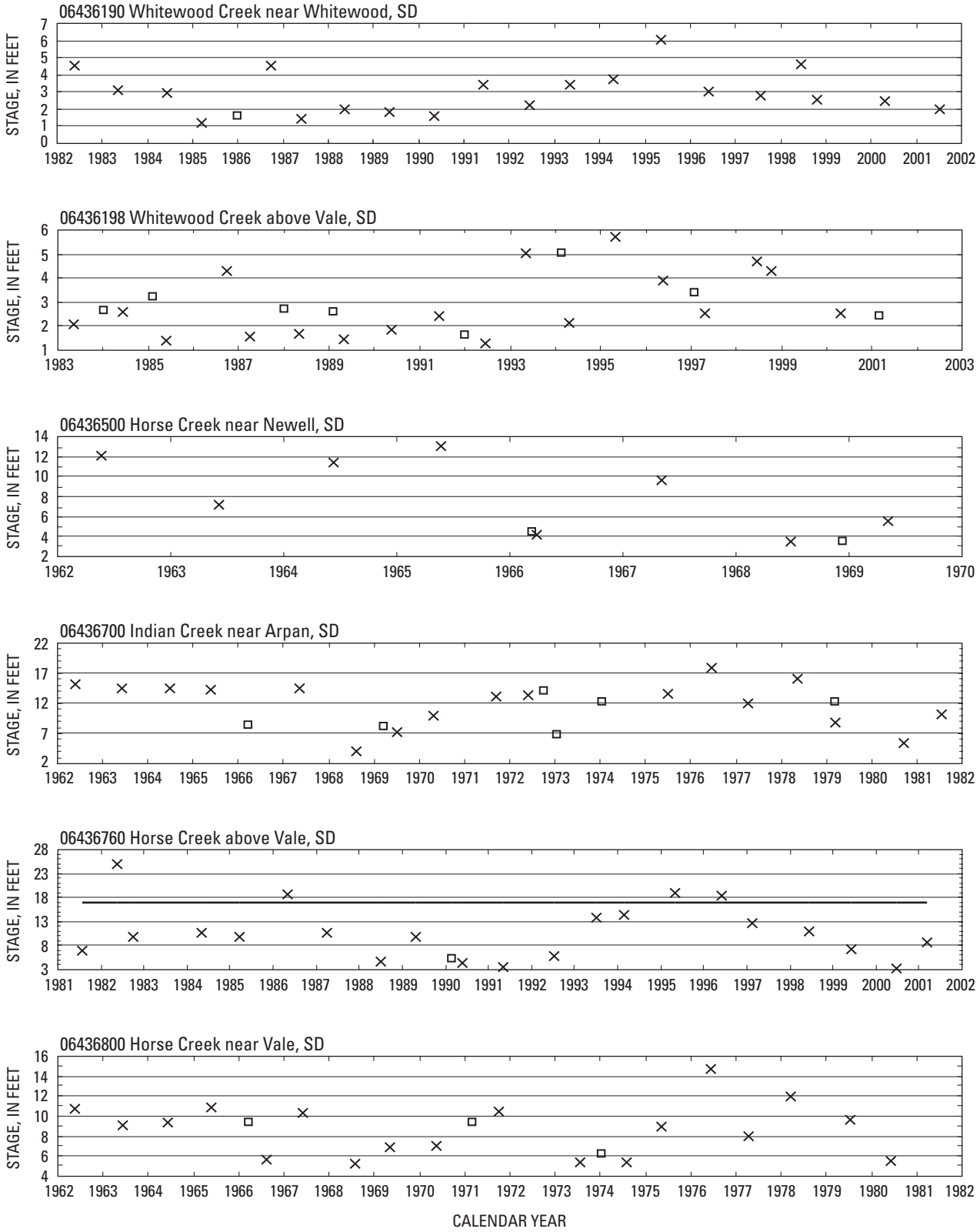


Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued



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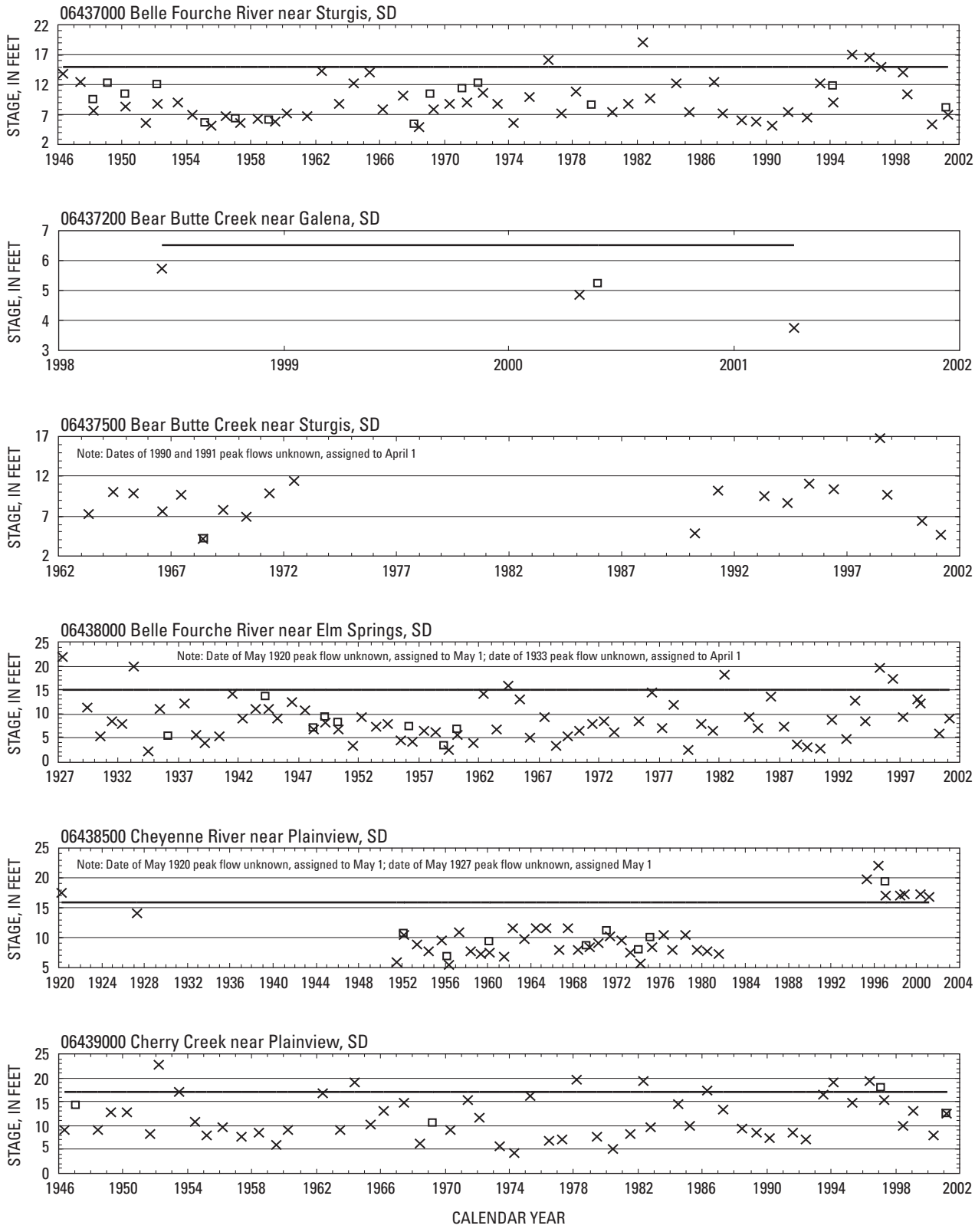

