HYDROLOGY

Precipitation

Average annual precipitation for the basin ranges from 32 inches in the northwest part of the basin to 36 inches in the southeast portion (USDA-SCS 1982). The greatest amount of precipitation normally occurs in May (4.49") and June (5.77") (USDA-SCS 1982). The basin is covered by glacial till, a clayey material that greatly retards movement of water to the subsurface (Detroy & Skelton 1983). Most rainfall runs off the surface of the land rather than soaking into the soil. Streams in the basin show rapid flow increases in conjunction with rains, but quickly return to low flow conditions when runoff stops (MDNR 1984). Runoff increases from 6" in the northwest to 8.5" in the southeast portion of the basin. Most runoff occurs in June (USDA-SCS 1982).

United States Geological Survey (USGS) Gaging Stations

There are four active USGS water stage gages throughout the basin (USGS 1992). Two stations are on the Grand River near
Gallatin (http://wwwdmorll.er.usgs.gov/rt-cgi/gen_stn_pg?station=06897500)
and Sumner (http://wwwdmorll.er.usgs.gov/rt-cgi/gen_stn_pg?station=06902000); two are on Thompson River at Trenton (http://wwwdmorll.er.usgs.gov/rt-cgi/gen_stn_pg?station=06899500)
and Davis City, IA (http:/wwwdiaiwc.cr.usgs.gov/rt-cgi/gen_stn_pg?station=06898000).
Several inactive gaging stations are also located throughout the basin. Figure gs shows the location of the active and inactive gaging stations in the Grand River basin.

Permanent/Intermittent Streams

There are more than 1,000 third-order and larger streams within the Grand River Basin. Due to the size and complexity of the Grand River Basin, individuals will need to look at specific reaches as the need arises to determine permanency of flow. To facilitate this, a listing of 7.5' topographic maps covering the entire reach of all fifth order and larger streams is provided in Table 4. Maps can be ordered from the United States Geological Survey (USGS) in Rolla, MO
(http://mapping.usgs.gov/mac/isb/pubs/booklets/usgsmaps/usgsmaps.html). The phone number is 1-888-ask-usgs. Most streams in the basin with drainage areas less than 50 square miles will stop flowing for seven consecutive days or more at some time every two years (Detroy and Skelton 1983).

Average Annual Discharge

The average discharge for the Grand River (Table 5) near Sumner, Missouri is 3,917 cfs (USGS 1992). The maximum instantaneous peak flow (180,000 cfs) occurred in June, 1947. Peak discharge for Grand River at Sumner during 1993 flooding was 150,000 cfs (Parrett et al. 1993).

Detroy and Skelton (1983) developed an equation for calculating average discharge for streams throughout the basin. Average flow can be estimated using the equation:

$$Q=0.73\ A^{0.97},$$

where average annual streamflow (Q) is in cubic feet per second, and drainage area (A) is in square miles.

The Grand River basin makes up approximately 1.5% of the Missouri River watershed but contributes 7% of the average annual discharge (USCOE 1989).

7-day Q_2 and Q_{10} Low Flows

According to Detroy and Skelton (1983):

> Streams in the Grand River Basin are not sustained by ground-water inflow because of the low hydraulic conductivity of the clays and shales of the area. Exceptions are the downstream reaches of the Grand and Thompson rivers.
>
> Most streams in the basin with drainage areas less than 50 square miles will cease to flow for 7 days every other year. Approximately half of the streams with drainage areas of 50 to 200 square miles will also cease to flow every two years. The other half of those streams will have flow of less than 0.7 cfs.
>
> Streams with drainage areas less than 150 square miles will almost always cease flowing every ten years. Approximately half of the streams draining 150 to 500 square miles will have seven day low flows of less than 2 cfs. Drainage area is not a good predictor of low flow in streams that drain larger watersheds.

Dam and Hydropower Influences

There are no major dams within the basin. Seven large flood control reservoirs were designed by the Corps of Engineers (USCOE 1963). A follow-up report concluded that the reservoirs and associated channel modification was not economically feasible. The projects were deauthorized in 1989 (USCOE 1989). Due to extensive flooding throughout the basin during 1993, support for reauthorization of these projects has surfaced in some areas. A federal buyout and relocation of Pattonsburg, Missouri appears to have satisfied most people in the area.

In the 1970's, there was an unsuccessful proposal to impound a large reach of Locust Creek in association with a proposed coal gasification plant near Milan (approximately river mile 46). In 1990, there was a renewed interest in constructing the same 5,800 acre lake for water supply and recreation. This second attempt was also unsuccessful because the Locust Creek Lake Committee could not acquire sufficient funding to construct the reservoir. This lake would have inundated several miles of unchannelized stream and altered downstream flows. There is still local interest in creating a water supply and recreation lake near Milan.

The number of lakes larger than two acres has changed dramatically since 1984. There are approximately 30 lakes larger than 50 acres within the basin. Numerous 5-10 acre watershed structures have been built both on public and private land in association with PL-566 and erosion control projects. There are concerns regarding the impact of numerous small flood control structures and their impact on low flow conditions. These structures intercept runoff and make no provisions for maintenance of stream flows.

Table 4. USGS 7.5 minute quadrangle maps covering main stream and longest arm of fifth order and above streams in the Grand River Basin. Maps are listed in order from mouth of stream to headwaters.

Stream	Order	Map Name
Big Creek (Carroll)	5	Brunswick West, Bosworth, Tina, Coloma, Bogard
Big Creek (Daviess and Harrison)	6	Coffey, Pattonsburg, Mitchellville, Bethany, Brooklyn, Pawnee, Kellerton
Big Creek, East Fork	5	Bethany, Gardner, Eagleville, Lamoni South, Lamoni North
Big Muddy Creek	5	Gallatin, Jameson, Gilman City West
Big Muddy Creek, East Fork	5	Albany North, New Hampton, Washington Center, Hatfield
Bridge Creek	5	Tina, Avalon
Brush Creek	5	Cainsville, Eagleville
Brushy Creek	5	Cameron East, Winston
Coon Creek	5	Meadville, Eversonville
East Locust Creek	5	Browning, Milan West, Milan East, Pollock, Unionville West
Elk Creek (Chariton)	5	Mendon, Sumner, Rothville, Marceline, Brookfield
Elk Creek (Decatur, IA)	5	Lamoni North, Grand River, Ellston

Table 4 continued

Grand River	8	Brunswick East, Brunswick West, Bosworth, Hale, Fountain Grove, Avalon, Utica East, Chillicothe, Sampsel, Breckenridge, Jamesport, Gallatin, Altamont, Coffey, Pattonsburg, Berlin, Albany South, Darlington, Gentry, Alanthus Grove, Parnell East, Sheridan, Blockton, Maloy, Benton, Diagonal, Shannon City, Arispe, Creston East
Grand River, East Fork	6	Albany South, Albany North, Allendale, Blockton S.E., Hatfield, Mount Ayr, Tingley, Arispe
Grand River Middle Fork	5	Darlington, Gentry, Grant City, Blockton S.E., Benton
Grand River (Old Channel)	5	Breckenridge, Nettleton, Gallatin
Grindstone Creek	7	Pattonsburg, Weatherby, Winston, Fordham, Cameron West
Honey Creek (Grundy)	5	Farmersville, Trenton East, Spickard, Mill Grove, Half Rock, Ravanna
Honey Creek (Daviess)	5	Gallatin, Nettleton, Kidder, Altamont
Island Creek	5	Stanberry, King City
Little Creek	5	Bethany, Brooklyn
Little East Locust Creek	5	Browning, Milan S.E., Milan East
Little Medicine Creek	5	Laredo, Galt, Half Rock, Ravanna, Cleopatra
Little River	5	Princeton, Lineville, Pleasanton, Leon, Davis City, Van Wert, Lacelle
Little Shoal Creek	5	Cameron West, Lathrop
Locust Creek	7	Fountain Grove, Sumner, Laclede, Linneus, Browning, Milan West, Pollock S.W., Pollock N.W., St. John, Seymour West
Log Creek	5	Hamilton East, Cowgill, Polo, Hamilton West, Elmira
Long Branch	5	Cameron East, Winston
Long Creek	5	Grand River, Van Wert, Hopeville, Murray
Lost Creek	7	Weatherby, Maysville, Wood, Ford City
Lost Creek, East Fork	5	Maysville, Berlin