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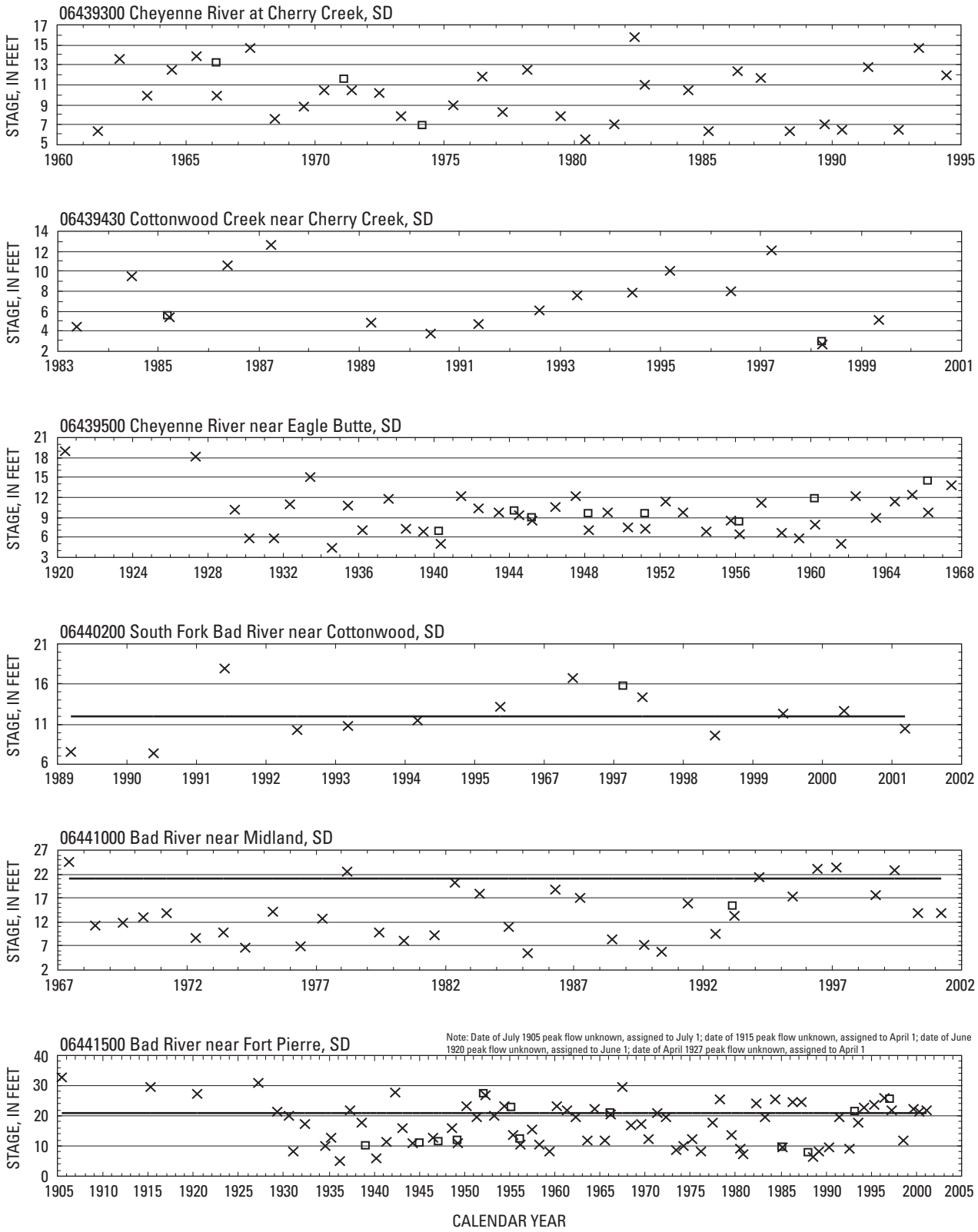
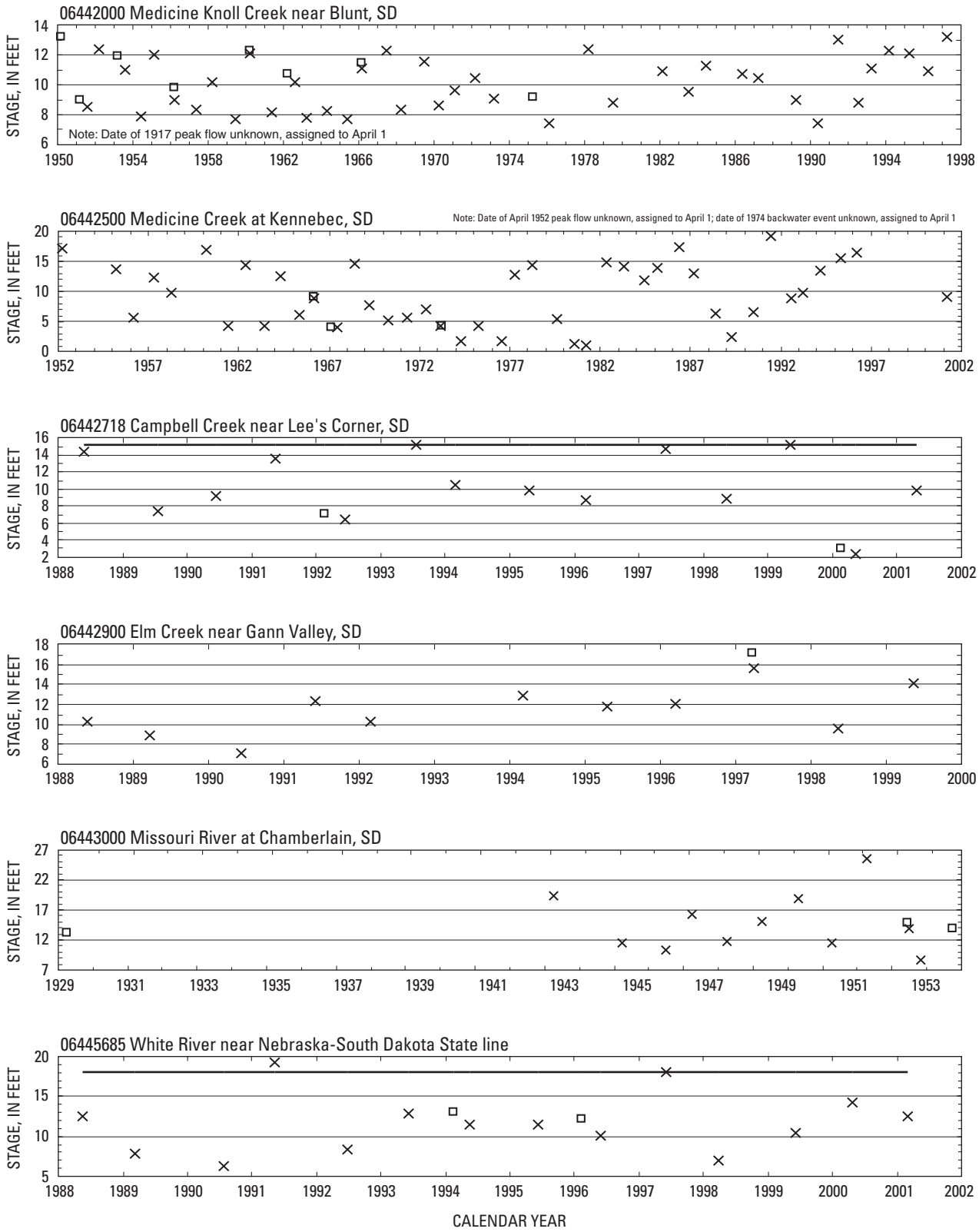


Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued



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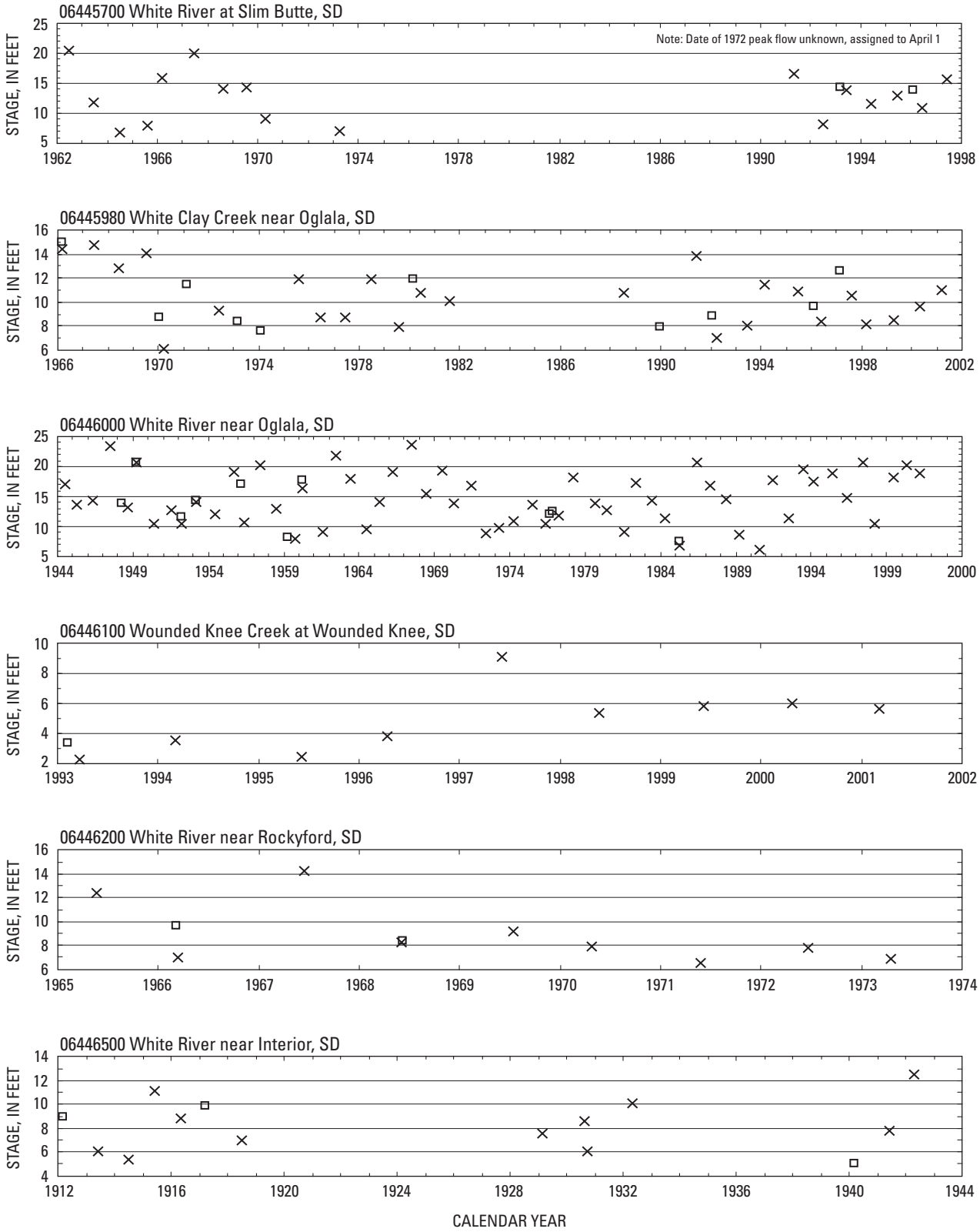

Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

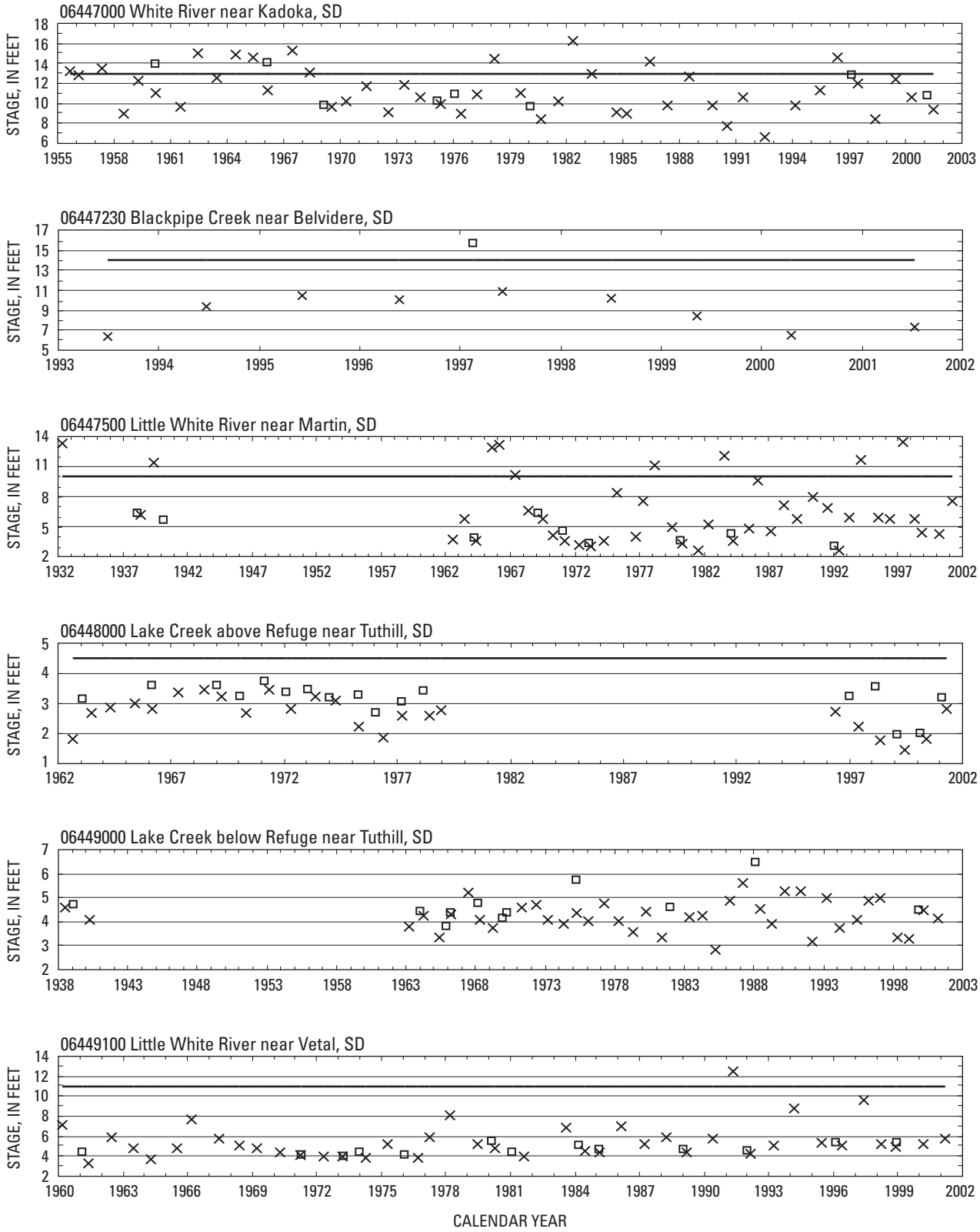

Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

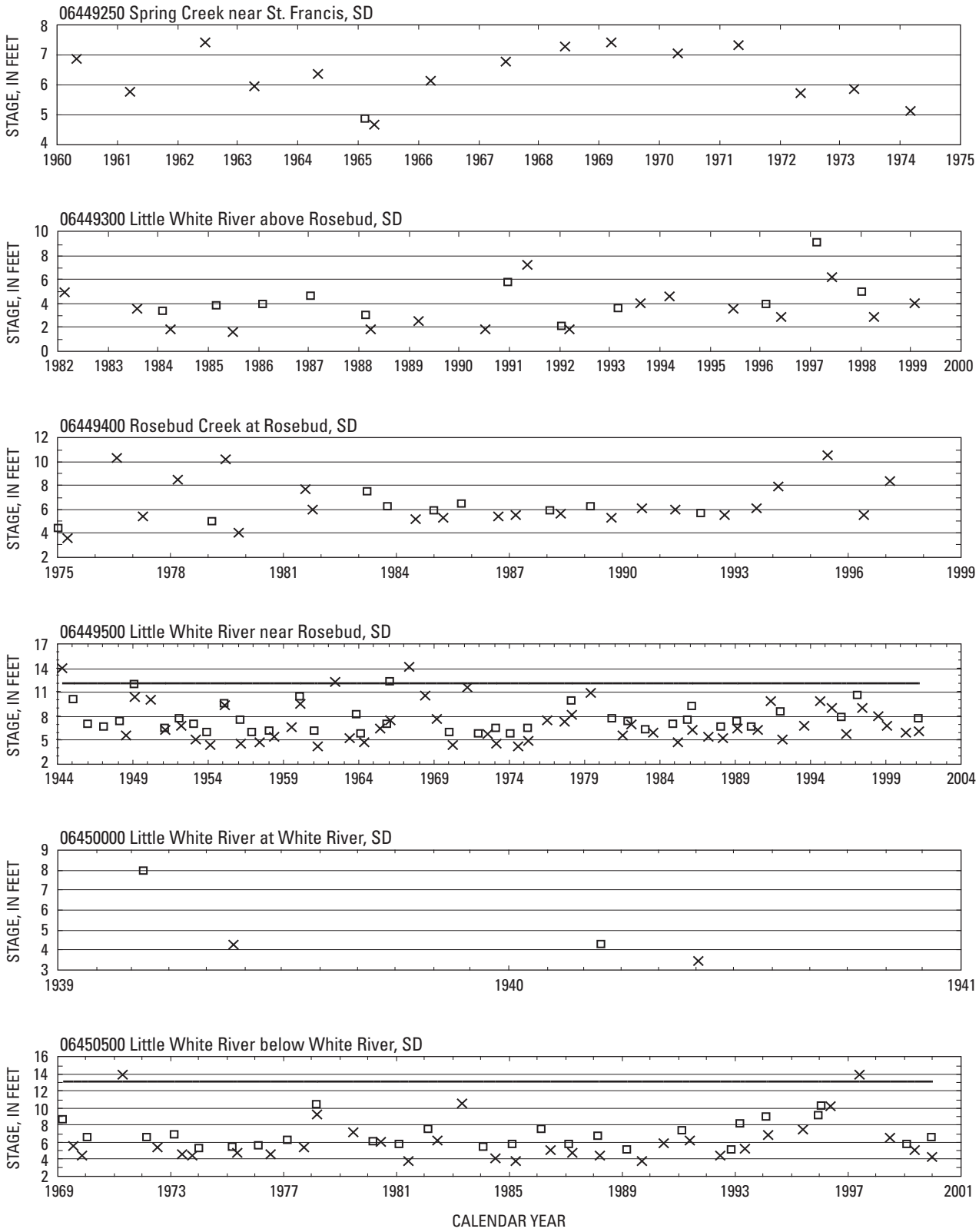

Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

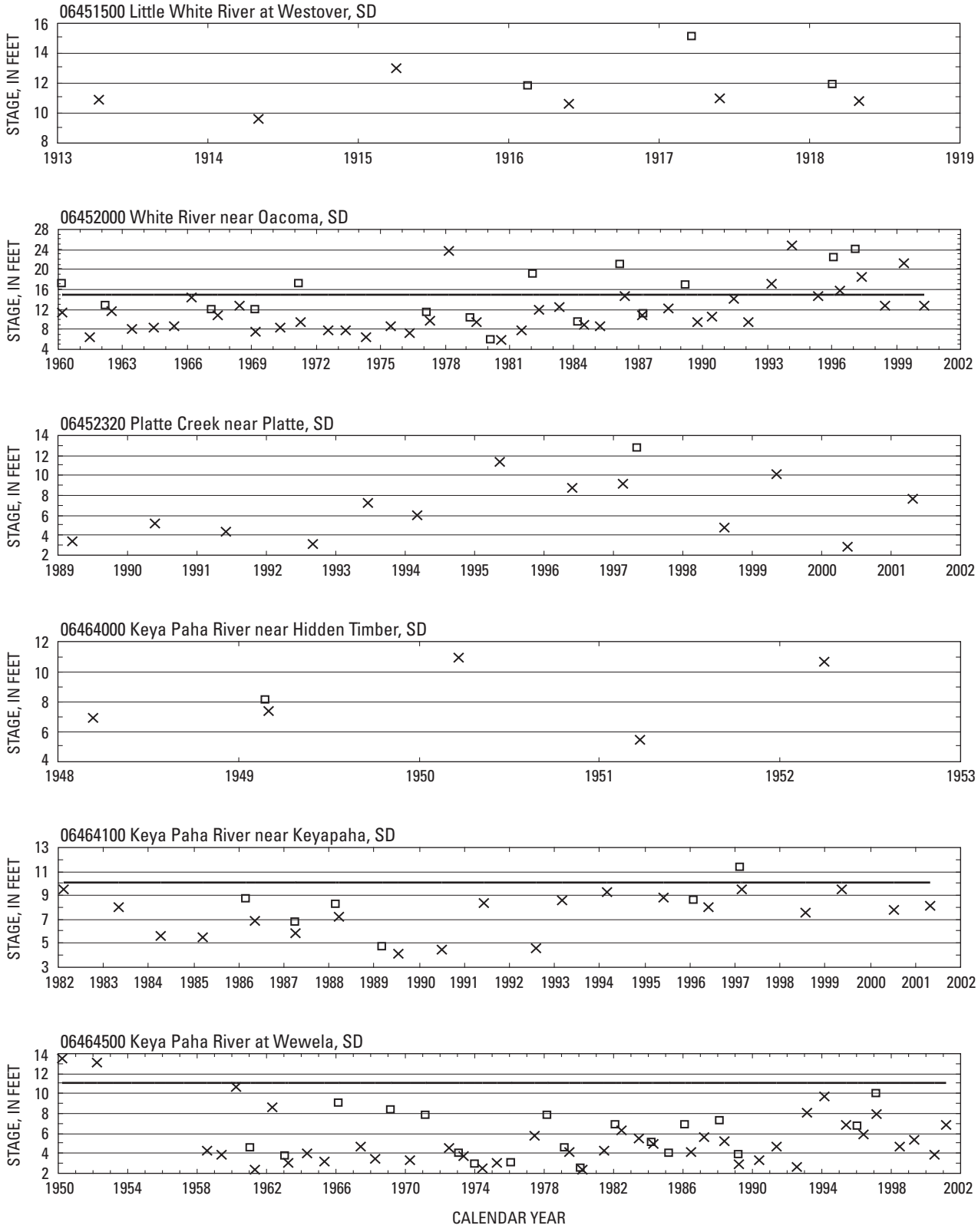

Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

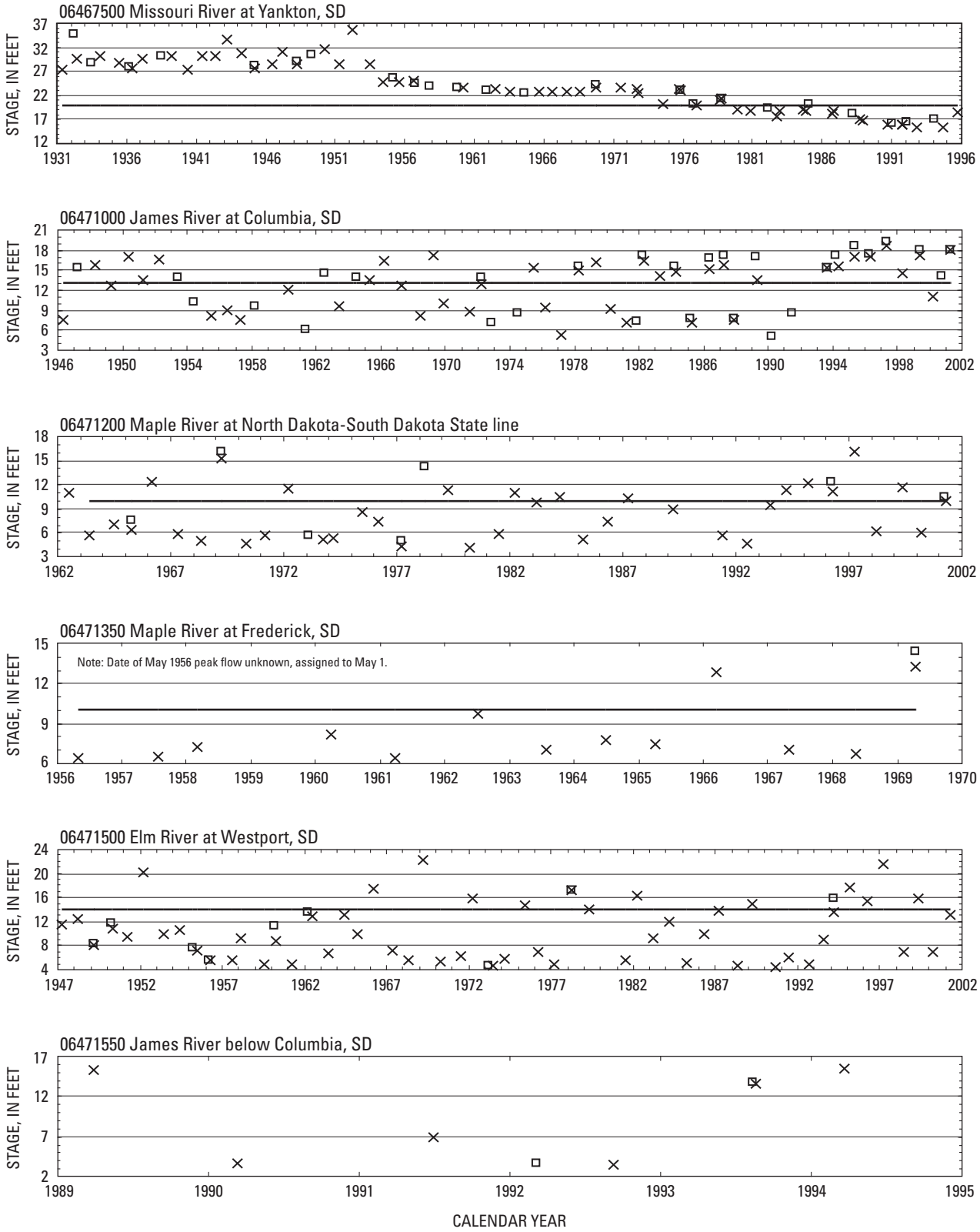

Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

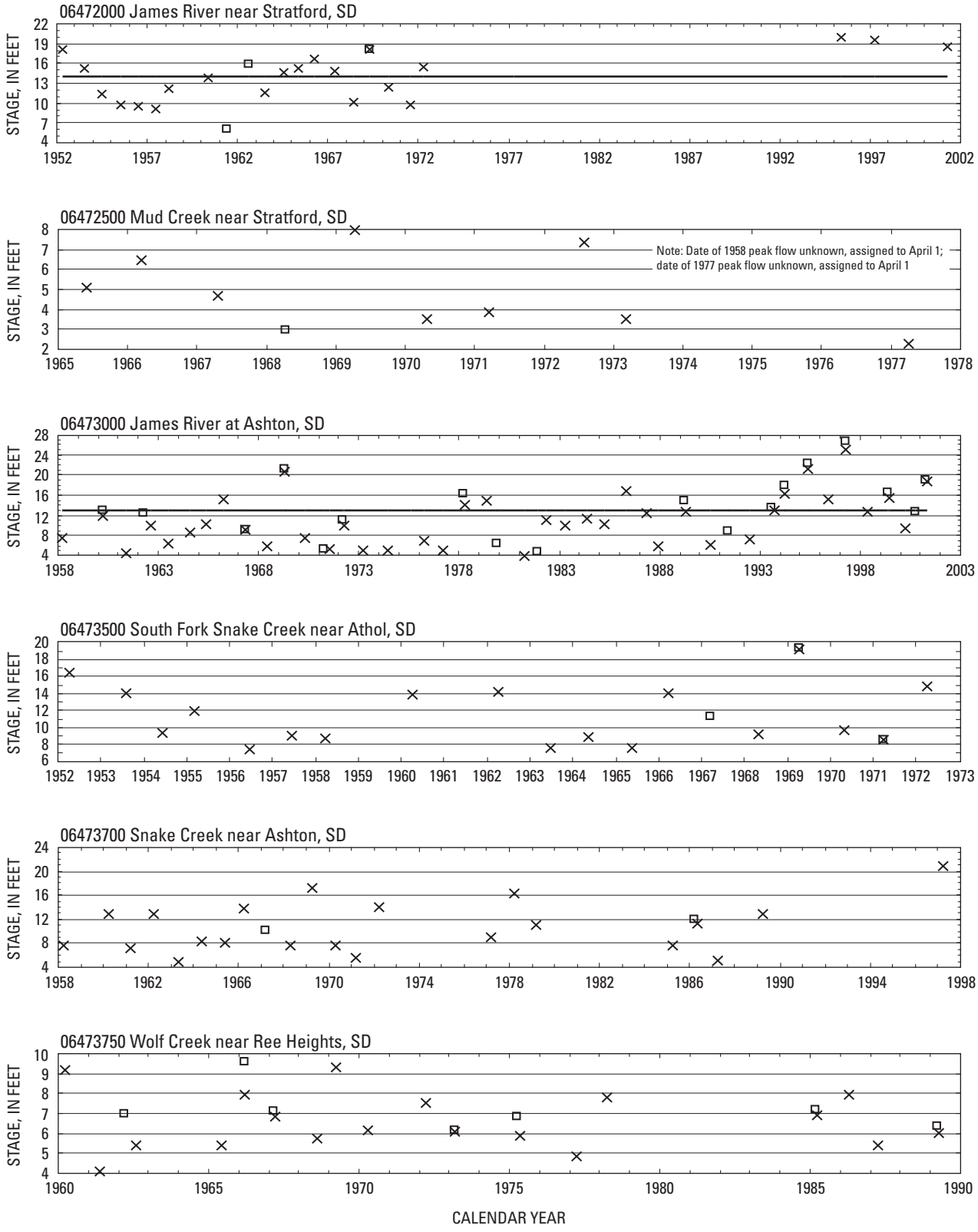

Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