Table 4 continued

Lost Creek, Middle Fork	6	Maysville, Berlin, Ford City
Lost Creek, West Fork	6	Maysville, Fordham, Amity
Lotts Creek	5	Allendale, Blockton S.E., Hatfield, Mount Ayr, Kellerton, Ellston
Marrowbone Creek	5	Nettleton, Kidder, Winston
Medicine Creek	6	Avalon, Wheeling, Chula, Laredo, Lindley, Osgood, Harris, Lucerne, Powersville, Allerton
Mill Creek	5	Hamilton West, Kidder
Mud Creek Ditch	5	Utica West, Braymer, Stet, Millville
Muddy Creek (Carroll County)	5	Avalon, Wheeling, Chula, Eversonville, Lindley, Osgood
Muddy Creek (Grundy County)	5	Trenton East, Spickard, Mill Grove, Princeton, Cleopatra, Lineville
Muddy Creek (Linn County)	5	Laclede, Linneus
No Creek	5	Farmersville, Trenton East, Laredo, Galt, Half Rock
No Name (T56N,R30W, S15)	5	Cameron West
No Name (T58N, R31W, S2)	5	Fordham, Amity, Wood
Parson Creek	6	Fountain Grove, Meadville, Eversonville, Lindley
Pops Branch	5	Princeton, Lineville
Raccoon Creek	5	Brimson, Trenton West, Bancroft
Sampson Creek	5	Pattonsburg, Matkins, New Hampton
Sheep Creek	5	Hamilton West, Winston
Shoal Creek	6	Utica East, Utica West, Flat Creek, Hamilton East, Hamilton West, Cameron East, Cameron West, Lathrop
Smith Branch	5	Weatherby, Winston
Sugar Creek	6	Brimson, Gilman City East, Gilman City West, Gardner
Thompson River (Old Channel)	5	Trenton East, Trenton West

Table 4 continued

Thompson River	7	Chillicothe, Farmersville, Trenton East, Trenton West, Brimson, Mount Moriah, Cainsville, Akron, Davis City, Lamoni North, Grand River, Tingley N.E., Lorimor South, Afton, Macksburg, Arbor Hill, Greenfield
Three-Mile Creek	5	Lorimor South, Afton, Creston East, Zion
Tom Creek	5	Hamilton East, Hamilton West, Kidder
Trail Creek	5	Mount Moriah, Gardner
Turkey Creek (Chariton County)	5	Sumner, Laclede, Linneus
Turkey Creek (Gentry County)	5	Stanberry, Guilford
Unnamed #31	5	Browning, Milan West, Osgood
Wamsley Creek	5	Fordham, Winston
Weldon River	6	Trenton West, Brimson, Spickard, Mill Grove, Princeton, Lineville, Woodland, Leon, Garden Grove S.W., Weldon, Lacelle
West Elk Creek (Decatur County, Iowa)	5	Lamoni North, Kellerton, Ellston
West Fork Lost Creek	6	Maysville, Fordham, Amity
West Locust Creek	6	Linneus, Browning, Milan West, Osgood, Harris, Lucerne
West Muddy Creek	5	Spickard, Brimson, Modena, Goshen
West Yellow Creek	5	Rothville, Brookfield, Shelby, Bucklin N.W., Milan S.E., Winigan, Milan East, Mystic, Green City, Pollock
Wildcat Creek	6	Darlington, Stanberry, Ravenwood
Wolf Creek	5	Trenton West
Yellow Creek	6	Hale, Mendon, Indian Grove, Rothville, Marceline, Bucklin, Bucklin N.W., Winigan, Mystic

Table 5. Discharge information (cfs) for the period of record at various locations within the Grand River Basin (USGS 1992, USGS 1993).