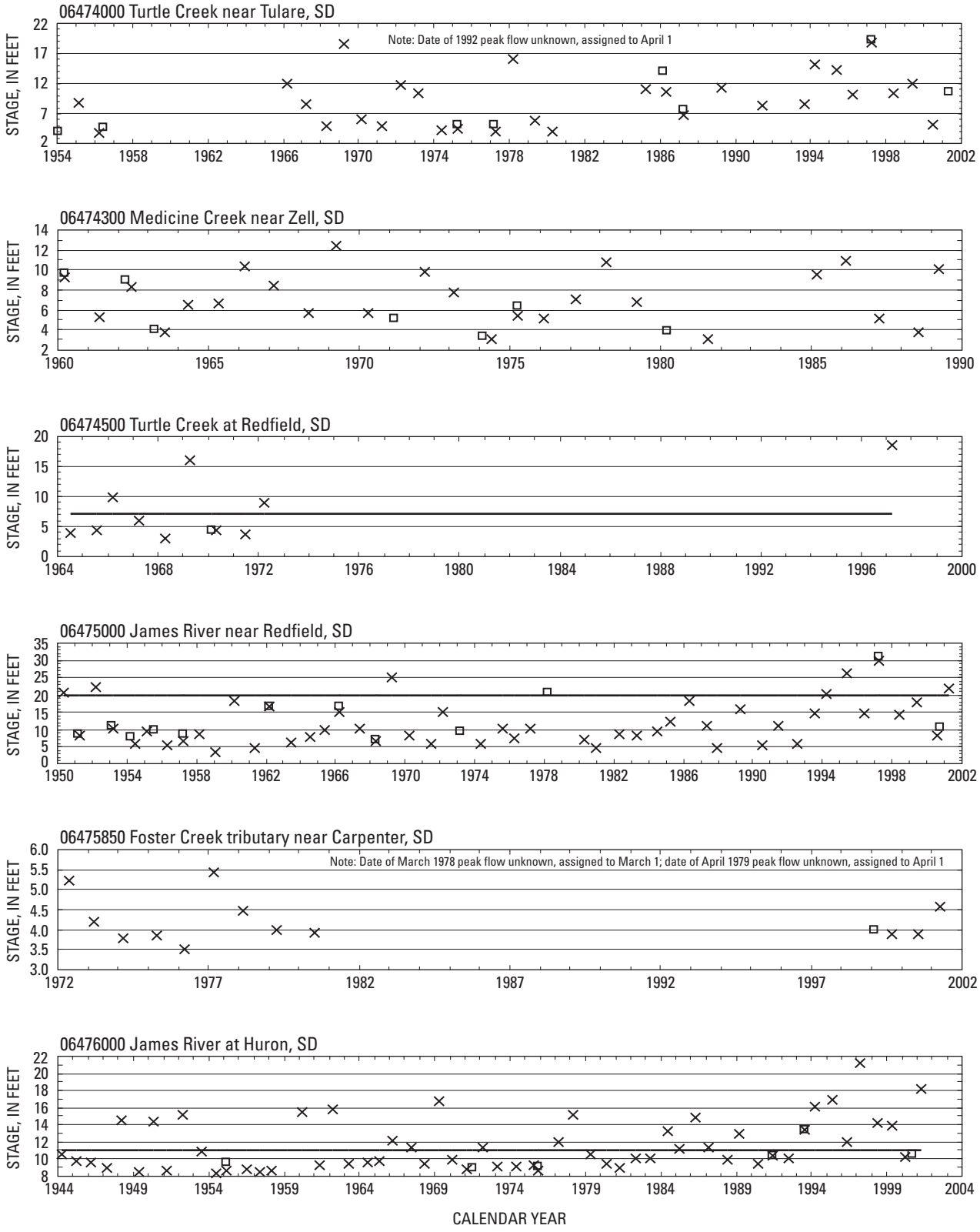

Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

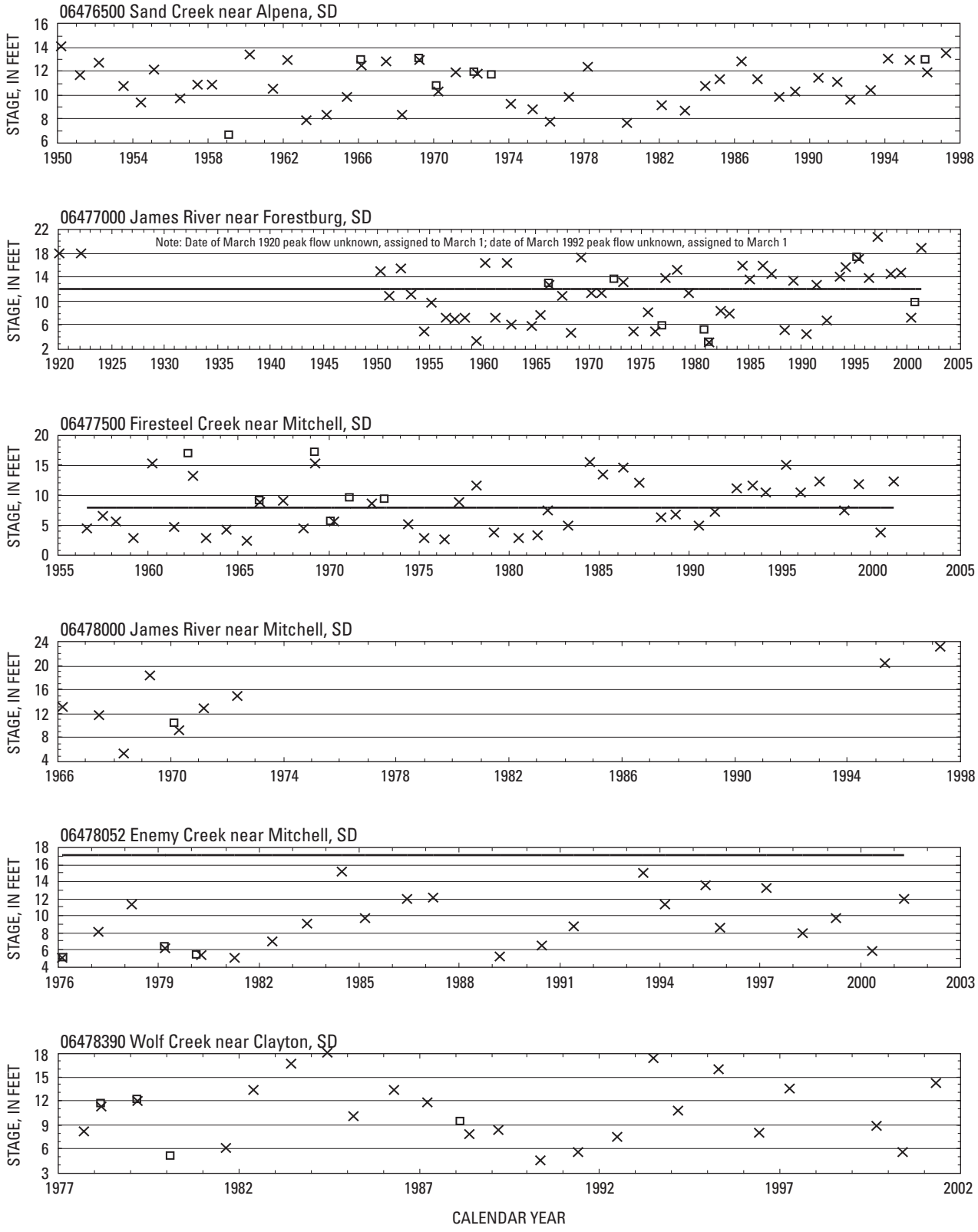

Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

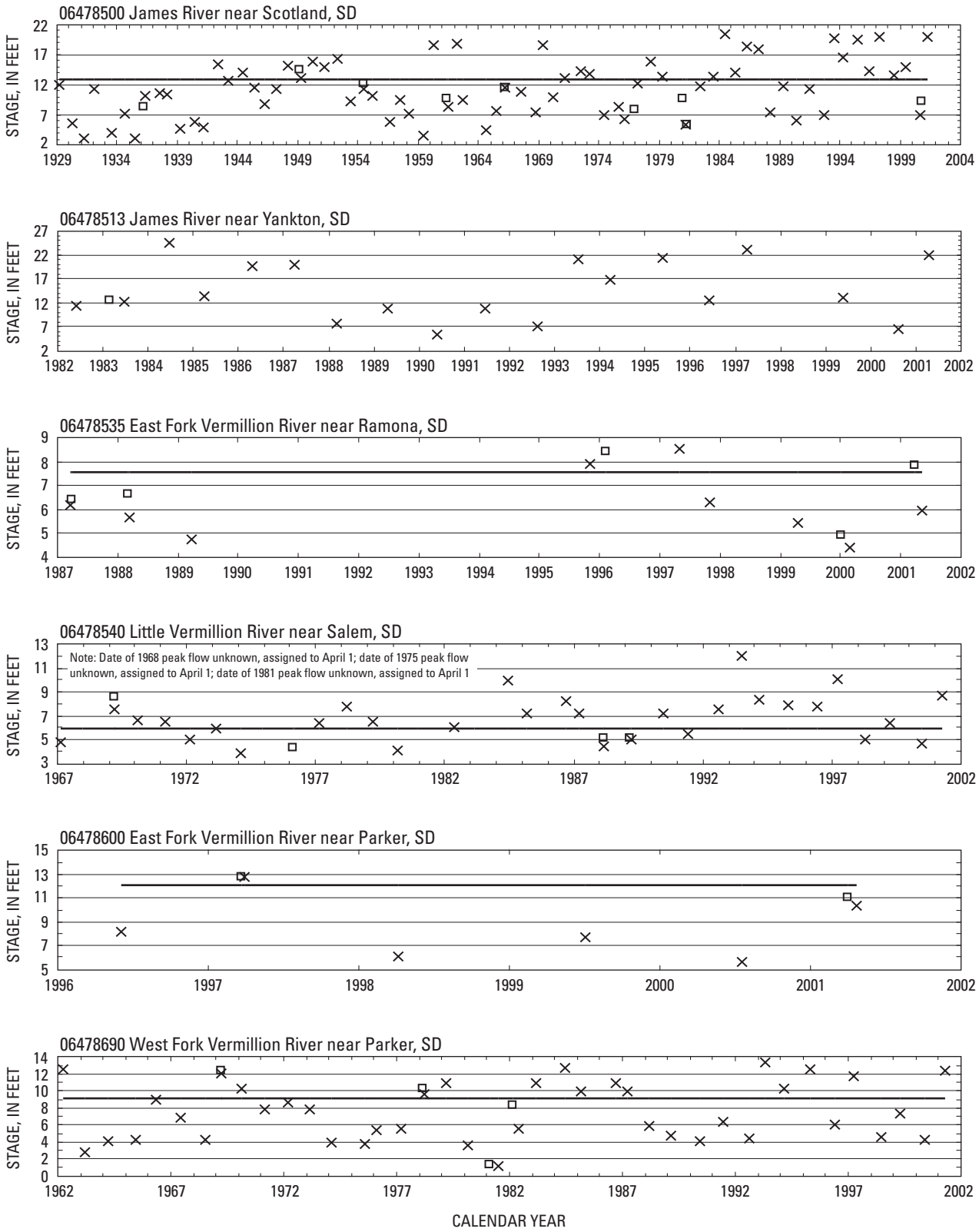

Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

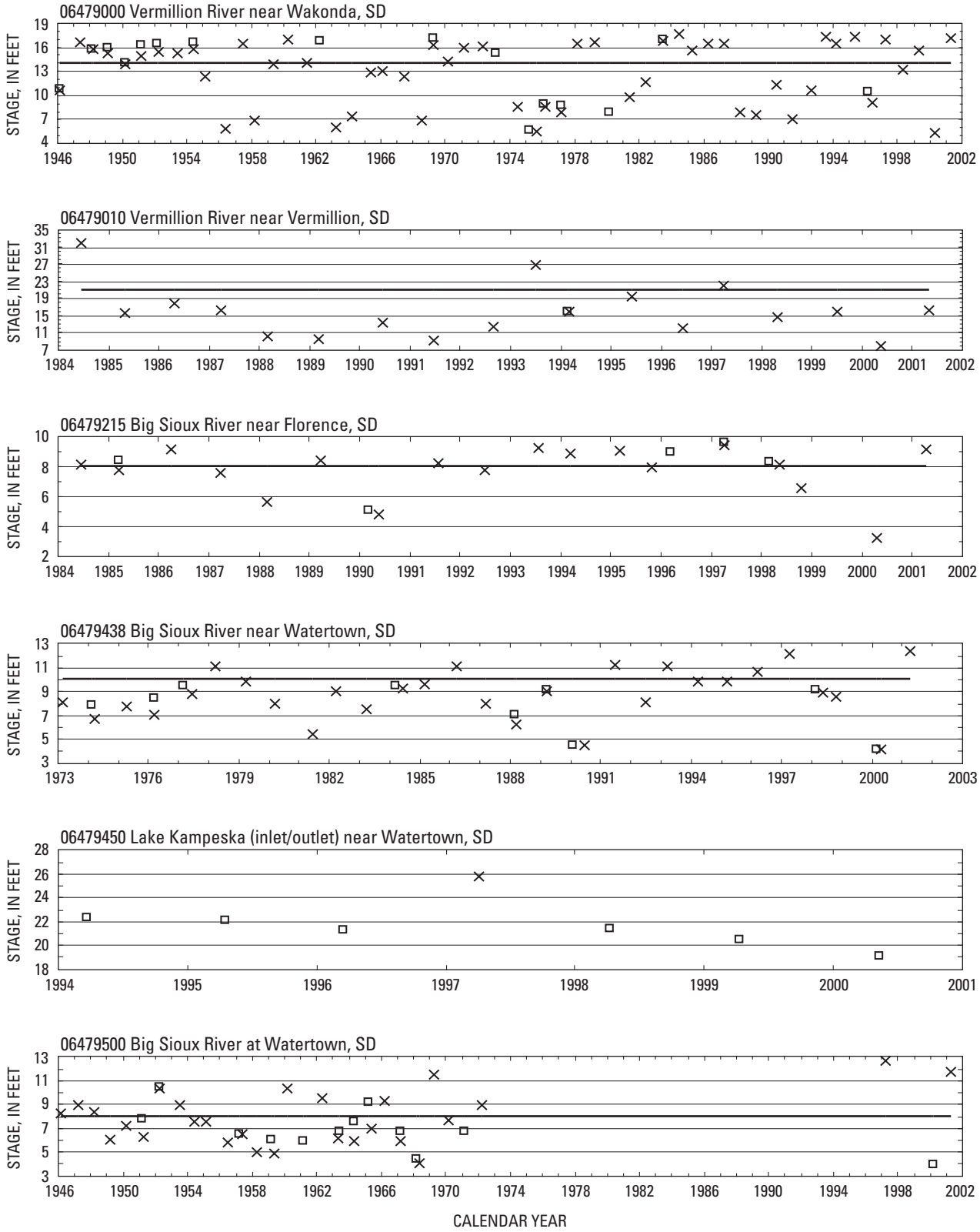

Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

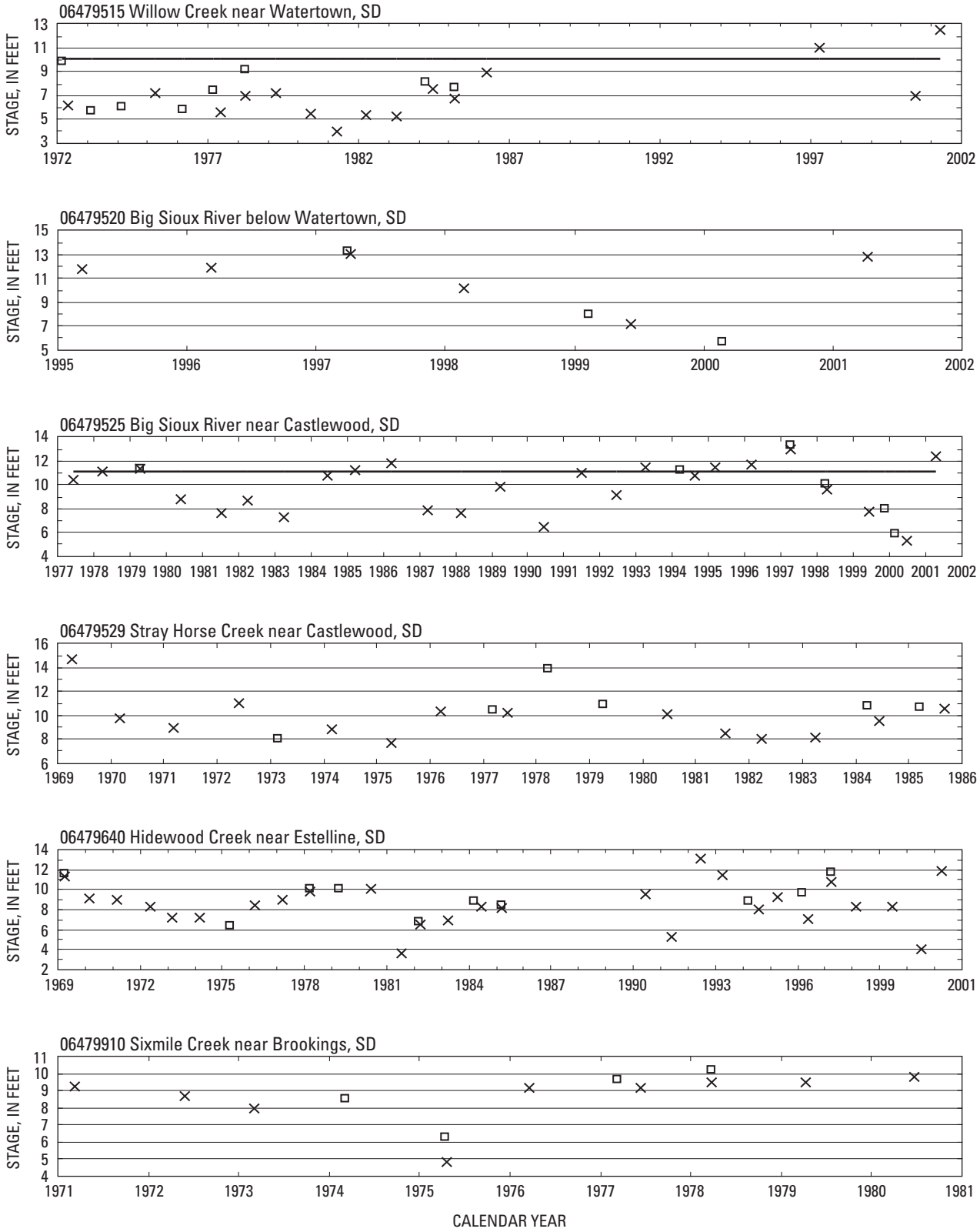

Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

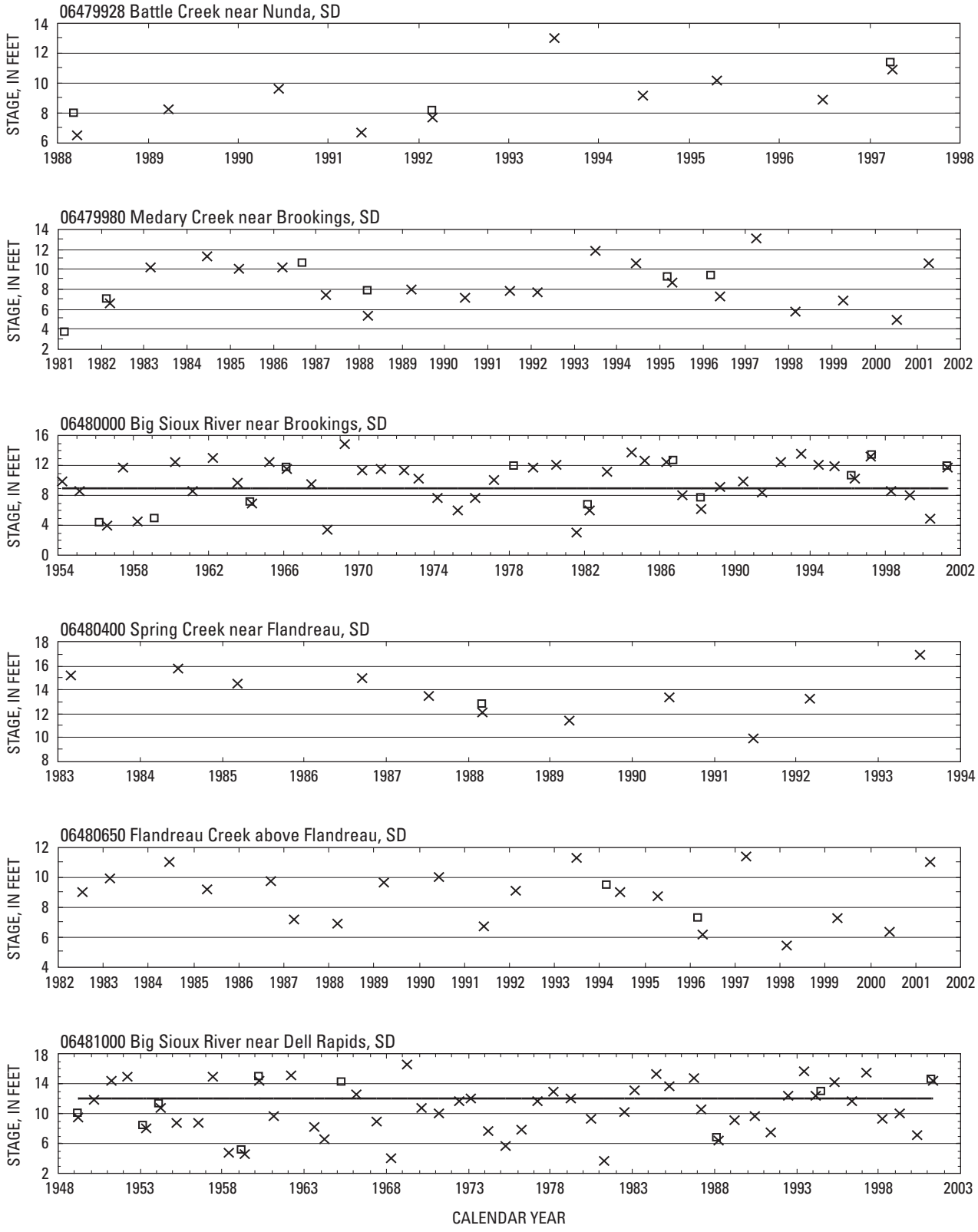

Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