Location	Max.	Min.	Mean	10% Exceeds	50% Exceeds	90% Exceeds
Grand River: Gallatin (1921 - 1992)	69,100	2.0	1168	2,330	205	25
Grand River: Sumner (1923 - 1992)	180,000	10.0	3896	9,810	925	121
Thompson River: Trenton (1928 - 1992)	95,000	1.0	969	2,230	200	27
Thompson River: Davis City, Ia (1941 - 1993)	57,0001	---	402	855	80	9
Elk Creek: Decatur, IA (1968 - 1993)	32,000	0.0	37	50	4	0

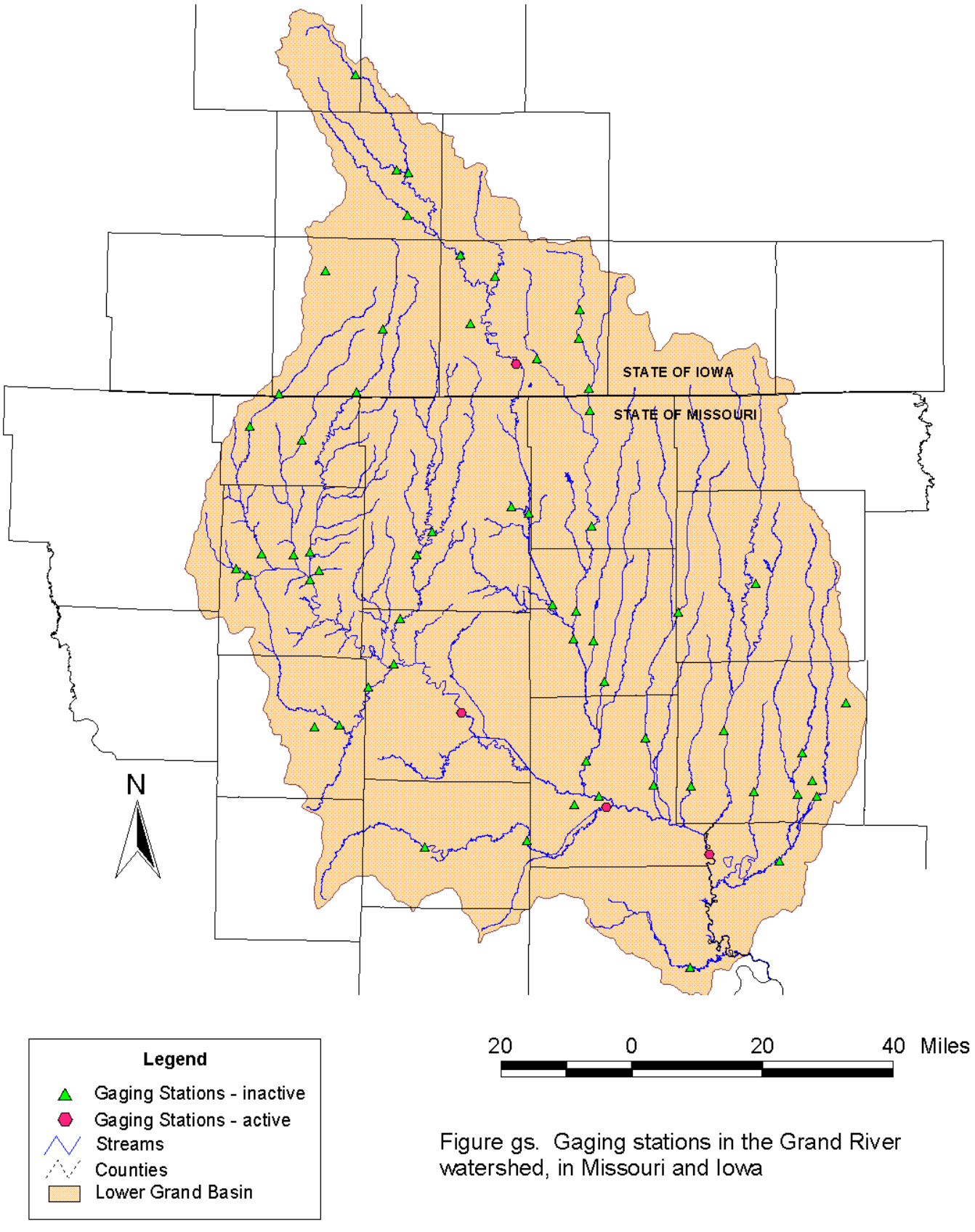

Figure gs. Gaging stations in the Grand River watershed, in Missouri and Iowa