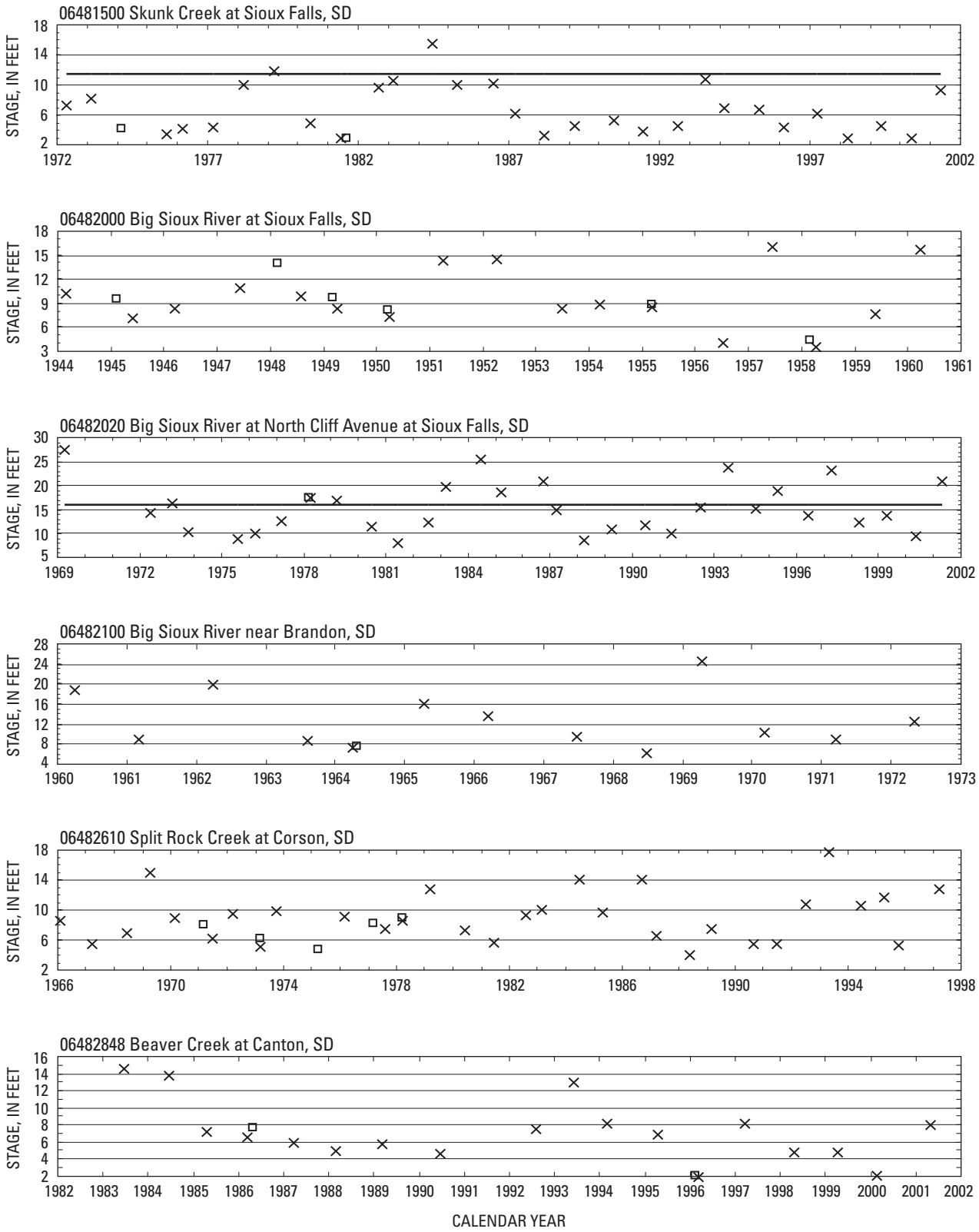

Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

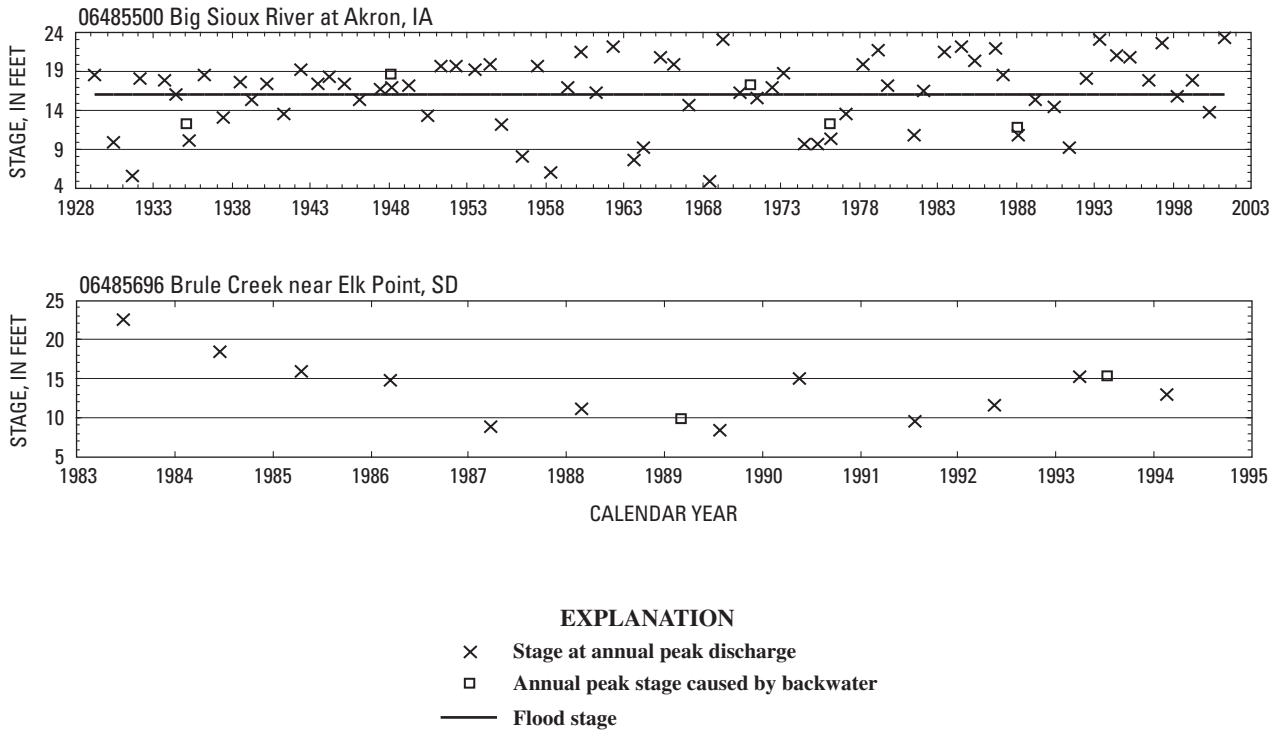

Figure A1. Plots of annual peak stage and stage at peak discharge.—Continued

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